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PROCEDURES REPORT

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USERS MANUAL FOR THE U.S. BASELINE CORN AND SOYBEAN SEGMENT CLASSIFICATION PROCEDURE

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16. Abstract

This document is a users manual for the classification component of the U.S. corn and soybean pilot experiment to be conducted by the FCPF project of AgRISTARS in FY81.

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PREFACE

This document describes the U.S. Corn and Soybean Baseline Segment Classification Procedure which was implemented under NASA Contracts NAS9-15476 and NAS9-14565 during the period November 15, 1979 to March 14, 1981 for the Foreign Commodity Production Forecasting Project of AgRISTARS.

The implementation was performed by the Environmental Research Institute of Michigan under Richard R. Legault, Vice-President of ERIM and Head of the Infrared and Optics Division, Robert Horvath, Program Manager and Head of the Analysis Department, and Richard C. Cicone, Program Area Manager; and at the Space Sciences Laboratory of the University of California at Berkeley under Dr. Robert Colwell, Principal Investigator, and Claire Hay, Program Manager.

The authors of this document, listed alphabetically, are C. Hay and J. Odenweller of UCB, and R. Cicone, M. Metzler, O. Mykolenko, and D. Rice of ERIM. In addition the following members of the ERIM staff contributed to the implementation effort: L. Aprill, J. Baker, E. Colbert, J. Finkler, S. McFarling, K. Pardiac, and T. Truax. Significant secretarial support was provided by P. Wessling.

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INTRODUCTION

This document is a user's manual for the classification component of the FY81 U.S. Corn and Soybean Pilot Experiment in the Foriegn Commodity Production Forecasting Project of AgRISTARS. This experiment is one of several major experiments in AgRISTARS designed to measure and advance the remote sensing technologies for cropland inventory.

The classification procedure, which is discussed in detail in Section 2, is designed to produce segment proportion estimates for corn and soybeans in the U.S. Corn Belt (Iowa, Indiana, and Illinois) using Landsat data. The estimates are produced by an integrated Analyst/Machine procedure. The Analyst selects acquisitions, participates in stratification, and assigns crop labels to selected samples. In concert with the Analyst, the machine digitally preprocesses Landsat data to remove external effects, stratifies the data into field-like units and into spectrally similar groups, statistically samples the data for Analyst labeling, and combines the labeled samples into a final estimate.

The aggregation of segment-level estimates produced in this manner and the formation of production estimates are functions outside the scope of this classification procedure.

This manual addresses the following audience: the Analysts, the machine users, the managers, and "external" users. This latter group is diverse, including a number of program elements (such as Accuracy Assessment, Quality Assurance, and Sampling and Aggregation) that do not carry out the actual running of the classification system. Figure 1 identifies the portions of this manual that are of principle interest to each category of user.

This manual was designed to require only a minimum of knowledge or experience on the part of the users. Analysts are expected to have some experience with image interpretation; machine users are expected to know how to log onto the computer and perform a small number of routine tasks on the system. However, users that must digitally access the stored data will need some knowledge of computer programming in order to use Appendix I.

FIGURE 1.
Classification System Users

User	Sections of Primary Interest
(All)	1, 2, 3.3, Appendix A
Analyst	5, 6, Appendices C, D, E, F
Machine User	4, 6, Appendices B, H
Managers	3
External	7, Appendix G
(a) Data Preparation (1)	6.1, Appendix E
(b) Data Base User (2)	Appendices I, J

NOTES:

    (1) Crop calendar and weather, packet preparation.

    (2) Accuracy Assessment, Quality Assurance, Sampling and Aggregation.

The baseline corn and soybean segment classification procedure is a technology for estimating the corn and soybean acreage in Landsat segments selected from the U.S. corn belt. The procedure is designed to run on either the LARS IBM 3031 computer at Purdue University or the Earth Observation Division Laboratory (EODL) AS/3000 at the Johnson Space Center (JSC), in conjunction with significant work carried out by Analyst Interpreters. This section provides a technical (Section 2.1) and operational (Section 2.2) overview of the procedure.

Segment-wide proportion estimates for corn and soybeans are generated using a stratified area estimation approach. The scene data are stratified; samples are allocated proportional to the size of the strata; the samples are labeled by Analysts and aggregated to produce crop estimates. Analysis for crop labels follows a "convergence-of-evidence" approach. That is, a progressive accumulation of information results in a final crop label. Multitemporal data is required since phenological patterns demonstrated through the spectral Landsat variables are key to crop separability. First, the multitemporal spectral patterns of pixels are examined by Analysts in order to stratify the scene into major crop groups. Field-like labeling targets, called blobs, are objectively selected and labeled by an Analyst according to crop type, specifically "corn", "soybean" or "other". The Analyst interpreters label the blobs using a well-defined decision logic with the aid of spectral plots and statistics provided by the machine as well as the Analysts knowledge of meteorological conditions and cropping practices of the area.

2.1   TECHNICAL OVERVIEW

The baseline procedure can be functionally viewed in three major stages as is illustrated in Figure 2. The three stages include preprocessing and initial segment analysis, stratification and sampling, labeling and proportion estimation.

FIGURE 2.
Functional View Of U.S. Baseline C/S Procedure

Preprocessing
and
Initial Segment
Analysis

⬇

Stratification
and
Directed Sampling

⬇

Target Labeling
and
Proportion Estimation
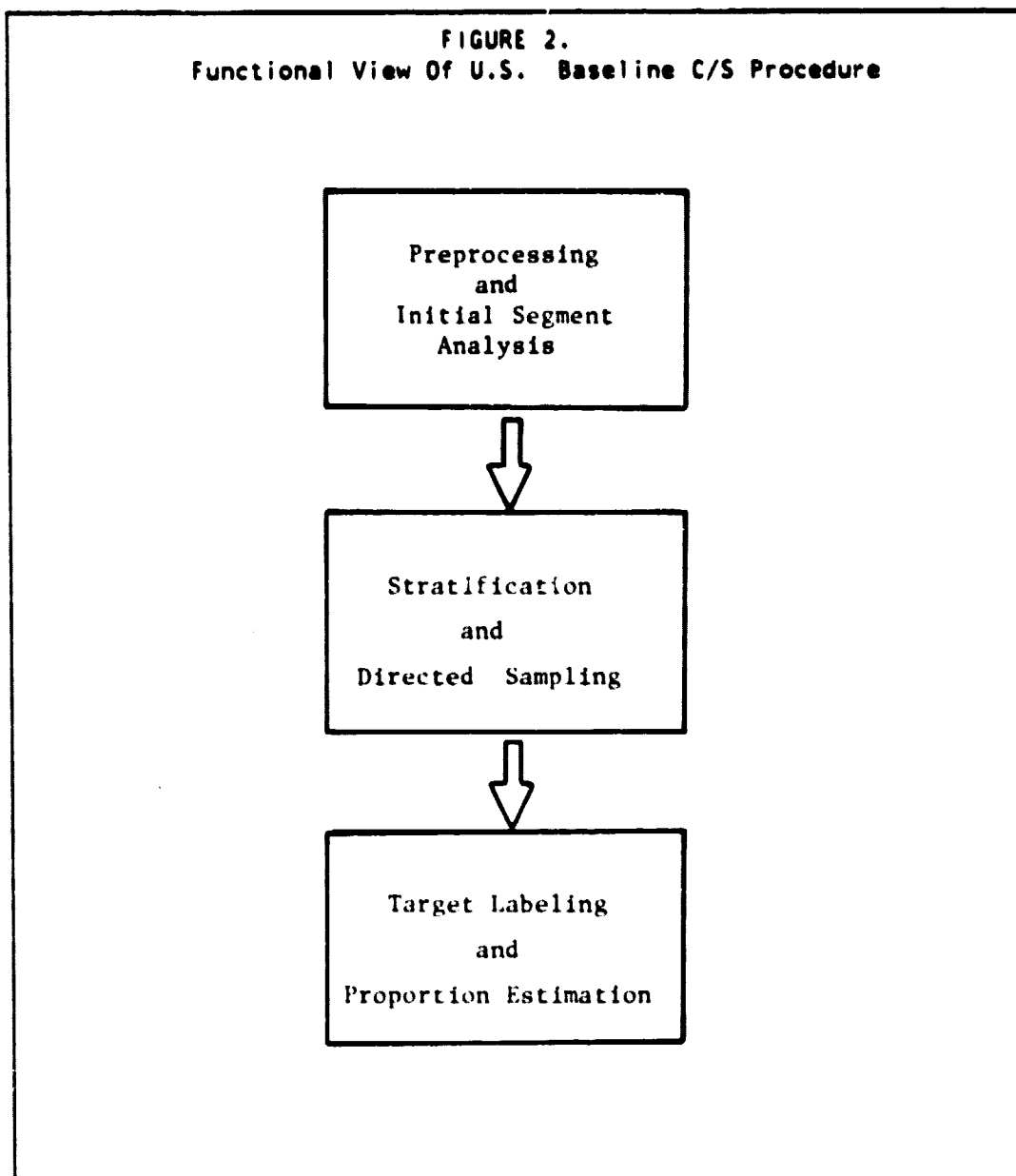
The purpose of the first stage is to extract information from both the Landsat segment image and from pertinent collateral data to provide a foundation for further labeling and estimation analysis. The second stage stratification and sampling results in the identification of targets for labeling and the formulation of decision criteria that will be used in the blob labeling process. The final stage involves the labeling of the selected set of blob targets and the aggregation of those labels to a segment wide proportion estimate.

2.1.1 FUNCTIONAL FLOW

The functional flow of the baseline corn and soybean classification procedure involves an integrated human and machine effort. The roles of each of these two components are mutually supportive. The machine performs major processing functions, supports the Analyst activities through the production of aids, maintains the data base, and insures statistical objectivity in the estimation process. The Analyst is responsible for data quality assurance through acquisition screening and selection, data verification and adjustment as with crop calendar model data, and data analysis through crop group stratification and target labeling.

Figure 3 illustrates Analyst and machine functions in each of the three principle stages of analysis. In each stage machine functions are preceded by Analyst functions. Each subsequent Analyst stage is preceded by a machine operation. In the following discussion each function illustrated in Figure 3 is in turn described.

Stage 1: Preprocessing and Initial Segment Analysis

Acquisition Screening And Selection:

(Analyst Function): Through the use of standard imagery (Product 1 and Product 3), acquisitions are visually screened and those with excessive cloud cover deleted. Based on inputs from the crop calendar analysis and acquisition priority listings. up to seven acquisitions are chosen for automatic temporal pattern class extraction. A total of up to ten acquisitions may be processed. These acquisition selections are identified to the computer for machine preprocessing.

FIGURE 3.
Analyst And Machine Functions In Procedure
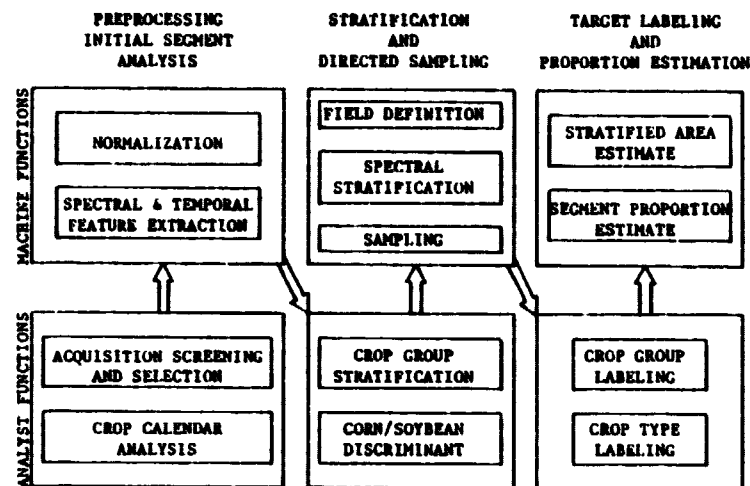
Crop Calendar Analysis:

(Analyst function): Crop calendars are used to identify expected phenological patterns and define biowindows of crops in the area of the segment. This requires the use of the best available phenological crop calendar. The Analyst translates the phenological crop calendar to a spectral crop calendar, associating each acquisition with a crop growth stage. Obvious discrepancies in the phenological crop calendar are adjusted based on the Analysts' judgment.

Normalization:

(Machine function): Normalization of spectral data is a process conducted to adjust for effects of haze, varying sun angle and sensor calibration, and to screen out clouds and other unusable spectral

data. The purpose of this step is to reduce the effect of phenomena that are external to or bear no information with respect to the agricultural phenomenon that is of interest. This provides the Analyst products that are multitemporally consistent with respect to crop reflectance characteristics, and minimizes segment-to-segment variations due to external effects.

Spectral And Temporal Feature Extraction:

(Machine function): Using normalized spectral/temporal data, features are extracted that correlate to agronomic conditions. Specifically, the Tasseled-Cap transformation is computed and a greenness measure related to the "GReenness Above Bare Soil" (GRABS) is derived. These features are used for crop discrimination. Since only GRABS and Brightness are required the dimensionality of the data is reduced by a factor of two. Multitemporally, temporal pattern class (TPC) features are extracted. This feature identifies the temporal vegetative development of each pixel. A report summarizing the temporal patterns in the segment is provided to the analyst for crop group stratification.

Stage 2: Stratification and Directed Sampling

Crop Group Stratification:

(Analyst function): Using information derived from crop calendar analysis and the TPC report generated in Stage 1, the Analyst carries out a stratification of the TPCs into major crop groups: summer crops, small grains, permanent vegetation, and non-vegetated areas. Crop group stratification is used both by the machine in producing the stratified area estimate, and by the Analyst to facilitate the analysis process in blob labeling. In particular the summer crop stratum is used to produce a spectral aid, a GRABS vs. Brightness scatter plot, which is used to establish a discriminant boundary between corn and soybean.

Corn/Soybean Discriminant:

(Analyst function): Using the GRABS vs. Brightness scatter plot of pixels in the summer crop stratum for each available acquisition, the Analyst determines when the best separability between corn and soybean distributions is achieved. Examining crop development along the "green arm" the Analyst looks for soybeans to cluster at higher GRABS values than corn. A boundary is placed between the distributions and perpendicular to the green arm for each acquisition exhibiting separability. This boundary and associated limitors will be used in preliminary labeling of blob targets as corn or soybeans.

At this point the analyst identifies a subset of acquisitions that are used in defining field-like targets (blobs).

Field Definition:

(Machine function): Field-like targets called blobs are defined. These targets are intended to correspond to farmers fields and provide candidate labeling targets. Ideally, each target is composed of a single crop type. The machine clusters pixels on the basis of their spectral characteristics and spatial position. Pixels grouped in a single blob must be spectrally similar and spatially contiguous. Once the blobs are formed they are separated into two groups according to their size. The first group, called "big blobs", consists of all blobs that have at least one pixel in their interior (i.e., one pixel left when a one pixel boundary is stripped off the blob). The second group, or "little blobs", has no interior. Only big blobs are candidate labeling targets. This segregation is carried out in order to isolate mixture pixels and very small fields which prove to be poor labeling targets. Each blob, big or little, is assigned to crop group strata according to the vegetative temporal pattern of their spectral means. This is done by the machine based on the temporal pattern class assignments previously defined by the Analyst.

Spectral Stratification:

(Machine function): Since it is too time-consuming to label all big blobs, it is desirable to produce a sample of blobs for labeling that would best represent the entire population. In order to realize a gain in sampling efficiency, big blobs are grouped into smaller strata within each crop group. An unsupervised clustering algorithm is used to group the blobs into spectrally homogeneous strata that ideally are homogeneous as well with respect to crop type.

Sampling:

(Machine function): Once strata are formed, a specified number of blobs are selected for labeling. The sample is allocated proportional to the size, in pixels, of each stratum. Since blobs are of different sizes, the Midzuno technique is used to select a sample that is an unbiased representation of each stratum. Once the sample is selected, a number of labeling aids are produced for the Analyst including GRABS vs. Time and GRABS vs. Brightness plots, a PFC overlay identifying the blobs to be labeled, and other diagnostic statistics.

Stage 3: Target Labeling and Proportion Estimation

Crop Group Labeling:

(Analyst function): Using aids produced by the machine, the Analyst follows a well-defined decision logic to label each sampled blob according to its major crop group. The crop group stratification assignment is used as an initial indicator of crop group. This assignment is refined using additional available information. The resultant label will be either "Summer Crop" or "Non-Summer Crop".

Crop Type Labeling:

If supported by the segment acquisition history, the Analyst will also label each blob sampled according to its crop type, in particular corn, soybean, or other. Again the Analyst makes use of a well-defined decision logic. Since this procedure was designed for the corn belt where corn and soybean are dominant, other summer crops are not discriminated. In addition to crop labels, the Analyst assigns a confidence to the label to indicate an expectation regarding the accuracy of the label. These labels are provided to the machine for the final estimate of crop area proportions.

Stratified Area Estimate:

(Machine function): A weighted aggregation of the labels of the sampled blobs in each spectral stratum results in an estimate of summer crop area, or, if information is sufficient for crop type labeling, corn and soybean area, for each stratum. An estimate is then produced for each crop group stratum by a simple weighted aggregation of the spectral stratum estimates.

Segment Proportion Estimates:

(Machine function): Each crop group stratum was previously assigned an estimate of summer crop area, or, corn and soybean area, according to a sample of big blobs. The segment area estimate is produced by extending the crop group stratum estimates to the in-stratum unsampled (little) blobs, and then aggregating the overall stratum estimates. In this process, the weights used are formed from the total number of pixels in each blob.

2.1.2   LABELING AND ESTIMATION ANALYSIS

The process of producing a segment-wide crop area estimate can be viewed as two interacting sub-processes, labeling analysis and estimation analysis. These processes need not be viewed as specifically Analyst or machine functions. The progression of labeling analysis and progression of estimation analysis can be viewed as parallel processes, each providing key inputs to the other that culminate in crop area estimates as illustrated in Figure 4.

Each process evolves an understanding of the segment under analysis in achieving their respective objectives. The estimation component attempts to preserve statistical objectivity in producing final estimates, while depending upon the labeling component to provide accurate crop labels. Figures 5 and 6 are useful in understanding the dynamics of the labeling and estimation processes.

FIGURE 4.
Interaction Between Estimation And Labeling Analysis

FIGURE 5.
Progression Of Labeling Analysis

FIGURE 6.
Progression Of Estimation Processing Analysis
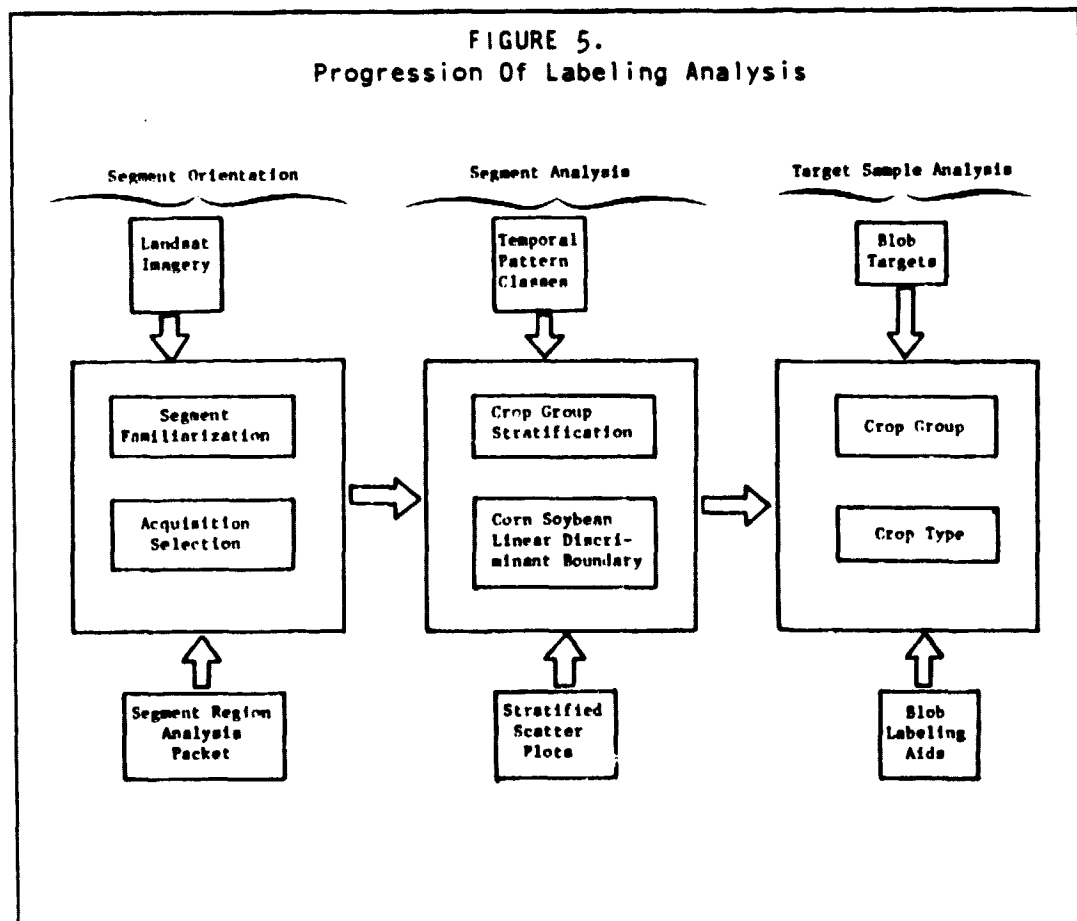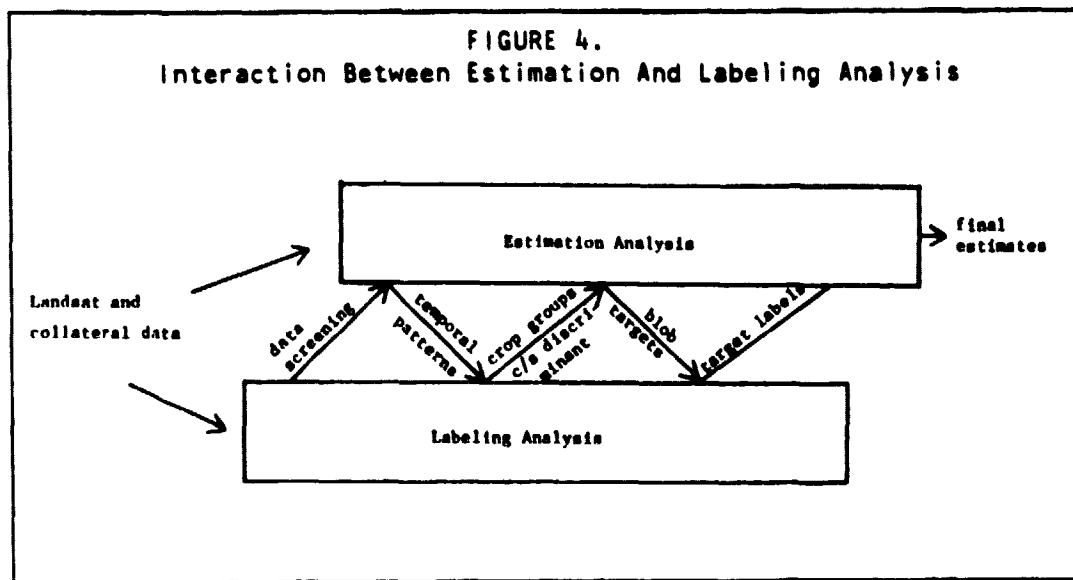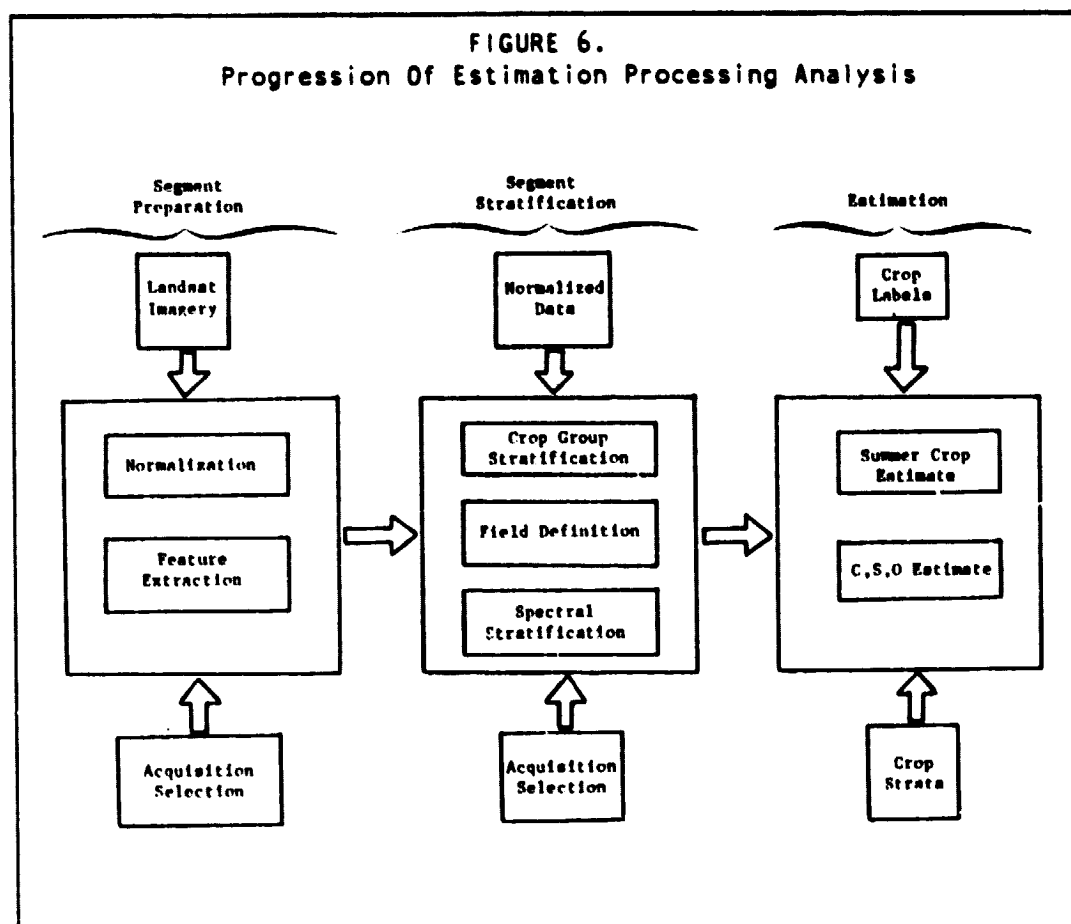
Labeling analysis requires a sequence of three steps that parallel the stages identified in Section 2.1.1. The overall process is one which information and understanding of the behavior of the crops are gradually assimilated and improved during analysis, until that understanding in the end becomes a set of final label assignments for the sample blobs. The first step is one wherein a general familiarization or orientation to the segment is achieved. Crop calendars are evaluated with historical information and correlated to the Landsat data. More detailed segment analysis is the next step. The estimation process supports this analysis through provision of normalized data and extraction of spectral and temporal features. At this point the labeling process has sufficient information to determine specific crop group patterns and spectral discriminant boundaries between key crop types. The final step is a more intensive analysis resulting in the assignment of specific labels to targets.

This requires a level of information and an objective framework which is provided by the estimation process. The end product, crop labels assigned to selected targets, is then achieved through a progressive understanding of the segment and how crops of interest therein are manifested.

Estimation analysis can be described in similar manner to the process of labeling analysis. Three steps paralleling the three procedural stages are required, each progressively providing information and understanding, the accumulation of which produces an objective estimate of the area of crops of interest. Throughout, the estimation process is supported by the labeling process. The first step in estimation analysis is data preparation and preprocessing wherein a normalized set of features are extracted and provide the foundation for subsequent stratification and estimation. The second stage parallels in purpose the labeling process achieving a more detailed analysis of the segment. Data are stratified into fields, crop group strata, and refined spectral strata. These provide a framework for the final step in the estimation analysis, wherein crop labels associated with selected targets are aggregated to produce final crop area estimates. As with labeling analysis, the estimation analysis is designed to progress from a general characterization of segment attributes to the specific determination of crop area estimates.

2.2   OPERATIONAL OVERVIEW

Discussion of the functional flow of the baseline corn and soybean classification procedure presented in Section 2.1 emphasized major functions and interacting components that comprise the procedure. The operational configuration of the procedure is presented in this section. Topics that will be addressed include the chronological processing sequence, the machine algorithms employed, a summary of products that are required or produced by the procedure and methods by which products are tracked. The purpose of this discussion is to provide an overview of the operational flow of the procedure. Details regarding operations are provided in later sections.

2.2.1   CHRONOLOGICAL PROCESSING SEQUENCE

Machine and Analyst interact in the baseline procedure. The chronological processing flow is illustrated in Figure 7. Steps are labeled A1 to M8 ("A" for Analyst, "M" for machine). Machine and Analyst functions cannot be separated, since the machine and Analyst depend upon one another for inputs in the sequence indicated. Hence

one cannot produce all Analyst products prior to all Analyst activity. Likewise the Analyst cannot label targets until the machine has defined and provided spectral aids for them.

Figure 7 illustrates that functions A1 to A5 are performed and supervised by a team of two Analysts. In the remaining steps, a single Analyst is required.

Figure 8 presents the sequence of activities operationally performed and the algorithms used in the baseline procedure. References are provided for detail. Analyst functions are explicitly carried out. However, machine functions are largely invisible to the Analyst since they are implicitly performed by the machine. A command language is provided to initiate each machine function. A description of the command language appears in Section 4.

FIGURE 7.
Chronological Processing Sequence

A1 — INITIAL SEGMENT ANALYSIS

M2 — NORMALIZATION AND FEATURE EXTRACTION

A3 — CROP GROUP STRATA   ANALYST TEAM (two members)

M4 — STRATIFIED SCATTER PLOTS

A5 — C/S DISCRIMINANT

M6 — SPECTRAL STRATIFICATION AND DIRECTED SAMPLING

A7 — BLOB LABELING   INDIVIDUAL ANALYST

M8 — STRATIFIED AREAL ESTIMATE

○ Analyst
□ Machine

ACTIVITY SEQUENCE IN BASELINE PROCEDURE
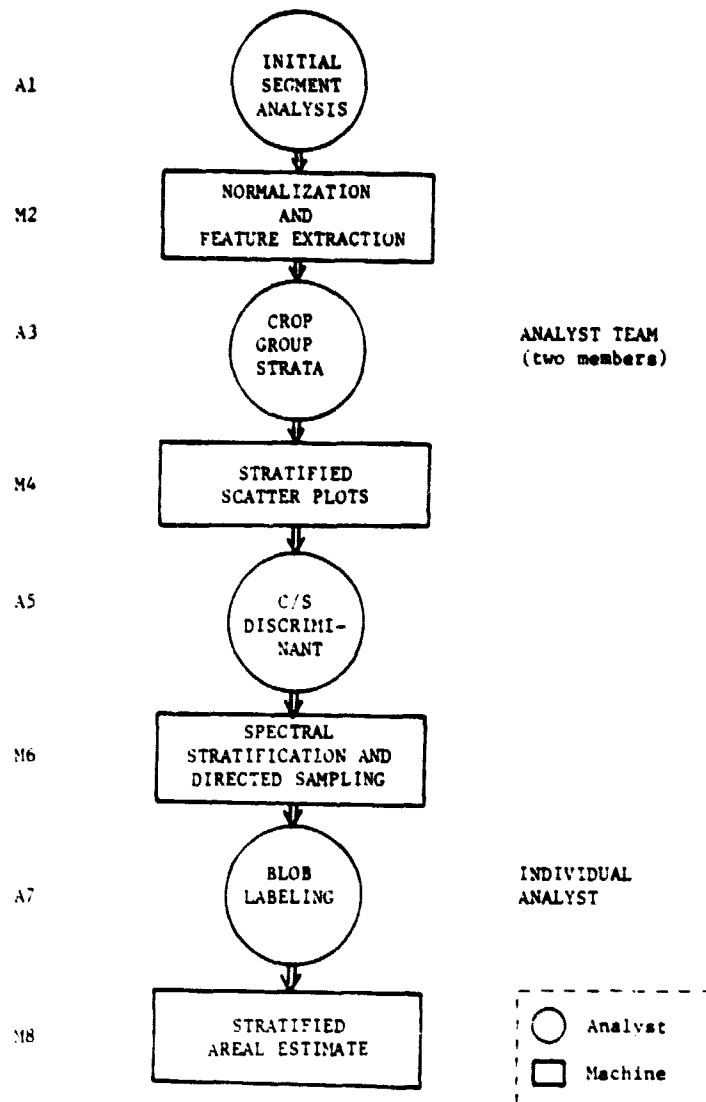
FIGURE 8.
Activity Sequence In Baseline Procedure

Processing Sequence	Activity Sequence	Inputs	Outputs	Method/Algorithm	Reference
A1 Initial Segment Analysis	A1.0 Familiarization	Reference Library	Familiarization	Reading, analysis	Section 6.2
	A1.1 Data Screening	Products 1 & 3	Screened Acquisitions	Ocular Appraisal	Section 6.2
	A1.2 Crop Calendar Verification	Products 1 & 3 Phenological Crop Calendar Historical Ag Stats	Spectral Crop Calendar	Binary Decision Logic	Section 6.2
	A1.3 Acquisition Selection	Products 1 & 3 Spectral Crop Calendar	Acquisition for machine processing (max 10) eTPC extraction (max 7) Expected TPCs	Prioritized Selection Criteria	Section 6.2
M2 Normalization and Texture Extraction	M2.0 Issue Commands 'Dataprep', 'Preprocess'	Acquisitions, Locations		Command Language	Section 6.3
	M2.1 Merge	Acquisition Data	Segment Data Base	Digital Processing	Section 6.3
	M2.2 Screen	Pixel Data	Screen Image	Spectral Thresholds	Section 6.3
	M2.3 Sun Angle Correction	Pixel Data, Sun Angle	Corrected Pixel Data	Cosine Correction	
	M2.4 Sensor Calibration	Pixel Data	Corrected Pixel Data	Multiplicative Adjustment	

FIGURE 8. (continued)
Activity Sequence in Baseline Procedure

Processing Sequence	Activity Sequence	Inputs	Outputs	Method/Algorithm	Reference
N2 Normalization and Feature Extraction (Continued)	M2.5 Haze Correction	Pixel Data, Screen Image	Normalized Pixel Data	Spatially Varying XSTAR	
	M2.6 Tasseled-Cap Transform	Normalized Pixel Data	Transformed Pixel Data G, B, Y, K	Tasseled-Cap	
	M2.7 Greenness Measure	Transformed Pixel Data	Green Measure Img.	GRABS	
	M2.8 Temporal Pattern Class Extraction	GRABS Image	TPC Image	TPC	
	M2.9 Generate Reports		TPC Report QA Report	Digital Processing	
A3 Crop Group Stratification	A3.1 Assign TPCs to Crop Group Strata	Expected TPCs TPC Report	Crop Group Strata	Defined Assignment	Section 6.4
	A3.2 Select TPCs for Spectral Aids	Summer Crop TPC	Selected TPC	Priority Tables	Section 6.4
M4 Stratified Scatter Plots	M4.0 Issue Command, 'DFS', 'Scatter'	TPC Sample		Command Language	Section 6.5
	M4.1 Produce Plots	Transformed Pixel Data	Stratified Scatter Plots	Digital Processing	Section 6.5
A5 Corn/Soybean Discriminant	A5.1 Determine Linear Discriminant	Stratified Scatter Plots for Each Acquisition	C/S Discriminant Boundaries & Separation Acquisitions	Placement Guidelines	Section 6.6
	A5.2 Determine Acquisitions for Blobbing	Products 1, 3 Scatter Plots	1-4 Acquisitions	Priority Tables & Selection Guidelines	Section 6.6

FIGURE 8.   (continued)
Activity Sequence In Baseline Procedure

Processing Sequence	Activity Sequence	Inputs	Outputs	Method/Algorithm	Reference
M6 Spectral Stratification and Sampling	M6.0 Issue Commands 'Cluster' 'Sample'	Discriminants Blob Acquisitions Separation Acquisitions		Command Language	Section 6.7
	M6.1 Define Fields	Transformed Pixel Data	Blob Image	SUPERB	
	M6.2 Define Boundaries	Blob Image	Boundary Image	STRIP	
	M6.3 Compute Blob Statistics	Blob Image Transformed Pixel Data	Blob Statistics	Digital Processing	
	M6.4 Assign Blobs to Crop Group Strata	Blob Statistics Analyst TPC Assignments	Crop Group Strata for Blobs	Assign According to TPC of Blob Mean	
	M6.5 Spectral Stratification	Blob Statistics	#18 Blobs Assigned to Substrata	BCLUSTER	
	M6.6 Sample 100 Blobs	Blob Statistics Substrata	List of 100 Blobs	MIDZUNG	
	M6.7 Generate Spectral Aids	TPC Image Blob Image Blob Statistics Sample	Temporal Plots TPC Map PPC Overlay	Digital Processing	Appendix 7

FIGURE 8.   (continued)
Activity Sequence in Baseline Procedure

Processing Sequence	Activity Sequence	Inputs	Outputs	Method/Algorithm	Reference
A7 Blob Labeling	A7.0 Label Targets	Products 1 & 3, PFC Blob Overlay, Blob List, Spectral Aids, Blob Statistics, Window Definitions, Recording Sheet	Labels: summer crop, acorn soy, econfidence	Network Design Logic	Section 6.9
M8 Estimation	M8.0 Issue Command 'Estimate'	Labels		Command Language	Section 6.10
	M8.1 Compute Estimates	Strata, Blob Statistics, Labels	Crop Estimate	Stratified Areal Estimate	

2.   GENERAL PROCEDURES DESCRIPTION

2.2.2   DATA FLOW

The management of data and flow of information in the baseline procedure requires both machine and Analyst participation. Four mechanisms are provided to facilitate management of data: the Analyst reference library, the Analyst packet, a Segment Analysis Log (SAL), and the Collateral Holding And Reference Library for Information Extraction (CHARLIE). The last structure is a data management system maintained through software, whereas the others require human maintenance.

Analyst Reference Library:
The reference library is used to maintain background materials for general use including (1) Landsat full-frame imagery, (2) reference books on crop phenology and cropping practices and (3) maps. In addition an information manual is available to each Analyst which provides: (1) segment locations, (2) phenological summaries for corn and soybeans, (3) general information regarding the region of interest, such as historical agricultural statistics, and (4) normal and wide area crop calendars (see Appendix E).

Analyst Packet:
The Analyst packet is a simple folder for each segment. It contains data generated that is specific to the segment. Prior to the initial segment analysis, the packet would contain PFC image Products 1 and 3 for all acquisitions, adjusted phenological crop calendars, historical crop statistics, and other ancillary data (see Appendix E). As labeling and quality assurance aids are generated by the machine, the packet serves as the receptacle for those aids. These aids would include stratified scatter plots, blob labeling aids and diagnostic aids (see Appendix F).

Segment Analysis Log (SAL):
SAL is a log that is kept by the Analyst (in the Analyst packet) wherein key decisions made by the Analyst are recorded. This log will provide a reference for quality assurance and will contain information of interest in accuracy assessment.

Collateral Holding And Reference Library for Information Extraction (CHARLIE):
CHARLIE is a computer data management and storage mechanism. Each segment has an associated CHARLIE data base. All data generated by any machine processing operation is stored and tracked through CHARLIE. This careful preservation of machine generated products serves the information needs of subsequent processing, as well as other pilot functions such as quality assurance, accuracy assessment, and sampling and aggregation.

Flow of information within the baseline classification procedure occurs between a number of components in the overall crop production forecasting system. Key interacting components include: the Landsat data acquisition system, Crop Calendar and Weather Analysis, qua.ity assurance, Accuracy Assessment, Sampling and Aggregation, the operations manager and of course the Analyst and machine that comprise the classification component. The operational baseline procedure is structured to support the information needs of each component. Figure 9 depicts information flow between these key components and the principle mechanism used to affect the transfer of information. Figure 10 illustrates the flow of data and information between the Analyst and machine.

FIGURE 9.
Information Flow Mechanisms
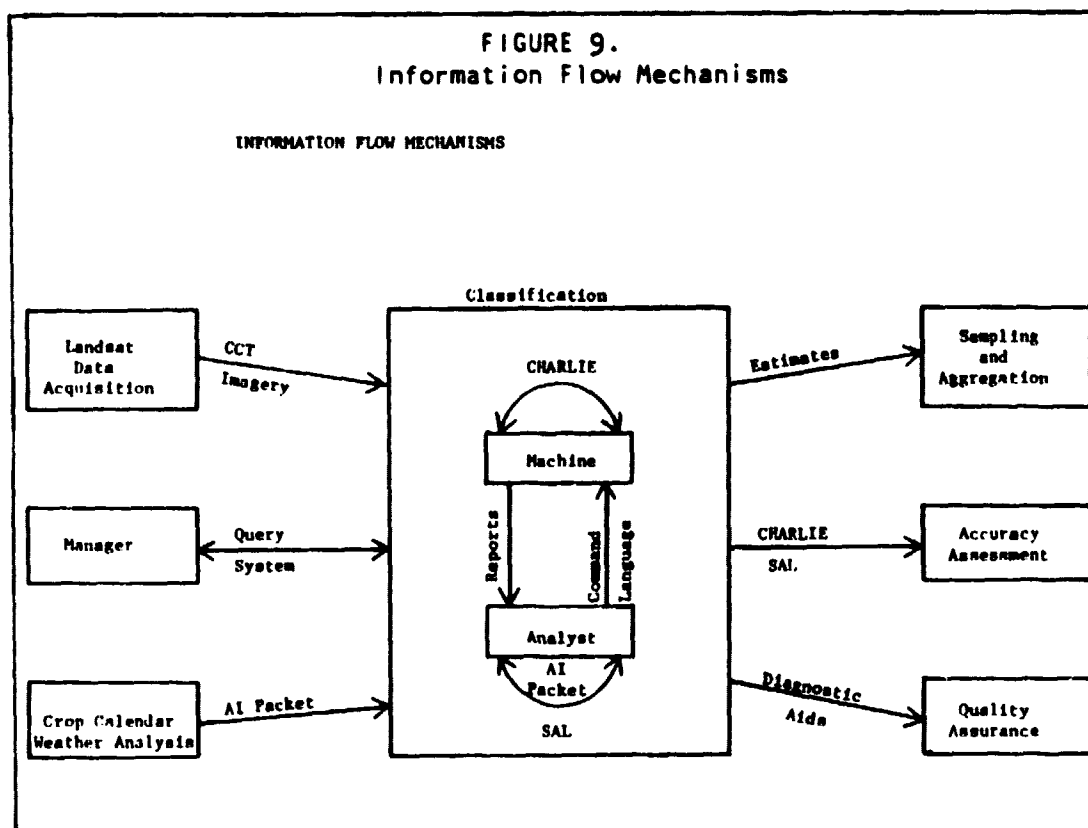
FIGURE 10.
Information And Data Flow
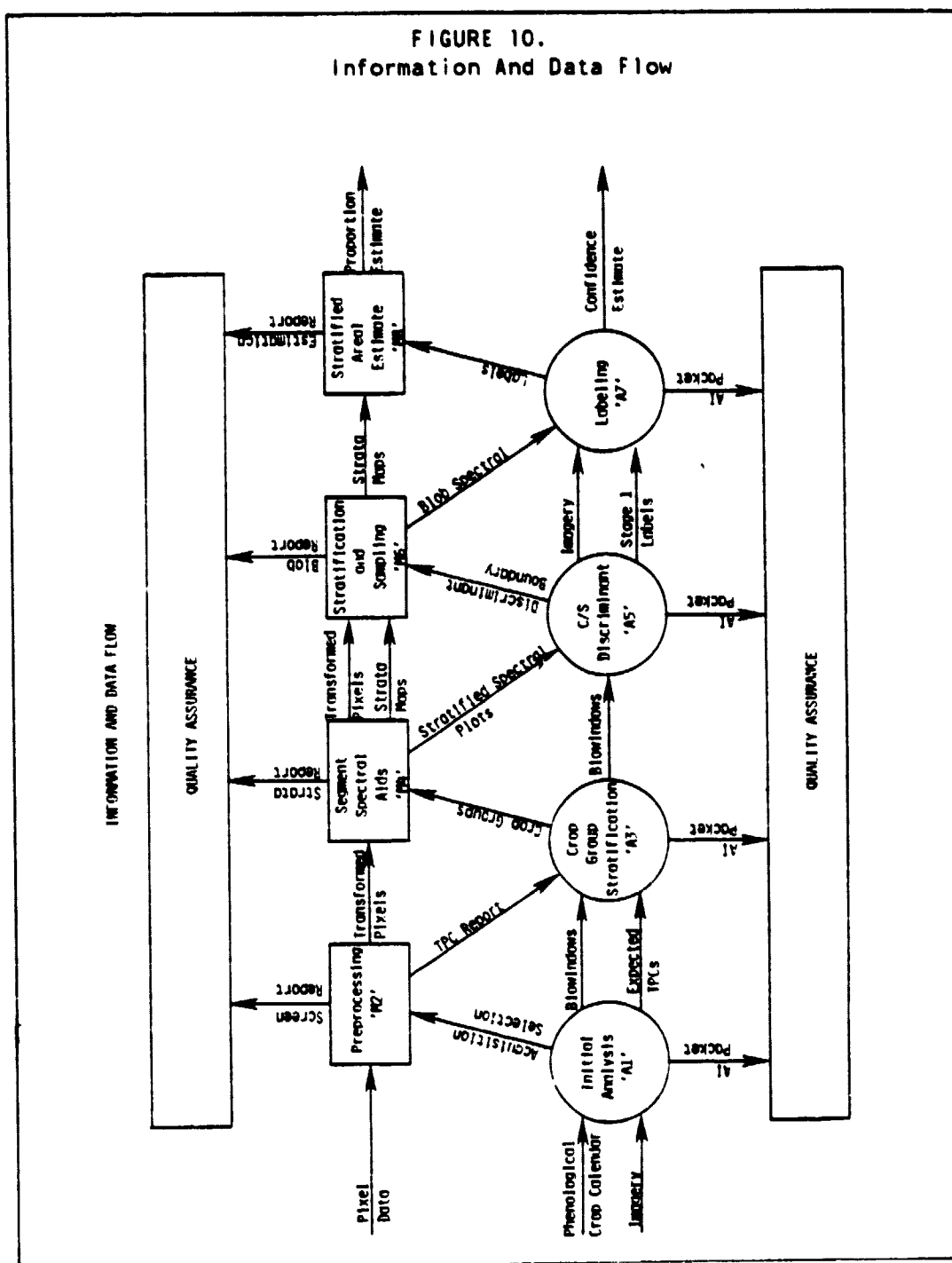
PILOT MANAGEMENT OF CLASSIFICATION PROCESSING

The baseline corn and soybean classification procedure has been implemented in a software architecture that is designed to facilitate processing a large number of segments multiple times. The purpose of this section is to identify general resource requirements and capabilities of the system that support large scale classification processing.

3.1 MINIMUM PROCESSING REQUIREMENTS

3.1.1 HUMAN RESOURCE REQUIREMENTS

Classification processing requires sufficient human resources to conduct five functions:

Data Acquisition

Initiation of classification processing requires knowledge of segments to be processed, associated acquisition histories and the physical location of those acquisitions. Specifically the tape location and file number of all acquisition data is required.

Packet Preparation

Before initial segment analysis, a packet for each segment requires preparation. Key enclosures are imagery Products 1 and 3 for each acquisition, adjusted crop calendars, and historical agricultural data. These are detailed in Appendix E.

Analysis

Analyst interpreters required for processing segments include a team of two for steps A1, A3 and A5, and a single Analyst for step A7. It is estimated in section 3.2.2 that a team of about eight Analysts will be required to conduct 180 segment processings in a three-month period.

Operation of Machine Steps

Each machine operation (M2, M4, M6, M8) requires preparation of either a computer batch job or an interactive terminal session, and the placing of produced reports into the analyst packet. The level of sophistication required is small due to the high level command language provided to the machine user. This function can be served either by an Analyst or by a computer specialist.

Management

The processing of multiple segments will require management of key resources, such as allocation of segments to Analysts, and use of computational and electronic storage media. Such processing will also require careful quality assurance testing. Sections 3.2 to 3.5 address capabilities available in the management of overall segment classification processing.

3.1.2 MACHINE RESOURCES

Figure 11 identifies minimum estimates of hardware facilities required for classification processing. Section 3.2.2 identifies that a maximum of six four-megabyte virtual machines active at a single time are sufficient to support 180 segment processings in a three-month period. Figure 12 identifies software facilities required beyond those provided with the baseline software package.

3.2 SEGMENT PROCESSING

Computer initialization of segment processing is described in Section 4.3. Operational flow control and timing characteristics are discussed in this section.

3.2.1 PROCESSING ONE SEGMENT

End-to-end processing of one segment is expected to require two to four machine processing hours and four to 10.5 Analyst processing hours. Assuming the maximum of ten acquisitions, total computer CPU processing required per segment is 30 minutes. A breakdown of the timing characteristics appears in Figure 13.

```
                          FIGURE 11.
                    Minimum Hardware Facilities

- IBM 4341-compatible architecture

- 30 megabytes of disk for each machine user

- 4 megabyte virtual machine for each machine user

- 2 additional virtual machines (data and software)

- Access to 1 tape drive per job; 2 would be advantageous

- 30 tapes (6250 BPI) permanently assigned to the pilot experiment

- Interactive (terminal) access to the computer
  (alternative or additional capability: Batch Access)

- Printer
```

```
+--------------------------------------------------------------+
|                          FIGURE 12.                          |
|                Minimum Software Facilities                   |
|                                                              |
| - VM/CMS operating system with LARS modifications            |
|                                                              |
| - plotting package; GCS                                      |
|                                                              |
| - from CMS macro library CMSBSE:                             |
|                                                              |
|       ADT, FSCB, FSCLOSE, FSERASE,                           |
|                                                              |
|       FSOPEN, FSPOINT, FSREAD, FSTD,                         |
|                                                              |
|       FSWRITE, NUCON                                         |
|                                                              |
| - from CMS macro library CMSLIB:                            |
|                                                              |
|       DMSFREE, DMSFRET, LINEDIT, PRINTL,                     |
|                                                              |
|       RDTERM, WAITT, WRTERM                                  |
|                                                              |
| - from OS macro library OSMACRO:                             |
|                                                              |
|       CALL                                                   |
|                                                              |
| - miscellaneous routines currently installed at LARS         |
|                                                              |
|       MOUNT,TAPOP,IDNAME,ENVIR                               |
|                                                              |
+--------------------------------------------------------------+
```

```
                          FIGURE 13.
              Timing Characteristics For A Single Segment


                          End-to-End    CPU
   Step      Process         Time*      Time      Comments

    A1    Initial Segment   1-2 hrs
          Analysis

    M2    Preprocessing     30 min-    20 min    machine load
                            2 hrs                dependent

    A3    Crop Group        30 min
          Stratification

    M4    Scatter Plots     30 min     2 min

    A5    C/S Discriminant  30 min-
                            1 hr

    M6    Stratification    30 min-    8 min     PFC turnaround
          and Sampling      1 hr                 impact unknown

    A7    Labeling          2-6 hrs

    M8    Estimation        30 min     5 sec


        * Estimated
```

3.2.2 PROCESSING FLOW FOR N SEGMENTS

It is not necessary to process in the mode of one segment at a time from beginning to end. A number of segments could be processed concurrently. Processing flow of the eight procedure steps can be divided into five stages as follows: {A1}, {M2}, {A3, M4, A5}, {M6}, {A7, M8}. The processing flow is depicted in Figure 14. The machine items M2 and M6 are isolated since they are machine intensive and should be processed in batch mode or during low computer load periods. For each of the five processing stages described in the following discussion, timing characteristics are described for two-member Analyst teams.

FIGURE 14.
Pilot Operations Within Baseline Procedure

Sequential Processing Mode	Machine Output	Step	Analyst Input	Analysis Mode
3 + segment/day		A1	Acquisitions	
Night Batch (4 segment/team)	M2	TPC Report		
1 segment at time 3 + segment/day	A3	DFS		Analyst Team
	M4	Scatter Plots		
	A5	Discriminant Blob Acquisition		
Night batch (n segment)	M6	PFC Plots		
1 segment at a time 1 segment/day	A7	Labels		Individual Analyst
	M8	Estimate		
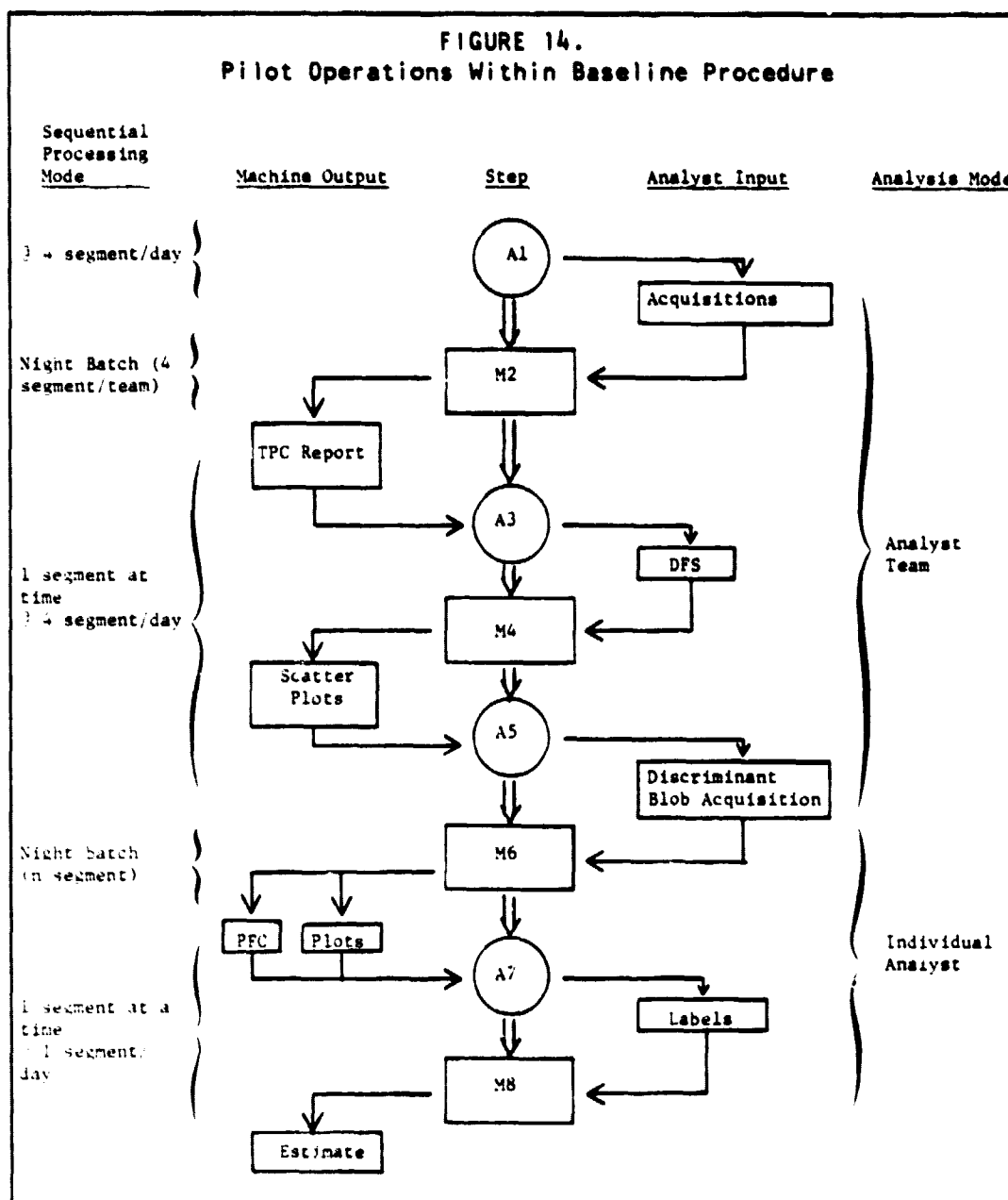
Processing Stage 1

A1 Initial Segment Analysis

The Analyst team will identify acquisitions to be used in machine processing in addition to using the crop calendars and other aids in preparation for later steps. The Analyst team could process three or

four segments before initiating the next step. Assuming a maximum of two hours per segment, four segments could be prepared a day. (Note that timing for any interactive use of the machine will depend on machine response). Processing Stage 2

M2 Normalization and Feature Extraction (DATAPREP, PREPROCESS)

This is a CPU intensive machine processing job that may best be run in batch mode or during low load periods. A single person could process a number of segments in one session if provided with the acquisitions to be processed (from step A1) and the physical location of the acquisition data. Several reports are produced automatically. Certain ones are diagnostics for quality assurance. The Analyst team receives a TPC report. (The segments should be grouped according to Analyst teams.)

Processing Stage 3

A3 Crop Group Stratification (DFS)

M4 Stratified Scatter Plots (DFS, SCATTER)

A5 C/S Discriminant

These three steps (A3, M4, A5) will take 1-1/2 to two hours per segment. Each segment should be processed through these three steps sequentially (no significant gain in operational efficiency by processing groups of segments is expected, whereas continuity of analysis on a single segment may be beneficial). This will require interaction with the machine (step M4) to input crop group strata and produce scatter plots (one for each acquisition), hence M4 should not be run in batch mode. Again, assuming two hours per segment, an Analyst team could process four segments per day.

Processing Stage 4

M6 Spectral Stratification and Directed Sampling (CLUSTER, SAMPLE)

This step is a key transition point. Analyst teams are not in use any longer, and a PFC turnaround is required (assuming that a PFC is available). A number of reports are produced at this point; these consist of two computer printed pages for each sampled field (approximately 200 pages per segment), and an overlay that is produced by the PFC. A large number of segments can be processed in batch mode at this stage. Segments could be accumulated until Analysts transition from team to individual mode. The required PFC turnaround after step M6 may be more efficient if the PFC data for a number of segments were placed sequentially on a single tape.

Processing Stage 5

A7 Blob Labeling

M8 Stratified Areal Estimate (ESTIMATE)

The final stages of processing require individual Analysts to label blobs (step A7) and input these into the computer to produce the final estimates (M8). Though these could be handled in groups of segments, they could just as well be handled separately a single segment at a time. However there may be a preference for performing step M8 interactively, rather than in batch mode, since a lengthy list of blob label entries is to be supplied, and the interactive mode provides some error recovery for these entries. The labeling stage is expected to take from two to six hours. As an upper bound, one could estimate one day per segment per Analyst.

Using estimates indicated above, processing stages 5, 1 and 3 require two analysts processing approximately four segments per day for each stage. In a four day period two Analysts would process eight segments up to the labeling stage. In stage 5 each Analyst processes 1 segment per day, enabling two Analysts to process eight segments in a four day period. Allowing for one additional day in each phase of analysis, two Analysts can process eight segments in a two week period. This estimate does not consider the associated machine processing load imposed. In the next subsection a possible example of an operational approach is presented approach that considers machine capacity as well.

3.2.3 OPERATIONAL EXAMPLE OF SEGMENT FLOW CONTROL

Assuming eight Analysts are available for a three-month period of time, consider the number of potential segment processings, and the processing load imposed upon the computer. Computer CPU useage estimates based on the LARS IBM 3031 computer are presented in Section 4.5.1. If

  A: is the number of Analyst teams;

  B: estimate of number of segments processed by Analyst team per week; and

  C: number of available weeks;

then

  number of segments processed = A*B*C.

Therefore, if A = 4 teams, B = 4 segments/team/week, and C = 12 weeks, then 192 segment processings are possible in a three month period.

Machine processing steps M2 and M6 are machine intensive operations requiring a maximum of 30 minutes per segment, while steps M4 and M8 require 2.2 minutes per segment. If 192 segments are processed in a three month period, then 3.2 segments are processed per work day. This implies a maximum use of the CPU of 3.2*28 = 82.6 minutes per day in batch mode, and a use of 3.2*2.2 = 6.9 minutes per day in interactive mode.

In rough numbers, the example provided would impose a load of 2 hours per day, or less than 10 percent load on the IBM 3031 machine. This figure may increase due to reruns, or decrease due to weekend batch runs. It would also depend on what machine is used to run the pilot experiment and on the configuration of resource use tradeoffs.

3.3   MANAGEMENT INFORMATION CAPABILITIES

In this section, the methods for obtaining pilot status information from the computer are discussed. Some of the information reports may be useful to other users as well. Note that status within an Analyst step is not stored within the computer. Figure 15 shows the types of information that can be displayed. All reports are self-explanatory. Following the table, the exact machine entries are described.

```
┌─────────────────────────────────────────────────────────────────┐
│                          FIGURE 15.                               │
│              Management Information Command "ASK"                  │
│                                                                   │
│                                                                   │
│   Request                     Display                             │
│                                                                   │
│   STATUS                      Processing stage of all segments    │
│                                                                   │
│                                                                   │
│   HISTORY                                                         │
│                                                                   │
│     --OUTLINE                 List of commands, errors, and error │
│                               recoveries for a segment            │
│                                                                   │
│     --RECENT                  Complete status track for a segment │
│                               starting with last successful command│
│                                                                   │
│     --FULL                    Complete status track for a segment │
│                               starting at the beginning           │
│                                                                   │
│                                                                   │
│   DATA                                                            │
│                                                                   │
│     --LIST                    List of all CHARLIE item names for  │
│                               a segment                           │
│                                                                   │
│     --ITEM                    Value of specified CHARLIE item     │
│                                                                   │
│                                                                   │
│   LOG                         A list of all files for a segment stored│
│                               in the database, along with their   │
│                               location (TAPE or DISK), and the ID │
│                               of the user who created the file    │
│                                                                   │
│                                                                   │
│   HELP                        A list of allowed status requests for│
│                               command "ASK" (A copy of this figure )│
│                                                                   │
│                                                                   │
│   COMMANDS                    A list of commands that may be entered│
│                                                                   │
└─────────────────────────────────────────────────────────────────┘
```

3.3.1 INFORMATION COMMAND "ASK"

Machine Function:
- **ASK**

Purpose:
- to display status information about pilot operations that would be of use to managers.

Inputs:
- Information requests
- Segment name

Outputs:
- One or more displayed or printed reports.

Comments:
- Figure 15 identifies the nature of the report produced for any of the valid requests.

How To Proceed:

1. Place the computer in command mode (see Section 4.1.1). Note: this command will retrieve information only for the userid which issues the command. To get information about all users of the system, or all segments in the system, the command must be executed from userid "CSDATA".

2. Enter the command.
   ASK

3. Enter the information request, which may be "HELP", "STATUS", "HISTORY", "DATA", "LOG", or "END". If "END" is entered, the ASK command terminates. If in doubt, type "HELP".

4. In interactive mode only, enter "YES, if the report is to appear on a printer, and "NO" if the report is to appear at the terminal.

5. Based on the entry of step 3, proceed to the step indicated by the following list:
   "HELP" - step 12
   "COMMANDS" - step 12
   "STATUS" - step 12

"HISTORY" - step 6
"DATA" - step 9
"LOG" - step 11
"END" - (exit command "ASK")

6. This step should be carried out if the information request is "HISTORY". Enter the sub-request "OUTLINE", "RECENT", or "FULL". Note that "OUTLINE" is the most concise and useful management report of segment history; the others may be more useful for problem solving.

7. Enter a segment name or "END". If "END" is entered, go back to step 3 for a new information request.

8. When the requested report is completed, proceed to step 7 (so the same report can be produced for another segment).

9. This step should be carried out if the information request (step 3) is "DATA". Enter the sub-request "LIST" or "ITEM". The "LIST" command identifies the elements currently in the database for a segment. Subcommand "ITEM" retrieves the value(s) of entities in CHARLIE (see Appendix J for entity names and descriptions). "ITEM" can be used, for example, to view the acquisitions that were selected or the final crop estimates, if they are on the database. Request item name of "ALL" to receive a listing of the values of all the items in the database. Requesting "ALL" will produce voluminous output not normally useful to a manager.

10. Proceed to steps 7 and 8.

11. This step should be carried out if the information request is "LOG". Enter the segment name or "ALL" (if all segments are desired) or "END". If "END" is entered, go back to step 3 for a new information request.

12. This step is reached if the information request of step 3 is "HELP", "COMMANDS", or "STATUS". The requested report is produced with no further interaction, and control is returned to step 3 for a new request.

13. Entering a segment name not currently in the system results in a fatal error message.

14. To exit this command at any stage (except step 4 where a yes/no answer is needed), type "END" once or twice until the command terminates. (If control is at step 3, only one "END" is required.)

3.4 DATA MANAGEMENT

In this section the storage resource management capabilities for
the electronic database are discussed. The purpose of this discussion
is to enable a Pilot manager to understand the provided mechanisms, to
handle problems (e.g., out of disk space), and to make trade-offs
among more and less overused machine resources (e.g., trade disk space
for CPU time, or CPU time for tape drive availability).

Figure 16 illustrates the two basic data base storage media, and
the system's ability to interact with them. The concept is that of a
primary medium (disk storage) and an archival medium (tape).   The
utilities DISKTAPE and TAPEDISK transmit datasets from one medium to
another. If the dataset as already at the destination (e.g., on tape
for DISKTAPE), no action occurs.

FIGURE 16.
Interaction Of System With Database Storage Media
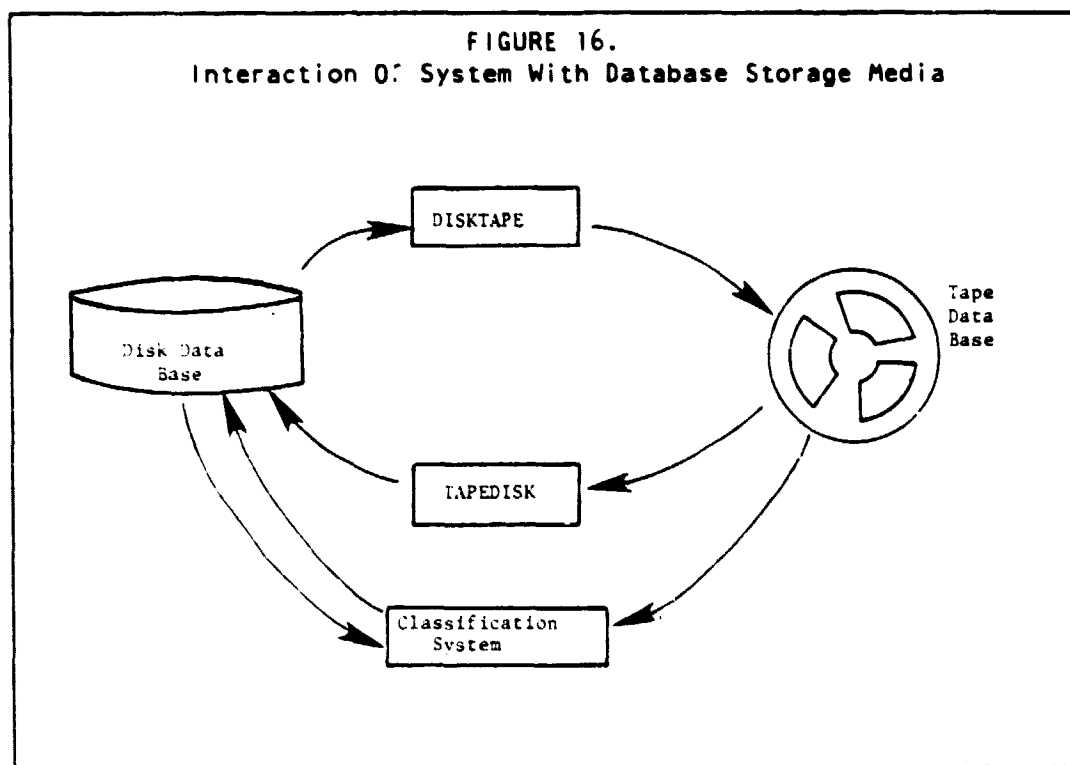
The system accesses data from wherever it is stored, invisibly to
the user.   The user would most normally not need to be aware of the
location of the dataset. The system will always write its output on
disk.

In order to avoid overfilling the scarce disk resource, the commands are configured to call the DISKTAPE utility for datasets when they have been referenced for the last time. But in order to avoid overusing the scarce tape drive resource, the commands are configured to call TAPEDISK for every referenced dataset. This configuration (which can be modified as discussed below) results in the use of a maximum of one tape drive. It reduces the total amount of disk space used, but does not provide for transfer to tape of datasets belonging to segments that are temporarily set aside. It does minimize CPU usage, however, in that a transfer of a particular data file to tape normally occurs only once, and transfers from tape are normally not needed.

The possibility exists that resources may become overloaded. Disk space may be exceeded, or tape drive availability may be discouraging. For these eventualities, the utilities DISKTAPE and TAPEDISK can be executed manually. The use of these utilities is more completely described in Section 4.5.4.

For example, if disk space is exceeded during a given step, the user can use the "ASK LOG" command (Section 3.3) to list datasets, decide which ones to send to tape, execute DISKTAPE for each, execute CLEAR (Section 4.2.2) to clear the error, then rerun the failed step. A similar procedure can be used if the error is that not enough tapes or tape drives are available.

In addition to this capability of manually controlling dataset location, it is possible to modify the automatic mechanisms described above. These modifications require minor software changes in the command modules. The changes that are possible involve adding or deleting TAPEDISK and DISKTAPE utility calls in the command modules. An example of such a change would be that if disk space becomes very scarce, but tape drives are normally available, large datasets would be placed on tape immediately after they are produced, and they would be read from tape rather than be transferred to disk. Or if both tape drives and disk are scarce, one can, at a cost of CPU time, arrange that <u>all</u> datasets get moved to tape after each command, and all required datasets get transferred back to disk before each command. Naturally, unless sufficient disk space is available to hold all files, it is not possible to reduce the maximum number of tape drives needed from one to zero.

In conclusion, this section makes three basic points: (1) the system automatically and invisibly manages the tape/disk resources, (2) manual intervention (TAPEDISK, DISKTAPE) is possible, and (3) the system can be modified somewhat if different resource tradeoffs are preferred.

3.5   QUALITY ASSURANCE

The maintenance of a high degree of reliability and protection against improper inputs or data flow is essential to pilot operations. Therefore a number of mechanisms were built into the computer software to provide this protection and to allow verification of correct operations, including:

1. A software detected error condition prevents further operations on a segment until the error is cleared and the database reset to the state preceeding the command in error.

2. A command will generate an error condition if it is performed out of sequence.

3. Numerous internal consistency checks are performed.

4. The user interface was designed to minimize the possibility of human error when entering data. In addition to simplifying the needed entries, all entries are echoed back to the user for confirmation.

5. A number of printed reports are produced that can be used by QA personnel to verify correct operations.

6. A complete status track is maintained by the system that logs start and stop of each command and application module, tne version of the module, all database actions, all errors, and all error "CLEAR" operations.

7. All significant user entries and significant intermediate data are maintained in the database where they can be examined by QA and Accuracy Assessment personnel.

Section 7.5 includes more discussion on the role of QA in the pilot experiment.

MACHINE PROCESSING FUNCTIONS

This section discusses several topics pertinent to carrying out the machine operations of the Pilot experiment. Of particular interest to machine users are sections 4.1 and 4.2 which cover general use instructions including error handling. The remaining sections cover the topics of system requirements, resource useage, and classification system setup. These topics are likely to be of interest to computer specialists involved in Pilot facility support.

4.1   GENERAL USER OPERATING INSTRUCTIONS

4.1.1   INTERACTIVE MODE

After the user has logged on to the system (see IBM Virtual Machine Facility/370: Introduction, order number GC20-1800-9, page 5), and one of the procedure commands has been entered (see Appendix B) control is passed to the pilot software. All subsequent interactions between the user and the system are of the following format:

1. The system will prompt the user for input, i.e.,

ENTER SEGMENT NAME

2. The user should respond, terminating the entry with a carriage return, i.e.,

Segment1463

3. The system will redisplay the data and request confirmation, i.e.,

'SEGMENT1463   '

OK?

4. The user may respond with one of the accepted affirmative (YES, Y, OK, TRUE, T, 1, or 1) or negative (NO, N, FALSE, F, 0) responses.

If the response is affirmative, the system will proceed with the next data item (if any) or continue execution. If the response is negative, the sequence will re-issue the prompt (step 1), continuing through the steps until an affirmative response is received in step 4.

If the requested data consists of a vector or array (more than one data element of the same type) the data elements may be separated by commas, blanks (if not character data), or carriage returns, i.e.,

prompt:
    ENTER ACQUISITION DATES: 'YYDDD'

response:
    78161,78180 78198 78207,78215

or

    78161
    78180
    78198
    78207
    78215

The redisplay and confirmation request will occur after all data elements of a request (in this case all acquisition dates) are entered, and the confirmation will be for all of those elements.

After all the user supplied data has been entered, the system inquire whether or not processing should proceed. If the user's response is negative, all processing of the command is terminated, and the system is placed back in command mode without altering any of the data base. Commands terminated in this manner need not be CLEAR'ed to be rerun as described in Section 4.2 .

4.1.2   BATCH MODE

Any of the commands may be executed in batch mode. The user must ensure that the job submitted to the batch machine has the data entries in the order they will be requested (see appropriate section and Appendix H for example). Any errors in the data entries will terminate the job and cause an error report to be issued. In batch mode, no request for confirmation will be made, nor will confirmation responses be accepted.

4.2   EXCEPTION CONDITIONS

The pilot recognizes exception conditions of varying levels of severity. The levels and their significance are:

level 0 - informational message

level 4 - warning message, processing continues
level 8 - error has occurred, data integrity may be compromised
level 12 - presently equivalent to level 8
level 16 - fatal error - execution will be terminated

All error messages are displayed to the user if in interactive
mode or printed on the printer if in batch mode. The message is also
placed in the history file (see section 3.3.1) and counted in an error
report. When the command terminates -- either normally or as a result
of a severity 16 error, an error report is displayed summerizing the
errors which occured during the command.

4.2.1   ERROR RECOVERY

After a command which caused an error message of level 8 or
higher to be issued has been completed the user should determine the
cause of the error, correct the problem, and re-execute the command
(see section 4.2.2). Some of the errors which can occur for any
command are listed below.

*** SEGMENT (name) DOES NOT EXIST ***

The segment named in the error message is not active. A segment
becomes active when the command DATAPREP is executed for that segment
name. This error is most commonly a result of a typing error in
entering the segment name, but it may also result if the segment is
active on one user id, but the command in error was run on another id.
The user should rerun the command with the correct segment name or use
the appropriate user id for the segment.

*** (name) DOES NOT EXIST ON DISK CHARLIE ***

A data item required for this command was not available. This
indicates that at least one of the preceding commands for this segment
terminated prematurely (with a level 16 error) or was omitted. The
user should determine which command did not complete successfully and
proceed from there (see section 4.2.2).

*** (name) ALREADY EXISTS ON DISK CHARLIE ***

An attempt was made to save a data item created by this command, but
it had already been saved. This will happen if a command is re-
executed for the same segment without taking a proper recovery action
first (see section 4.2.2).

*** DATA KEY NOT FOUND IN MASTER CATALOG ***

A data set (probably an image) required for this command was not

available. This indicates that at least one of the preceding commands
for this segment terminated prematurely (with a level 16 error) or was
omitted.   The user should determine which command did not complete
successfully and proceed from there (see section 4.2.2).

    *** DISK IS FULL ***

Too much data has been stored on disk, probably as a result of having
many partially processed segments. The pilot manager should have some
files transferred from disk to tape.

    *** NO TAPE SPACE AVAILABLE FOR FILE ***

Too much data has been stored on tapes. The pilot manager should have
additional tapes made available to the system, or have some files
transferred from tape to disk.

    *** SPACE NOT AVAILABLE - UNSUCCESSFUL ALLOCATION ***

Insufficient virtual memory exists for command. The machine should be
configured to 2 Megabytes.

        .
        .

    4.2.2   CLEARING OF ERROR CONDITIONS

    Before a command may be re-executed, the system must perform some
housekeeping functions. To instruct the system to do this, the user
must issue the command CLEAR.   The system will then request the
segment name and command name, and will restore the data base to the
state it was in before the command being CLEAR'ed was originally
executed. Note that this means all commands which followed the
CLEAR'ed command will need to be re-executed after the CLEAR has
completed.

    For example, suppose the following commands were executed in
sequence:
    DATAPREP
    PREPROCESS
    DFS
    SCATTER
    CLUSTER

and at this point it was determined that the step PREPROCESS needed to
be redone, the user would do the following:

user   - clear
system - ENTER SEGMENT NAME
user   - seg1234
system - ENTER COMMAND TO CLEAR TO

user   - **preprocess**

This would have the same effect as issuing CLEAR for CLUSTER,
SCATTLR, DFS, and then PREPROCESS in that sequence, removing all data
generated by those commands from the data base and requiring that they
be rerun.   The status and tracking log will indicate which commands
were CLEAR'ed to and what data was removed from the data base.

4.3   HARDWARE REQUIREMENTS

A virtual machine with a userid CSPILOT must be defined with a
minidisk of at least eight (8) Megabytes at address 191 with a read
password of ERIM. This minidisk will provide storage for the pilot
software.

The data needed to run the pilot is maintained by a virtual
machine which must have the userid CSDATA and must have a minidisk of
at least one (1) Megabyte at address 191. An additional one (1)
Megabyte minidisk must be defined at address 200, and an additional
thirty (30) Megabyte minidisk must be defined for virtual machine
CSDATA for each userid which will be running the pilot software.   The
minidisk on CSDATA must have a specific write password [withheld from
this document] and no multiple access password. The read password is
not needed by the pilot software.

There are no special disk requirements for the virtual machines
of the individual users. All pilot data is stored on tapes or on
minidisks owned by CSDATA. A maximum virtual storage size of four (4)
Megabytes is sufficient to execute the pilot software.

4.4   SOFTWARE REQUIREMENTS

4.4.1   OPERATING SYSTEM

The pilot software has an interface provided for the VM/CMS
operating system with the addition of VM/370 Basic System Extensions
Program Product. The dependence of the pilot software on the
operating system is isolated to this interface package. The interface
package (system interface routines) is primarily written in OS
Assembler, using the following macros:

4. MACHINE PROCESSING FUNCTIONS   43

From Library CMSBSE:
    ADT, FSCB, FSCBD, FSCLOSE, FSERASE, FSOPEN, FSPOINT, FSREAD,
    FSSTATE, FSTD, FSWRITE, NUCON

From Library CMSLIB:
    DMSFREE, DMSFRET, LINEDIT, PRINTL, RDCARD, RDTERM, WAITT, WRTERM

From Library OSMACRO:
    CALL

The remaining system interface routines and most of the pilot
software are written using the PREFOR preprocessor in conjucnction
with the FORTRAN H compiler.

The system interface routines also require the following routines
available on LARS:
- ENVIR   – determines if job is being run in batch mode
- IDNAME   – returns userid of virtual machine
- GTDATE   – provides date and time of day
- TAPMOUNT – mount a tape
- TAPOP   – read, write, and position tapes

4.4.2   SOFTWARE PROVIDED BY ERIM

The software provided by ERIM may be divided into two classes:
that which is independent of the operating system, and that software
which provides the interface with the operating system.   The system
interface routines consist of:
- BATERM – determines if system is in batch or interactive mode
- GTIME – returns date and time
- GTSPAC – gets block of virtual storage
- FRSPAC – returns block of virtual storage
- MGUNIT – provides access to file or device
- MREAD – reads record from logical data set
- MWRITE – writes record to logical data set
- MDELET – deletes record(s) from file
- MCLOSE – closes logical data set
- MDSKTP – ensures a file is on tape
- MTAPDK – ensures a file is on disk
- MDSTRY – removes file from disk or tape
- MLOGIN – provides access to tape files from outside the pilot-
       controlled database
- MLOGOT – releases LOGIN'd tapes
- MDUMP – dumps a file onto a tape that is not part of the
       pilot-controlled tape library (e.g., tape for PFC)
- CHAOS – provides lowest level of error handling

● Secondary subroutines used solely by the system interface
   routines: MCKMST, MERR, MFIDEL, MFSIZE, MGETTL, and MPUTTL.

The software which is independent of the operating system may be
further categorized as commands, application modules, utilities, and
data service routines. Only the commands will be listed here. The
commands consist of:

- DATAPREP   – prepares system for processing of segment
- PREPROCESS – normalizes data and extracts features
- DFS   – tabulates DFS assignments
- SCATTER   – produces GRABS VS. BRIGHTNESS SCATTERPLOTS
- CLUSTER   – spatially and spectrally stratifies data
- SAMPLE   – selects blobs for labeling
- ESTIMATE   – produces segment-wide estimates

- CLEAR   – allows command to be re-executed
- ASK   – produces status information reports
- DISKTAPE   – moves data files from disk to pilot tapes
- TAPEDISK   – moves data files from pilot tapes to disk
- TRANSMIT   – copies file to tape which is external to data
                base
- USERINIT   – initializes user access file
- TAPELOG   – initializes available tape log

4.5 SYSTEM RESOURCE USE

4.5.1 PROCESSOR TIME

The approximate central processor time requirements for the various commands are given in Figure 17.

```
┌─────────────────────────────────────────────────────────────────┐
│                            FIGURE 17.                            │
│                AS/3000 Processor Time Requirements               │
│                                                                  │
│                                                                  │
│      COMMAND        CPU SECS  COMMENTS                           │
│                                                                  │
│      DATAPREP         16*N                                       │
│      PREPROCESS      100*N     Spatially varying XSTAR           │
│      DFS              <5                                         │
│      SCATTER         13*N     Default options selected           │
│      CLUSTER         25*N     For 4 blob acquisitions            │
│      SAMPLE          16*N     For 100 sample blobs               │
│      ESTIMATE         <5                                         │
│                                                                  │
│   Note: "N" is total number of acquisitions selected (maximum of 10) │
│                                                                  │
└─────────────────────────────────────────────────────────────────┘
```

4.5.2 PROCESSOR MEMORY

All commands will execute in a four (4) Megabyte virtual machine. Most of them will execute in a 1 Megabyte virtual machine.

4.5.3 PRINTER

The printer requirements are approximately 30 pages plus 2 pages per sampled blob for complete processing of a segment (not including re-work or management reports).

4.5.4   DISK AND TAPE

The maximum required disk load is during step "PREPROCESS", where up to eight (8) Megabytes of disk may be needed during processing. Note that this is an instantaneous figure, and may be decreased after the command completes by moving some data to tape. Each command checks to see if data which is required to be on disk is in fact on disk, and if not transfers the data from tape to disk. Similarly, each command transfers from disk to tape any data which will not be needed on disk by the following commands. In addition, with the commands DISKTAPE and TAPEDISK files can be explicitly transferred between disk and tape storage.

Note: Commands DISKTAPE and TAPEDISK must be executed on the virtual machine to/from which the transfer is to be made.

DISKTAPE:
This command is used to transfer data from a pilot-controlled disk file to a pilot-controlled tape file. After entering the command, the user is prompted for the segment name and file name (see Appendix J for file names).   The file will be transferred to an available tape from which it may be transferred back to disk (TAPEDISK) or used directly by the pilot software. If the file is already on a pilot-controlled tape, the command does nothing (it does not replace the tape file).

TAPEDISK:
This command is used to transfer data from a pilot-controlled tape file to pilot-controlled disk file. After entering the command, the user is prompted for the segment name and file name (see Appendix J for file names).   The file will be transferred from the appropriate tape to the users disk. If the file is already on disk, the command does nothing (it does not replace the disk file).

4.6   SYSTEM INITIALIZATION

4.6.1   USERIDS

Before the pilot may be run, several system initialization steps must be performed. Each user must have a virtual machine, and a minidisk on machine CSDATA dedicated to that use as described in section 4.3. In addition, several files on the 200 disk of CSDATA

must be initialized.

4.6.2 USER ACCESS FILE

To establish the association between userids and minidisks on the virtual machine CSDATA, the command USERINIT must be executed from virtual machine CSDATA. After typing the command USERINIT the operator will be prompted for input of the form:

Userid, vaddr

The operator should make one entry per line, with an entry consisting of the pair userid/vaddr. To complete the initialization the operator should enter a carriage return with no data. The file USER ACCESS is created by this command on the 200 minidisk of CSDATA.

4.6.3 T. °E LOG FILE

All tapes which will be controlled by the pilot software must be cataloged in the file TAPE LOG which resides on the 200 minidisk of CSDATA. To establish this log, the operator must enter the command TAPELOG from virtual machine CSDATA. After typing TAPELOG the operator will be prompted for input of the form:

Tape id, mode, available space

where tape id is an 8 character tape identifier, mode is a 4 digit density (800, 1600, or 6250 BPI) and available space is the length of usable tape in feet. One entry (tape id, mode, available space) should be entered per line, with entries separated by carriage returns. The login procedure is terminated by entering a carriage return with no data.

5
GENERAL ANALYST FUNCTIONS

In this section we consider Analyst topics that are general in nature. In particular, the segment analysis log (SAL) and its use is addressed. In addition to the material of this section, Analysts should be familiar with general guidelines that are presented in Appendix D.

5.1 SEGMENT ANALYSIS LOG

The medium through which all manual processing and analysis activities are recorded is the Segment Analysis Log (SAL). This log documents all major Analyst decisions as well as the progression of segment processing. SAL consists of six parts listed below:

(a) General Status Sheet
(b) Acquisition Summary Sheet
(c) Crop Calendar Verification/Adjustment Form
(d) Crop Group Strata Assignment Summary
(e) Label Recording Form
(f) Decision Logic Record Form.

These elements are described in the subsections below, and their use is further discussed in the detailed analysis procedures found in Section 6.

5.1.1 STATUS SHEET

The status sheet shown in Figure 18 is a summary of activities within each major procedural step. A box appears to the left of each activity. This box is to be checked when that activity has been completed, thereby allowing an immediate determination of the point to which segment processing has progressed. The status sheet also reminds the Analyst of documentation that is required in other parts of SAL for that activity. Finally, space is provided to record the processing time for each major procedural step. Processing time for individual activities within each step may also be recorded if desired. (Elapsed time and time/date stamp should both be entered.)

5.1.2   ACQUISITION SUMMARY SHEET

The acquisition summary sheet shown in Figure 19 provides an initial list of available acquisitions that will be supplemented by the Analyst teams during data screening, acquisition selection, and data analysis to indicate subsets that are used for various processing steps. This initial list will be recorded when the PFC products are placed into the Analyst packet and before initial segment analysis begins. Corresponding tape and file numbers as well as other information required for machine processing are to be entered adjacent to each acquisition. Analyst teams then record acquisitions for

(1) Overall machine processing -- Section 6.2,
(2) TPC extraction -- Section 6.2,
(3) BLOBbing -- Section 6.6, and
(4) Corn/Soybean separation -- Section 6.6.

In addition to the acquisition lists, the composite subwindow represented by each of the machine-processed acquisition (Section 6.2) and linear discriminant coordinates for each Separation acquisition (Section 6.6) are placed on this form.

5.1.3   CROP CALENDAR VERIFICATION/ADJUSTMENT FORM

This form, shown in Figure 20, is a work sheet on which crop calendar verification (Section 6.2) is carried out. At the top of the form are time lines on which five biowindows are defined for each of three crop groups (summer crops, winter small grains, and spring small grains) from a crop calendar model or historical data. Adjustments made by Analyst teams to these boundaries are recorded below along with composite subwindows defined for the purpose of optimizing acquisition selection. The selected overall machine-processing acquisitions, acquisitions for TPC extraction, and the expected TPC binary patterns are listed at the bottom of the form. The acquisition selections, with their associated composite subwindows, will be transferred to the Acquisition Summary Sheet.

5.1.4   CROP GROUP STRATA ASSIGNMENT SUMMARY

This summary, shown in Figure 21, provides Analyst team assignments of TPC's to crop group strata (DFS) in a form convenient for computer input. All TPC's are recorded in integer form for five of the six strata (summer crop, small grain, pasture, non-vegetated, and unknown). As explained in detail in section 6.4, TPC's that are not pure or that are ambiguous as to crop group are so designated in columns marked '"A" Subclass TPC's', "Assoc. Pure TPC", and "Alternatives". Finally, "A" subclasses of summer crop TPC's that are selected for inclusion in the scatter plots at the discretion of the Analyst team are recorded by checking the "Scatterplot" column.

All trivial TPC's will automatically be assigned by the computer.

5.1.5   LABEL RECORDING FORM

This form, shown in Figure 22, summarizes the Stage 1 and 2 labels assigned to each sampled blob. The Stage 1 labels are derived from the crop group stratification (Section 6.4) and corn/soybean discriminant (section 6.6) steps of the procedure, in which Analyst teams stratify segment-wide and stratum-specific pixel data into corn, soybeans, and other. The Stage 2 labels are a refinement of these initial labels based on more complete information for specific labeling targets (blobs). The blobs are analyzed by an individual Analyst using a detailed network decision logic (Section 6.9).

The recording form is a printer product on which sampled blobs are automatically listed along with their accompanying Stage 1 labels. The blobs are printed in the order in which they are to be evaluated, i.e., in decreasing order of interior size within each crop group beginning with summer crops. The labels that appear on the form are : "SC" (Summer Crop), "C" (Corn), "S" (Soybeans) and "0" (Other).

The Stage 1 labels set the initial expectations of the Analyst. If they are verified through application of the decision logic, no Stage 2 labels are recorded. More than one label in a given position indicates a mixture.

Misregistration and missing data are flagged by checking the appropriate columns. This indicates that the Analyst did not have a complete set of numeric data to work from in making the label assignment.

A confidence code is listed for each blob to indicate the confidence the Analyst has in the label assignment. A segment-wide confidence factor is recorded on the first page of the recording form.

5.1.6   DECISION LOGIC RECORD

The Decision Logic Record illustrated in Figure 23 consists of decision logic flow diagrams. This record is supplied for each sampled blob and is used to trace the flow of Analyst decisions during labeling.

FIGURE 18.
Status Sheet Example

Segment Name _____

SEGMENT ANALYSIS LOG (SAL) AI Team (A1 - A3) _____

PART 1: STATUS SHEET Analyst (AJ) _____

Step	Activity (Check When Done)	Where in SAL to Record	Time
0	Packet Preparation (Section 6.1)		
	☐ Initial packet preparation completed		
	☐ All available acquisitions listed, with corresponding tape and file numbers	II	
A1	Initial Segment Analysis (Section 6.2)		——
	☐ Available acquisitions screened, and screened-out acquisitions deleted from acquisition list	II	
	☐ Preliminary Spectral Biowindows plotted	III	
	☐ Spectral Biowindows verified or adjusted	III	
	☐ Crop Group Separation Windows plotted	III	
	☐ Composite Crop Group Separation Subwindows plotted	III	
	☐ Acquisitions selected for TFC extraction	II and III	
	☐ Expected pure TFC's recorded	III	
	☐ Candidate Corn/Soybean Separation Window plotted	III	
	☐ Additional machine processing acquisitions selected	II and III	
A2	Preprocessing (Section 6.3)		——
	☐ Preprocessing initiated		
	☐ Preprocessing completed; screen and TFC reports added to analyst packet		
A3	Crop Group Stratification (Section 6.4)		——
	☐ TFC's assigned to strata	IV	
	☐ "A" subclasses selected for scatterplot production (optional)	IV	
A4	Preparation of Spectral Aids (Section 6.5)		——
	☐ Strata assignments submitted to computer		
	☐ DPS report received and added to analyst packet		
	☐ Scatterplots requested		
	☐ Scatterplots received and added to analyst packet		
A5	Specification of BLOB and Separation Acquisitions (Section 6.6)		——
	☐ Corn/soybean separability on candidate separation acquisitions verified	II and III	
	☐ Linear discriminants defined	II	
	☐ BLOB acquisitions selected	II	
A6	Spectral Stratification and Sampling (Sections 6.7 and 6.8)		——
	☐ Clustering initiated		
	☐ Clustering completed		
	☐ Sampling initiated; separation acquisitions and discriminants submitted to computer		
	☐ Sampling completed; blob aids added to analyst packet; PFC tape created		
	☐ PFC tape submitted for generation of file product		
	☐ PFC file product generated and added to analyst packet		
A7	Blob Labeling (Section 6.9)		——
	☐ Stage I labels for all sampled blobs verified or corrected	V and VI	
	☐ Segment-wide confidence recorded	V	
A8	Label Entry and Estimation (Section 6.10)		——
	☐ Labels submitted to computer and estimation initiated		
	☐ Estimation completed; area estimation report added to analyst packet		

FIGURE 19.
Acquisition Summary Sheet Example

FIGURE 20.
Crop Calendar Verification/Adjustment Form Example

CROP CALENDAR VERIFICATION/ADJUSTMENT FORM

	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER

ACQUISITION

PHENOLOGICAL
- SUMMER CROP
- WINTER SMALL GRAINS
- SPRING SMALL GRAINS

SPECIAL
- SUMMER CROP
- WINTER SMALL GRAINS
- SPRING SMALL GRAINS

CROP GROUP SEPARATION WINDOW

COMPOSITE SEPARATION WINDOW

EXPECTED IPC'S	SELECTED IPC ACQUISITIONS	ADDITIONAL ACQUISITIONS
SUMMER CROPS	1	8
	2	9
	3	10
WINTER SMALL GRAINS	4	
	5	SEGMENT LOCATION
SPRING SMALL GRAINS	6	SEGMENT #
	7	

FIGURE 21.
Crop Group Strata Assignment Summary Example

SEGMENT ANALYSIS LOG   Segment _____

PART IV: CROP GROUP STRATA ASSIGNMENT SUMMARY

	Pure TPC's		"A" Subclass TPC's					
	Class #		Class #		Assoc. Pure TPC	Alternatives		Scatter Plot?
	Decimal	Binary	Decimal	Binary		Assoc. TPC	Stratum	
Summer Crop								
Grain								
Pasture,Trees,etc.								
Non-Veg.								
Unknown								

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FIGURE 22.
Label Recording Form Example

FIGURE 23.
Decision Logic Record Example

PART VII: DECISION LOGIC RECORD

6
DETAILED SEGMENT ANALYSIS PROCEDURES

This section details all activities required to carry out the U.S. Corn/Soybean Classification procedure that was described in Section 2. In carrying out these procedures, users should be familiar with other sections as suggested in Figure 1. Experienced users may find the summaries of Appendix B (machine) and Appendix C (Analyst) to be useful. Appendix B also provides a table (Figure 52) that presents standard inputs and indicates which group or project element is responsible for each input setting. Figure 24 provides a cross reference between the processing steps and the page and section numbers in this document.

FIGURE 24.
Documentation Cross-Reference Table

Procedure Step	Description	Section	Page
AO	Preparing the Analysis Data Base	6.1	60
A1	Data Screening and Selection, Spectral Crop Calendar Definition	6.2	65
M2	Preprocessing, Feature Extraction	6.3	91
A3	Crop Group Stratification	6.4	94
M4	Stratified Scatter Plot Generation	6.5	98
A5	C/S Discriminant	6.6	100
M6	Stratification and Sampling	6.7, 6.8	107 108
A7	Labeling	6.9	110
M8	Label Entry and Estimation	6.10	130

6.1   PREPARING THE ANALYSIS DATA BASE

Hardcopy (non-electronic) Analyst aid materials in support of the U.S. Corn and Soybean Pilot Experiment will be assembled into three elements:
(1) a reference library,
(2) an Analyst information manual, and
(3) segment-specific Analyst packets.

The reference library will contain materials that are not feasible to duplicate in large quantities. Reference materials that are easily duplicated and apply to a broad area (e.g., a state, a stratum or a CRD) will go into the information manual. Data specific to each sample segment will be collected in individual packets (one per segment).

Each of these elements will be discussed in the subsections below. The preparation and assembly of these products must be completed prior to analysis and processing of a segment.

6.1.1   REFERENCE LIBRARY

The purpose of the reference library is to provide easy access to background materials that cannot be duplicated for each Analyst but may be needed in specific interpretation situations. This library will be set up in a convenient location. Circulation of the data will be monitored closely in order that the whereabouts of any given item can be determined immediately. The following data will be included in the reference library.

Landsat full-frame Imagery:
Full-frame imagery will be available for each sample segment in the pilot test (more than one segment will be covered by a Landsat image). Several current-year acquisitions throughout the Corn/Soybean growing season are desirable. Previous year acquisitions should also be included if available. An acetate overlay with delineations of county boundaries and sample segment locations is to be provided with each Landsat image.

<u>Reference Books And Crop Phenology And Cropping Practices Information</u>:
Leonard and Martin's <u>Principles of Field Crop Production</u> (3rd ed.) and Chapman and Carter's <u>Crop Production</u> are highly recommended.

<u>County Soil Surveys</u>:

<u>United States And World Atlas</u>:

6.1.2   ANALYST INFORMATION MANUAL

Each Analyst should be supplied with a copy of the Analyst information manual. The manual is intended to familiarize the Analyst with the natural and agricultural environments in the region of interest (in this case, the U.S. Corn Belt states of Illinois, Indiana and Iowa). The materials contained in the manual are generally applicable to a whole region and therefore will pertain to many sample segments.

The following data are to be included in the Analyst information manual:

<u>A Tri-state Map</u>:
With all sample segment locations indicated.

<u>Crop Phenological Summary For Corn And Soybean Confusion Crops</u>:
Although textbooks and articles will be available in the reference library, summaries of crop growth are to be provided to each analyst. These summaries are to include a description of each growth stage, the characteristic Landsat spectral response associated with that stage (as best as it is presently understood) and the effect of episodic events (drought, hail, etc.) on overall crop development. This information is to be used by the AI to assimilate meteorological statistics and calibrate crop calendars to the segment level for crop

identification.

Land Use And Physical Environment Descriptions:

General descriptions for the following, preferably for each APU but at least for each state:

(a) Agricultural land use, cropping practices.
(b) Climate.
(c) Geomorphology.
(d) Soils.
(e) Native vegetation.

These descriptions are to be similar to the Universal Strata Descriptors in LACIE. Particular emphasis is to be placed on characteristics and interrelationships that will help the AI to interpret features detectable in Landsat data. Descriptions at the agrophysical unit (APU) level are to be used if obtainable. Otherwise descriptions at the state or tri-state level are to be provided with significant reference to regional trends. Landform and soils maps are helpful in supplementing the written descriptions and are to be provided if available.

Crop Calendar Products:

Refined crop calendar information is crucial to the accurate identification of crop development patterns in Landsat data. The crop calendar enables the Analyst to match temporal patterns detected in the satellite data to actual or predicted crop development patterns on the ground. Analysts for the Corn/Soybean pilot will draw upon crop calendar data throughout all major manual analysis components of the baseline area estimation procedure:

- (1) acquisition selection,
- (2) crop group stratification and
- (3) labeling of field-like targets.

The following crop calendar data products are to be supplied in support of U.S. Corn and Soybean Pilot Experiment:

(a) Current year crop calendar, adjusted to the segment level by a meteorologically driven model.
(b) Current year CRD-level crop calendar derived from ESCS data.
(c) Current year statewide crop calendar derived from ESCS data.
(d) Statewide normal crop calendar.
(e) CRD-level normal crop calendar.
(f) Year-specific statewide crop calendars, three previous years.
(g) Year-specific CRD-level crop calendars, three previous years.
(h) CRD-level crop calendar variation from statewide.
(i) CRD-level deviation of soybean and other summer crop

development patterns from corn.

Segment-specific, adjusted corn and soybean crop calendars are to be included along with statewide and CRD-level crop calendar products. All crop calendar products except the segment-level adjusted crop calendar are to be included in the information manual for reference.

6.1.3   INITIAL SEGMENT PACKET DESCRIPTION AND PREPARATION

Analyst packets will contain data specific to the sample segment. One packet will be assembled for each segment. The following data are to be placed in the packet before the AI begins the first manual analysis step of the Corn/Soybean Area Estimation procedure:

Acquisition Summary Sheet (SAL, Part II):
   All available acquisitions, with corresponding tape and file numbers, should be listed in chronological order on the form.

PFC Image Products:
   The image Products 1 and 3 are to be available for all acquisitions.

Meteorological Summary:
   The following meteorological data products are to be provided:
   (a)   Temperature climagraph (Appendix E, Figure 58).
   (b)   Precipitation climagraph (Appendix E, Figure 58).
   (c)   Crop Moisture Index climagraph (Appendix E, Figure 59).
   (d)   Listing of reported significant ecological events by date and region (Appendix E, Figure 60).

   These products are discussed in greater detail in the relevant figures.

   The first four products were developed for the wheat/barley pilot. Alterations in format for the Corn/Soybean pilot are limited to extension of the time axis through November to include the end of the corn and soybean growing seasons.

Crop Calendar Data:
   (a)   See "Crop Calendar Products" under Section 6.1.2
   (b)   Adjusted Crop Calendar Information

Historical Crop Statistics:

These data are used by the Analyst to determine which crops are to be expected within a segment and in what general relative proportions (i.e., one crop relative to another).

County historical crop statistics for the three years prior to the inventory year are to be provided in the analyst packet. These data are to include information on the following categories as well as information on year-to-year variation in the categories.

(a) Total county area.

(b) Total acreage in county in crop land.

(c) Most recent year statistics on each crop:
- Planted acreage
- Harvested acreage, including alfalfa and hay
- Harvested acreage as a percent of total cropland
- Acreage under special cropping practices (absolute and percent of total acreage in that crop): irrigation, double cropping, and strip fallow, etc.

Spatial Context Information:

(a) Reference to the appropriate Landsat full-frame file.

(b) 1:250,000 USGS topographic map annotated with segment location.

6.1.4 ADDITIONS TO THE SEGMENT PACKET

During the processing of the segment, additional reports and spectral aids will be generated and provided to the Analyst for addition to the segment packet. The additional items will include:

(a) A TPC report.

(b) A DFS report.

(c) Stratified Scatter Plots.

(d) A cluster report.

(e) List of BLOB labeling targets.

(f) BLOB overlay (PFC).

(g) BLOB report for each BLOB labeling target.

6.2   DATA SCREENING AND SELECTION

6.2.1   INITIAL SCREENING OF SEGMENT ACQUISITIONS

Analyst Team Function (Step A1):
- Data Screening

Purpose:
- To eliminate acquisitions with little or no recoverable field data from the set of candidate machine-processing acquisitions.

Inputs:
- List of all available acquisitions
- PFC Products 1 and 3 (all available acquisitions)

Outputs:
- Set acquisitions screened for heavy haze, clouds, bad data, and obvious misregistration.

Comments:
- The general method employed is visual appraisal of image products.
- To increase processing efficiency, this step may be performed by one member of the Analyst team at the same time Step 2 in section 6.2.2 is being carried out by another member.
- An Acquisition Summary Sheet, completed to the extent required in this section, is shown in Figure 25.

How To Proceed:

1. Obtain the list of available segment acquisitions (Acquisition Summary Sheet - SAL, Part II).

2. Using the image products, visually screen each available acquisition for the following conditions:
    (a) Heavy cloud cover   Twenty percent cloud-cover may be used as an approximate threshold for screening out cloudy acquisitions, but distribution of clouds should also be taken into account. For example, if clouds are concentrated in one corner of the segment and the remainder is cloud-

free, the acquisition should be passed as a candidate for machine processing.

(b) Heavy haze. Screen out acquisitions on which haze obliterates field definition or appears to distort color signatures.

(c) Bad data. Acquisitions with _severe_ striping or data dropout should not be used. As with cloud cover, the overall extent of the bad data should be considered carefully before a segment is excluded from further consideration.

(d) Obvious misregistration. Screen out acquisitions that are found to be badly misregistered (e.g., 5 pixels or more) after a _brief_ comparison of available acquisitions.

3. On the Acquisition Summary Sheet, draw a line through each screened-out acquisition and indicate the reason for deleting it in the "Comments" column. Be su:e not to delete acquisitions that are crucial to crop calendar verification if they have sufficient recoverable field information to analyze visually.

FIGURE 25.
Status Of Acquisition Summary Sheet Following 6.2.1

6.2.2   VERIFICATION AND ADJUSTMENT OF CROP CALENDAR

Analyst Team Function (Step A) Continued):
- Crop calendar analysis

Purpose:
- To transform the phenological crop calendar data for summer crops and small grains into a spectral crop calendar for summer crops and small grains.
- To check for obvious discrepancies between the phenological crop calendar data and the segment spectral data.

Inputs:
- PFC Products 1 and 3.
- Phenological crop calendar data for summer crops (corn and soybeans) and winter and spring small grains at the following levels:
  - (a) Year-specific segment-level data derived from an adjustable crop calendar model, or year specific statewide and Crop Reporting District (CRD)-level data from ESCS.
  - (b) Statewide and CRD-level historical normal data (optional).
- County historical crop statistics for each crop grown in the county in which the segment is located. These should include total harvested acreage and harvested acreage as a proportion of cropland for the three most recent years.
- Other ancillary data relative to cropping practices, landscape information, and climatic information as found in the segment packet, Analyst information manual, and the Analyst reference library.
- Appendix D: Crop Calendar Verification and Adjustment Guidelines.

Outputs:
- A verified or adjusted spectral crop calendar for summer crops, winter small grains, and spring small grains.
- Crop Group Separation Windows and Composite Subwindows.

Comments:
- To increase processing efficiency, Step 2 of this section may be performed by one member of the Analyst team at the same time the screening activities in Section 6.2.1 are being carried out by another member.
- A Crop Calendar Verification/Adjustment Form, completed to the

extent required in this section, is shown in Figure 41.

How To Proceed:

1. On the Crop Calendar Verification/Adjustment Form (SAL, Part III), plot all available acquisitions that remain after initial screening in Section 6.2.1 (see Figure 41).

2. On the crop calendar form's "Phenological" time axis, plot the following preliminary Spectral Biowindows using the year-specific phenological crop calendar data (use the most segment-specific data available) and the definitions in Figure 26:
   (a) Summer crops as a group.
   (b) Winter Small Grains as a group (plot windows for the crop year of interest, and plot WSG1 and WSG2 for the upcoming year if data are available).
   (c) Spring Small Grains as a group.

3. From the county historical crop statistics, determine the proportions in which each of the following crops are generally expected to occur in the region occupied by the segement:
   - Corn
   - Soybeans
   - All other summer crops
   - All winter small grains
   - All spring small grains
   - Alfalfa
   - Hay
   - Pasture

Use these expected proportions to provide a context for crop calendar verification/adjustment. Crops that make up a significant proportion of the total cropland (i.e., 5% or more) are likely to be found in the segment. Coversely, crops in smaller proportions may not be detectable witnin the segment. Keep in mind, however, that segment proportions do not always match county proportions.

4. Using the PFC products and the guidelines below and in Appendix D, verify or adjust the preliminary Spectral Biowindows defined in Step 2, and plot the results on the crop calendar form's "Spectral" time axis.
   (a) Rely primarily onthe Product 3's to determine the presence or absence of vegetation.
   (b) Make boundary adjustments only where available acquisitions support the adjustments.
   (c) When in doubt as to the presence of summer crop emergence in early season acquisitions, place the acquisition in SC1, not in SC2.

5. When either winter small grains or spring small grains do not

appear to be represented in the segment in sufficient proportions to allow verification or adjustment, do one of the following:

    (a)   If the biowindows defined for the other crop groups required little or no adjustment, carry the preliminary biowindow definitions from the "Phenological" axis down to the "Spectral" axis as is.

    (b)   If the biowindows defined for the other crop groups required substantial adjustment, leave the "Spectral" axis blank for the missing crop group and omit that group from further consideration.

6. Using the definitions in Figure 27 and the verified or adjusted Spectral Biowindow plots for each of the three crop groups, determine the major Crop Group Separation Windows and plot them on the crop calendar form in the space provided.

7. Using the definitions in Figure 28 and the verified or adjusted Spectral Biowindow plots, determine the Composite Crop Group Separation Subwindows and plot them on the crop calendar form in the space provided. If WSG1 and WSG2 have been defined for the upcoming crop season, ignore these definitions in this step and consider the time period as WSG => 5.

8. If either winter small grains or spring small grains were omitted as per Step 5b, "collapse" the Composite Subwindow definitions as follows:

    (a)   Use the remaining biowindow pair rather than the triplet.

    (b)   Label each time period according to the highest order Composite Subwindow definition satisfied by the pair. For example, the time period defined by the intersection of SC2 and SSG3 would be labeled "C3", not "C2" or "C1".

FIGURE 26.
Definition Of Spectral Biowindows For Crop Groups

SUMMER CROPS SPECTRAL BIOWINDOWS

Spectral Biowindow Designation	Start of Window	Close of Window
SC1	1 week prior to 5% planting date for earliest occurring summer crop - most probably corn. Use corn if there are any doubts.	1 week after 5% of corn is emerged, or 2 weeks after 5% planting date for corn if emergence information is lacking.
SC2	1 week after 5% of corn is emerged, or 2 weeks after 5% planting date for corn if emergence information is lacking.	1 week after 95% soybeans emerged, or date of 95% soybeans reaching full stand if emergence data are lacking.
SC3	1 week after 95% soybeans emerged, or date of 95% soybeans reaching full stand if emergence data are lacking.	Date of 25% corn matured or date of 25% soybeans leaves shedding, which-ever date is earlier.
SC4	Date of 25% corn matured or date of 25% soybeans leaves shedding, which-ever date is earlier.	Date of 95% corn at harvest maturity (Hanway scale 10.5) or 95% soybeans at harvest maturity (Fehr-Caviness Scale 8.0), whichever date is later. Use the date half-way between 95% matured and 95% harvested if date of harvest maturity is not reported.
SC5	Date of 95% corn at harvest maturity (Hanway scale 10.5) or 95% soybeans at harvest maturity (Fehr-Caviness Scale 8.0), whichever date is later. Use the date halfway between 95% matured and 95% harvested if harvest maturity is not reported.	Date 95% of all summer crops are harvested. Use the 95% harvested date of the latest summer crop.

FIGURE 26. (continued)
Definition Of Spectral Biowindows For Crop Groups

WINTER SMALL GRAINS SPECTRAL BIOWINDOWS

Spectral Biowindow Designation	Start of Window	Close of Window
WSG1*	1 week prior to 5% planting date for the earliest occurring winter small grain. This is, of course, in the preceding year.	1 week after 5% emerged date for the earliest occurring winter small grain, or 2 weeks after 5% planted if emergence data are not available. This is still in the preceding year.
WSG2*	1 week after 5% emerged date for the earliest occurring winter small grain, or 2 weeks after 5% planted if emergence data are not available. This is in the preceding year.	Date of 50% jointed for latest occurring winter small grain, or 1 week prior to date of 5% headed for latest occurring winter small grain.
WSG3	Date of 50% jointed for latest occurring winter small grain, or 1 week prior to date of 5% headed for latest occurring winter small grain.	Date of 5% turning for earliest occurring winter small grain, or date halfway between 5% headed and 5% harvested for earliest occurring winter small grain if turning information is lacking.
WSG4	Date of 5% turning for earliest occurring winter small grain, or date halfway between 5% headed and 5% harvested for earliest occurring winter small grain if turning information is lacking.	Date of 95% harvested for latest occurring winter small grain.
WSG5	Date of 95% harvested for latest occurring winter small grain.	Date of 95% stubble plowed down for latest occurring winter small grain.

*Note: It is not critical to plot WSG1, the start of WSG2 or the close of WSG5.

FIGURE 26. (continued)
Definition Of Spectral Biowindows For Crop Groups

Spectral Biowindow Designation	Start of Window	Close of Window
	SPRING SMALL GRAINS SPECTRAL BIOWINDOWS	
SSG1	1 week prior to 5% planting date for earliest occurring spring small grain.	1 week after 5% emerged date for earliest occurring spring small grain, or 2 weeks after 5% planting if emergence data are not available.
SSG2	1 week after 5% emerged date for earliest occurring spring small grain, or 2 weeks after 5% planted if emergence data are not available.	Date of 50% jointed for latest occurring spring small grain, or 1 week prior to date of 5% headed for latest occurring spring small grain.
SSG3	Date of 50% jointed for latest occurring spring small grain, or 1 week prior to date of 5% headed for latest occurring spring small grain.	Date of 5% turning for earliest occurring spring small grain, or date half-way between 5% headed and 5% harvested for earliest occurring spring small grain if turning information is lacking.
SSG4	Date of 5% turning of earliest occurring spring small grain, or date half-way between 5% headed and 5% harvested for earliest occurring spring small grain if turning information is lacking.	Date of 95% harvest for latest occurring spring small grain.
SSG5*	Date of 95% harvested for latest occurring spring small grain.	Date of 95% stibble plowed down for latest occurring spring small grain.

*Note: It is not critical to plot the close of SSG5.

FIGURE 27.
Definition Of Crop Group Separation Windows

Crop Group Separation Window Designation	Start of Window	Close of Window
GSW1*	Starting date of adjusted Spectral Bio-window WSC2 or SSC2, whichever crop group occurs and whichever date is the earliest (but not earlier than 15 March in the Corn Belt).	Closing date of adjusted Spectral Bio-window SSG3 or WSC4, whichever crop group occurs and whichever date is the earliest.
GSW2	Closing date of adjusted Spectral Bio-window SSG3 or WSC4, whichever crop group occurs and whichever date is the earliest.	Closing date of adjusted Spectral Bio-window SC3.
GSW3	Closing date of adjusted Spectral Bio-window SC3.	Closing date of adjusted Spectral Bio-window SC3.

*Note: It is not critical to plot the beginning of GSW1.

FIGURE 28.
Definition Of Composite Crop Group Separation Subwindows

Composite
Crop Group
Separation
Subwindow
Designations   Definition*

Designation	Definition*
A1	$(<1,2,\leq1)$ and/or $(<1,2,2)$
A2	$(<1,2,3)$ and/or $(<1,3,\leq1)$ and/or $(<1,3,2)$
A3	$(<1,3,3)$ and/or $(1,4,3)$ and/or $(<1,\geq5,3)$
B1	$(1,2,\leq1)$ and/or $(1,2,2)$
B2	$(1,2,3)$ and/or $(1,3,\leq1)$ and/or $(1,3,2)$
B3	$(1,3,3)$ and/or $(1,3,4)$ and/or $(1,4,3)$ and/or $(1,4,4)$ and/or $(1,\geq5,3)$ and/or $(1,\geq5,4)$
C1	$(2,2,2)$ and/or $(2,2,3)$ and/or $(2,3,2)$ and/or $(2,3,3)$ and/or $(2,3,4)$
C2	$(2,4,3)$ and/or $(2,4,4)$
C3	$(2,4,\geq5)$ and/or $(2,\geq5,3)$ and/or $(2,\geq5,4)$ and/or $(2,\geq5,\geq5)$

* The intersection of the grouped Spectral Biowindows defines the specific Crop Group Separation Subwindows. The Summer Crop (SC) Spectral Biowindow is given first in the triplet, Winter Small Grains (WSG) second, and Spring Small Grains (SSG) third, e.g., $(1,2,3)$ = SC1, WSG2, SSG3.

FIGURE 28. (continued)
Definition Of Composite Crop Group Separation Subwindows

Composite Crop Group Separation Subwindow Designations	Definition
D1	(3,3,2) and/or (3,3,3) and/or (3,3,4)
D2	(3,4,3) and/or (3,4,4)
D3	(3,4,$\geq$5) and/or (3,$\geq$5,3) and/or (3,$\geq$5,4)
E	(3,$\geq$5,$\geq$5)
F*	(4,$\geq$5,$\geq$5)
G	(5,$\geq$5,$\geq$5)
H	(>5,$\geq$5,$\geq$5)

* The first half of this time period is F1, the second half F2.

FIGURE 29.
Crop Calendar Verification/Adjustment Form Following 6.2.2

6.2.3   SELECTION OF ACQUISITIONS FOR MACHINE PROCESSING

Analyst Team Function (Step A1 Continued):
- Acquisition selection

Purpose:
- To select a maximum of ten acquisitions for machine processing, including:
    (a)   Acquisitions for optimum crop group separation
    (b)   Potential Corn/Soybean separation acquisitions
    (c)   Potential BLOB acquisitions

Inputs:
- PFC Products 1 and 3
- Verified or adjusted spectral crop calendar
- Crop-Group Separation Windows and Composite Subwindows
- Year-specific segment-level phenological crop calendar for corn

Outputs:
- Specified set of acquisitions for machine processing
- Specified set of acquisitions for Temporal Pattern Class (TPC) extraction
- Expected "pure" TPC's for crop groups
- Candidate Corn/Soybean Separation Window definition

Comments:
- Examples of the Crop Verification/Adjustment Form and the Acquisition Summary Sheet, including additions required in this section, are shown in Figures 36 and 37.

How To Proceed:

1.   Keep the general guidelines in Figure 30 in mind when selecting acquisitions for machine processing.

2.   Select acquisitions to be used for Temporal Pattern Class (TPC) extraction   ⁺ing to the guidelines in Figures 31 and 32. If the minimum data set cannot be selected, do not process the segment further.

3.   Record selected TPC acquisitions in the space provided on the Crop Calendar Verification/Adjustment Form (SAL, Part III).

4.   Using the instructions in Figure 33 and the expected binary

codes indicated in Figures 34 and 35, record on the crop calendar form all expected _pure_ TPC's for each of the following crop groups:

(a) Summer Crop
(b) Winter Small Grains
(c) Spring Small Grains
(d) Pasture/Trees/Permanent Vegetation

5. Plot the candidate Corn/Soybean separation window from the crop calendar form using the corn phenological crop calendar and the following definition:

● Open: Date of 90% corn tasseling or opening date of verified or adjusted Summer Crop Biowindow 3 (SC3) which ever is later
● Close: Closing date of verified or adjusted SC3 plus 14 days

6. Add all remaining acquisitions within the candidate separation window to the acquisition list at the bottom of the crop calendar form.

7. Add to the list any remaining acquisitions that might be required for BLOBbing according to the guidelines in Figure 43 (section 6.6).

8. If ten machine-processing acquisitions have not been selected by this time, choose extra acquisitions from those remaining according to the criteria in Figure 30. If no suitable acquisitions are left from which to choose, pass less than ten acquisitions for machine processing (do not include undesirable acquisitions just to fill up space).

9. If seven acquisitions were selected for TPC extraction and more than three additinal candidate separation and/or BLOB acquisitions must be processed (Steps 6 and 7), replace the _least critical_ TPC acquisitions (up to _two_) with the required additions. Be certain to maintain the TPC acquisition selection priorities described in Figure 31.

10. Record the complete list of machi e-processing acquisitions on the Acquistion Summary Sheet (SAL, Part III) by checking the "machine processing" column opposte the appropriate dates. Record the subset of acquisitions to be used for TPC extraction by checking the "TPC Acquisition" column as well. Do not check the "BLOB Acquisition" or "Separation Acquisition" columns at this time.

11. Record on the Acquisition Summary Sheet the Composite Crop Group Separation Subwindow to which each machine-processing acquisition belongs.

FIGURE 30.
General Guidelines For Selecting Machine-processing Acquisitions

1. Choose from the set of acquisitions that remain after initial screening (Section 6.2.1).

2. Choose <u>ten</u> acquisitions whenever possible, but

3. <u>Never</u> include more than one acquisition from a sequential-day pair.

4. When choosing between two sequential-day acquisitions, t. / to choose one from the same Landsat frame path as the majority of the other selected acquisitions. This will help minimize scan angle effects.

5. However, if the choice is between an acquisition from the same path and an acquisition with higher data quality, opt for the higher-quality acquisition.

6. Select early-season acquisitions (March, April, May) if they are required for optimum crop group separation during Temporal Pattern Class (TPC) extraction and BLOBbing, but emphasize later acquisitions (June through October) when rounding out the list of ten.

FIGURE 31.
Temporal Pattern Class (TPC) Acquisition Selection Guidelines

Background

A TPC is a group of pixels with the same temporal vegetative pattern. This temporal pattern is expressed as binary string of 0's and 1's, each bit corresponding to a selected TPC acquisition. A "0" indicates an absence of detectable vegetation (i.e., a GRABS value of less than (6). Conversely, a "1" indicates the presence of detectable vegetation (i.e., a GRABS value of 6 or greater). See Figure 38 in Section 6.4 for examples.

The overall goal of TPC acquisition selection is to choose a set of acquisitions over which summer crops are expected to have the following pattern: Unvegetated (0) -> Vegetated (1) -> Unvegetated (0). Acquisitions to support this desired sequence are drawn from the three Crop Group Separation Windows (GSW's) as follows:

- The initial unvegetated acquisitions are selected from GSW1, a time period during which summer crops are most probably not yet emerged, but small grains and pasture are greening up. The most desirable acquisitions within this GSW are those from Composite Crop Group Separation Subwindow B, which corresponds to the "absolute" summer crop pre-emergence biowindow (SC1).

- The vegetated acquisitions are selected from GSW2, when summer crops and pasture are expected to be green, and small grains are in the maturity-to-harvest stage. The most desirable acquisitions within this GSW are those from composite Subwindows E and D, which corresponds to the "absolute" summer crop green canopy biowindow (SC3).

- The final unvegetated acquisitions are selected from GSW3, when most vegetation, including summer crops, is senescing, but some pasture and newly emerged winter wheat may be green. The most desirable acquisitions within the GSW are those from Composite Subwindow G, which corresponds to the "absolute" summer crop harvest maturity/harvest biowindow (SC5).

FIGURE 31.   (continued)
Temporal Pattern Class (TPC) Acquisition Selection Guidelines

Selection of two acquisitions representing each of the three phases is advisable in order to handle misregistered classes ("A" subclasses - see Setion 6.4) properly.   A third vegetated acquisition is desirable to cover variation within summer crops.

Acquisition Selection

1.   Apply the following criteria when selecting acquisitions for TPC extraction:
(a)   Avoid acquisitions with cloud cover or heavy haze. However, slightly hazy acqusitions or those with few popcorn clouds may be included if they are crucial to optimum crop groups separation.
(b)   The total range of misregistration should not exceed three pixels.
(c)   Select acquisitions to cptimize separation between summer crops and other crop groups.   Do not select acquisitions to enhance separation among non-summer crop groups (e.g., spring small grains, winter small grains, and pasture/permanent vegetation) at the expense of separating Summer Crops from Other.
(d)   Avoid selecting a set of acquisitions that would result in the same expected pure pattern (see Figure 38) for both summer crops and another crop group.

2.   Choose as many acquisitions as possible, up to a maximum of seven:
(a)   A minimum of two acquisitions are required.   If only two acquisitions are used, they must be distributed as follows:
● One acquisition from Composite Subwindow E, and
● One acquisition from Composite Subwindow B, A or G.
(b)   A set of at least five acquisitions is desirable (preferably selected so that the expected summer crop pattern is 00110), but
(c)   A complete set of seven acquisitions (over which the expected summer crop pattern is 0011100) is the optimum.

```
                    FIGURE 31.   (continued)
    Temporal Pattern Class (TPC) Acquisition Selection Guidelines


    3.  TPC acquisition selection guidelines  are  summarized  in
Figure  32.   Use  the prioritized list of Composite Subwindows to
select acquisitions within  each  Crop  Group  Separation  Window.
Work  through the list until the desired number of acquisitions is
selected or  no  further  acquisitions  are  available.   Use  the
highest  priority  acquisitions with acceptable data quality, even
if this  means  choosing  acquisitions  from  the  same  Composite
Subwindow   (for    example,    two    acquisitions   from   B3,   three
acquisitions from E, and two from G would be optimum).
    (a)  First, try to select the following minimum desirable set:
  ● Two acquisitions from GSW1
  ● Two acquisitions from GSW2
  ● One acquisition from GSW3
    (b)  If successful, add a third acquisition from GSW2.
    (c)  Finally, add a second acquisition from GSW3 or, if that is
         not available, a  third  acquisition  from  GSW1.   This
         completes the optimum set of TPC acquisitions.
    (d)  If  the  optimum set can not be selected, come as close to
         it as possible.  Try  to  choose  at  least  the  minimum
         desirable  set.   If  even  this is not possible, do the
         best you can, in  accordance  with  the  guidelines  and
         restrictions in this figure and in Figure 30.
```

FIGURE 32.
Summary Of TPC Acquisition Selection Guidelines

Phase In Summer Crop Development Sequence	GSW From Which To Select Acquisitions	Prioritized List For Composite Subwindows for Acquisition Selection[a]	Number of Acquisitions For Optimum Set	Number of Acquisitions For Minimum Desirable Set	Number of Acquisitions For Minimum Processable Set
Unvegetated (Pre-emergence) Binary Code = 0	GSW1	B_3, B_2, B_1, A_3, A_2, A_1, C_1, C_2	2	2	1** (A or B)
Vegetated Binary Code = 1	GSW2	E, D_3, D_2, D_1, C_3, F_1	3	2	1 (E)
Unvegetated (Harvest Maturity/Harvest) Binary Code = 0	GSW3	G, F_2	2	1	1** (G)

[a] Use highest priority acquisitions available.
** One acquisition from either GSW1 or GSW3.

```
                          FIGURE 33.
         Instructions For Recording Expected Pure TPCs


    1.  A  pure  TPC  has  no reversals in the vegetated sequence
(see Figure 38, Section 6.4, for examples).  Record only expected
pure patterns at this time.


    2.  To record the expected pure patterns for summer crops, do
the following:
    (a)  Using  the  verified  or  adjusted  Summer  Crop  Spectral
         Biowindows,  determine  the  biowindow  to  which  each
         selected TPC acquisition belongs.
    (b)  In  chronological order, record either a 0 or a 1 for each
         acquisition as indicated in Figure 34.
    (c)  If one acquisition falls in a transitional window,  record
         two  expected patterns with the transitional acquisition
         receiving a 0 and a 1, respectively.
    (d)  If more  than  one  acquisition  is  from  a  transitional
         window,  record  as many TPC's as are necessary to cover
         the expected range of pure patterns.
    (e)  Do not record patterns that are not pure.  Once a  1  has
         been  recorded  in  Biowindow 2 for a given pattern, all
         remaining acquisitions from that window must be recorded
         as 1's to complete that pattern.  Likewise, once a 0 has
         been recorded in Biowindow 4 for a  given  pattern,  all
         remaining acquisitions from that window must be recorded
         as 0's to complete that pattern.
    (f)  Record  the  decimal  class number adjacent to each binary
         string.


    3.  To record the expected pure  patterns  for  winter  small
grains  follow  the  instructions  in Step 2 using the verified or
adjusted Winter Small Grain Spectral Biowindows.  If Biowindows  1
and  2  have  been  defined for the next year's growing season, be
sure to include them in the expected patterns (e.g., 1100011).


    4.  To record the expected pure  patterns  for  spring  small
grains,  follow  the  instructiions in Step 2 using the verified or
adjusted Spring Small Grain Spectral Biowindows.
```

FIGURE 33. (continued)

Instructions For Recording Expected Pure TPCs

5. To record the expected pure patterns for pasture/trees/permanent vegetation, do the following:

(a) Determine the Composte Crop Group Separation Subwindow to which each selected TPC acquisition belongs.

(b) In chronological order, record a 0 or a 1 for each acquisition as indicated in Figure 35.

(c) If one acquisition falls in a Composte Subwindow for which both a 0 and a 1 are indicated, record two expected patterns with the acquisition in question receiving a 1 and a 0, respectively.

(d) If more than one acquisition should be represented by both a 0 and a 1, record as many TPC's as are necessary to cover the expected range of pure patterns.

(e) Do not recode patterns that are not pure. Once a 1 has been recorded in Composite Subwindow A1 through B1 for a given pattern, all remaining acquisitions from those windows must be recorded as 1's to complete that pattern likewise, once a 0 has been recorded in Composite Windows G and H for a given pattern, all remaining acquisitions from those windows must be recorded as 0's to complete that pattern.

(f) Record the decimal class number adjacent to each binary string.

6. If after all expected pure patterns have been recorded a summer crop pattern is found to be identical to that of another crop group stratum, do the following:

(a) Re-evaluate the set of selected TPC acquisitions to determine whether a different choice of acquisitions would eliminate the overlap. If so, replace the old list of expected pure patterns with the expected pure patterns of the new acquisitions.

(b) If the required acquisitions are not available, determine whether an acquisition has been or can be chosen from the first half of summer crop biowindow 2. If so, re-record expected pure summer crop patterns by assigning acquisitions in the first half of SC2 a 0 only, and acquisitions in the second half of SC2 a 0 and a 1 as before.

(c) If the overlap still can not be eliminated, treat the patterns in question as "A" subclasses in the crop group stratification (Section 6.4).

```
                        FIGURE 34.
        Expected Binary Codes For Summer Crops And Small Grains


                        Spectral Biowindow

Crop Group                  ≤1      2      3      4      ≥5


Summer Crops (SC)           0      0,1     1     1,0     0

Winter Small Grains
  (WSG)                      0      0,1     1     1,0     0

Spring Small Grains
  (SSG)                      0      0,1     1     1,0     0
```

```
                        FIGURE 35.
        Expected Binary Codes For Permanent Vegetation


A1-3     B1     B2-3    C1-3    D1-3    E     F      G       H


0,1     0,1      1       1       1      1     1     1,0     1,0
```

FIGURE 36.
Crop Calendar Form Following Section 6.2.3

Analyst step: DATA SCREENING AND SELECTION 6.2

FIGURE 37.
Acquisition Summary Sheet Following Section 6.2.3

Segment Name _127_

SEGMENT ANALYSIS LOG

PART II: ACQUISITION SUMMARY SHEET

Acquisition (YYMMDD - Mo./Day)	Tape #	File #	Density	Machine Process	Composite Subindex	TFC Acquisition	BLOB Acquisition	Separation Acquisition	Corn/Soy Discriminant ($BR_1, GR_1; BR_2, GR_2$)	Comments
780A - MR30	7451	40	1600							
78107 - AP17	"	41	"	✓	B_1	✓				
78152 - JN01	"	42	"	✓	B_3	✓				
78161 - JN10	"	43	"	✓	B_3	✓				
78147 - JL16	"	44	"	✓	C_3					
78207 - JL26	"	45	"	✓	E	✓				
78216 - AG04	"	46	"	✓	E	✓				
78243 - AG31	"	47	"	✓	E	✓				
78252 - SP09	"	48	"	✓	F_1					
78268 - SP26	"	49	"	✓	F_1	✓				
78306 - NY02	"	50	"	✓	G_1					
78344 - NY10	"	51	"							Completely unregistered
71333 - NY29	"	52	"							
78356 - DC16	"	53	"							

6.2.4   DETERMINATION OF POTENTIAL SEPARATION ACQUISITIONS

1.   Using the crop calendar data specified in Section 6.2.2, Step 1, plot the candidate Corn/Soybean Separation Window as follows:
- Open: Date of 90% corn tasseling or opening date of SC3, whichever is later.
- Close Closing date of Summer Crop Biowindow 3 plus 14 days.

2.   All acquisitions that fall in the candidate Separation Window and meet the initial data screening criteria are to be passed for machine processing.

6.2.5   DETERMINATION OF POTENTIAL BLOB ACQUISITIONS

1.   Review BLOB acquisition selection guidelines in Figure 43.

2.   If a potentially important BLOB acquisition has not been included in the set of TPC and candidate Corn/Soybean separation acquisitions selected up to this point, add it to the list for machine processing.

6.2.6   DEFINITION OF TOTAL ACQUISITON SET FOR MACHINE PROCESSING

1.   A maximum of <u>ten</u> acquisitions may be passed for machine processing.

2.   The total acquisition set must include: TPC acquisitions, potential separation acquisitions, and potential blob acquisitions.

3.   If seven acquisitions were selected for TPC extraction and more than three additional separation and/or BLOB acquisitions need to be processed, replace the <u>least</u> <u>critical</u> TPC acquisitions (up to <u>two</u>) with the required additions. Be sure to maintain the TPC acquisition selection priorities set forth in Section 6.2.3.

6.3 PREPROCESSING

Machine Function (Step M2):
- DATAPREP
- PREPROCESS

Purpose:
- To prepare and normalize the spectral data for analysis. The steps include: (Merge, Satellite correct, Sun angle correct, Screen for clouds and such, XSTAR haze correct, Tasselled Cap and GRABS transform, and TPC feature extract.)

Inputs:
- Segment name
- Overall list of acquisitions
- List of tape number, tape file, and recording density for each acquisiton
- Method to be used for SCREEN and XSTAR

Outputs:
- A printed SCREEN report
- A printed TPC report
- (Prepared spectral data stored into the data base)

How To Proceed:

1. Place the computer in command mode (see section 4.1.1)

2. Enter the command:
DATAPREP

3. Enter the segment name. This should be up to 16 nonblank characters including the segment number and any codes distinguishing one segment-use from another.

4. Enter the number of acquisitions to use for general processing (integer between 1 and 10 inclusive).

5. Enter the list of acquisitions to use for general processing (integers). Each entry is an integer of the form yyddd, where yy is the year and ddd is the day of year.

6. Enter the list of tape numbers, one for each acquisition, for tapes containing 4-channel raw image data in UNIVERSAL format (up to 12 characters each).

7. Enter the corresponding list of tape file numbers, one for each acquisition (integer).

8. Enter the corresponding list of tape recording densities, one for each acquisition (integer).

9. If the default window is to be used, enter "yes" and proceed to Step 11. If a different window is desired, go to Step 10.

10. Enter the subset of the image to be used in the following order: beginning line number, ending line number, line increment, beginning pixel number, ending pixel number, and pixel increment.

11. This command should execute. Check for error messages.

C-2

12. Enter the command
PREPROCESS

13. Enter the segment name, same as (3) above.

14. Enter the desired method of SCREENing (8 characters) must be "none" for no screening, "spatial" for spatially varying XSTAR, or "global" for global XSTAR.

15. Enter the desired method of XSTAR haze correction (integer); which must be "none" (no haze correction), "spatial" (spatially varying XSTAR) or "global" (global XSTAR).

16. Enter the number of acquisitions to use for the TPC feature (integer). This must be no greater than 7, and no greater than the overall number of acquisitions entered in (4).

17. Enter the acquisitions for TPC (integer), in the form yyddd, as above. These must be a subset of the overall acquisition list entered in (5), and should be in chronological order.

18. If you do not wish to change the satellite numbers or sun angles, enter "no" and skip to Step 21. If either the satellite numbers or sun angles are to be changed, go to Step 19.

19. Enter the correct sun angle for each acquisition (real).

20. Enter the correct satellite number for each acquisition (integer).

21. This command (PREPROCESS) should now execute. Check for error messages.

22. Place the screen report and the TPC report into the Analyst packet.

6.4   CROP GROUP STRATIFICATION (DFS)

Analyst Function (Step A3):
- DFS

Purpose:
- To provide a crop group level stratification for the stratified areal estimator.
- To enable production of effective spectral aids.
- To provide Stage 1 crop group labels for blob labeling.

Inputs:
- List of binary patterns representing the expected pure Temporal Pattern Classes (TPCs) for each crop group.
- TPC report.

Outputs:
- Record of TPC assignments to crop group strata.
- List of TPC's to be used for stratified spectral aids.

Comments:
- A completed Crop Group Stratum Assignments Sheet is shown in Figure 39.

How To Proceed:

1. Obtain the TPC report on which the TPC's are ordered by the number of pixels in each class (largest class first).

2. TPC's with less than 50 pixels are considered trivial classes and are automatically assgned to the "Trivial" stratum. Do not assign trivial classes to other crop group strata.

3. Assign pure non-trivial TPC's (see Figure 38) to crop group strata as follows:

   (a) Review the expected pure patterns (from Section 6.2.3) that were recorded on the Crop Calendar Verification/Adjustment Form (SAL, Part III).

   (b) Match non-trivial pure TPC's that appear on the TPC report to these expected patterns and label them accordingly.

   (c) If an expected pure pattern is shared by summer crop and another crop group stratum, reserve it for assignment in Step 4 below.

   (d) Record pure TPC stratum assignments on the Crop Group

Stratum Assignments Sheet (SAL, Part IV) by listing each TPC (decimal number and binary pattern) in the "Pure TPC's" column opposite the appropriate crop group.

4. Assign all remaining non-trivial TPC's to strata as follows:
   (a) Compare each TPC to the list of pure patterns that are present and determine whether it is an "A" subclass (see Figure 38) of one or more of those patterns. Note: There should not be any "A" subclasses if only two acquisitions were used for the TPC extraction.
   (b) Assign each "A" Subclass TPC to the same stratum as that of the pure TPC with which it is associated.
   (c) If an "A" Subclass TPC is associated with two or more pure TPC's in different strata, assign it to the stratum to which the pure TPC with the greatest number of pixels belongs.
   (d) Record "A" Subclass TPC stratum assignments on the stratum assignments sheet by listing each TPC (decimal number and binary string) in the "A" Subclass TPC's column opposite the appropriate crop group. Also record the decimal number of the associated pure TPC. If a TPC is associated with more than one pure TPC, list the decimal numbers of the other TPC's as well as alternative stratum assignments, if applicale.
   (e) List on the stratum assignments form, opposite "Unknown", all remaining non-trivial TPC's that could not be assigned to crop group strata.

5. There should be fewer pixels in an "A" subclass than in its associated pure TPC. If the "A" subclasses within a segment consistently have more pixels than their associated pure TPC's, check that the crop calendar verification and adjustment was done correctly. If not, rerun Sections 6.2.2, 6.2.3, and 6.4.

6. All pure Summer Crop TPC's will automatically be used to generate stratified scatterplots. Significantly large "A" subclasses (i.e., classes that account for 30% or more of the pixels in all non-trivial Summer Crop TPC's combined) may be added if it is felt that summer crop variation would not be represented sufficiently without them. If "A" subclasses are to be included in the plots, check the "Scatterplot" column on the stratum assignments form opposite the appropriate TPC's.

FIGURE 38.
TPC Type Definitions

Pure TPC: No Reversals in Vegetated Sequence

                        Ex.   0001110,   0011000,   0100000
                                1111111,   1111110

"A" Subclass TPC: One Misregistered 'Bit' Relative
                       to an Expected and Present Pure TPC

                        Ex.   0101110,   0011100,   0100100
                                0111111,   1011110

Unassignable TPC: Two or More Misregistered 'Bits'
                       Relative to an Expected and Pure TPC

                        Ex.   0100110,   0011011,   0100110
                                0101111,   0111101

Trivial TPC: Less than 50 Pixels in the Class

FIGURE 39.
Completed Crop Strata Assignment Summary

SEGMENT ANALYSIS LOG   Segment 127

PART IV: CROP GROUP STRATA ASSIGNMENT SUMMARY

	Pure TPC's		"A" Subclass TPC's					
	Class #		Class #		Assoc. Pure TPC	Alternatives		Scatter Plot?
	Decimal	Binary	Decimal	Binary		Assoc. TPC	Stratum	
Summer Crop	14	0001110	78	1001110	14			
			47	0101110	14	62	Pasture	
			30	0011110	14	62	Pasture	
			15	0001111	14			
Grain	96	1100000						
Pasture,Trees,etc.	127	1111111	124	1111100	126			
	126	1111110	31	0011111	63			
	63	0111111						
	62	0111110						
Non-Veg.	0	0000000	1	0000001	0			
Unknown	22	0010110						

6. DETAILED SEGMENT ANALYSIS PROCEDURES   97

6.5   PREPARATION OF SPECTRAL AIDS

Machine Function (Step M4):
- DFS
- SCATTER

Purpose:
- To tabulate DFS assignments and to generate stratified scatterplots of GRABS versus Brightness.

Inputs:
- Optional nonstandard list of DFS categories.
- List of TPC's and TPC types assigned to each DFS category.

Outputs:
- TPC assignment report, printed
- Stratified scatterplots, printed.

How To Proceed:

1. Ensure that the size of the virtual machine is 4 megabytes or larger. Place the computer in command mode (see section 4.1.1.

2. Enter the command:
DFS

3. Enter the segment name (up to 16 non-blank characters).

4 Carry out Steps 5 and 6 once for each stratum (SUMMER, GRAIN, PASTURE, and NON_VEG), Then go to Step 7.

5. Enter the number of TPC's assigned to the next (first) stratum.

6. Enter the list of TPC entries for this stratum. A TPC entry is a character string composed of the integer TPC value, followed by at most one character that gives the TPC-type. A "pure" TPC is indicated by supplying no "type" character. A TPC that is one bit different from normal is given the "type" character "A". A TPC that is two or more bits different is given "B". For example, a list of TPC entries may be:
                37, 36A, 89A, 42

6. This command (DFS) should now execute.

7. Check for error messages and for mistakes in the TPC assignment report. Place this report into the Analyst packet.

9. Enter the command <u>SCATTER</u>.

10. Enter the segment name (up to 16 non-blank characters)

11. Enter the number of TPC's to be included in scatterplot, or enter '0' for default class. If '0' is entered, go to Step 13.

12. Enter the list of TPC classes to be included in scatterplot.

13. Enter "yes" if default scatterplot options are desired. The default options are line and pixel skip factors of 1 (see Step 14) and symbol assignment method "0" (see Step 15). If this question is answered "yes" go to Step 16.

14. Enter the line and pixel skip factors to be used in scatterplots. (skip factors of 1 and 1 will cause <u>all</u> pixels in the selected TPC classes to be plotted, skip factors of 5 and 5 will cause only 1/25th of the pixels to be used, etc.).

15. Enter the method of symbol assignment as follows:
- 0 - Divides the range of values to be plotted into 10 equal sized bins and assigns "density symbols" to the bins, the first bin getting a blank and each succeeding bin receiving a symbol of increasing darkness.
- 1 - All pixels with a count of 1 get assigned to bin 1, all with counts of 2 go to bin 2, and so on, with all pixels with counts of 10 or more being assigned to bin 10.
- 2 - The bins are assigned such that each bin has an equal number of counts.

16. This command should now execute.

17. Check for error messages. Place the stratified scatter plots into the Analyst packet.

6.6   SPECIFYING BLOB AND SEPARATION ACQUISITIONS

Analyst Team Function (Step A5):
- Blob and separation acquisition selection

Purpose:
- To select acquisitions for clustering.
- To define linear discriminants for Corn/Soybean labeling.
- To provide Stage 1 crop type labels.

Inputs:
- PFC Products 1 and 3
- Stratified scatterplots
- Composite Crop Gtoup Separation Subwindow and candidate Separation Window definitions
- Template with linear discriminant and limitors at scatterplot scale

Outputs:
- List of acquisitions for BLOB
- List of verified separation acquisitions
- Linear discriminant definition for each separation acquisition

Comments:
- A completed Acquisition Summary Sheet, including the final additions required in this section, is shown in Figure 44.

How To Proceed:

1. Verify the presence of Corn/Soybean separability on each acquisition in the candidate Separation Window using the separability criteria in Figure 40. If there are no acquisitions in the window, proceed directly to Step 5.

2. On the Crop Calendar Verification/Adjustment form (SAL, Part III), adjust the boundaries of the separation window to exclude acquisitions that do not meet the criteria in Figure 40 (see Figure 41). If no acquisitions remain in the window after this Step, proceed directly to step 5.

3. Record verified separation acquisitions on the Acquisition Summary Sheet (SAL, Part II) by checking the "Separation Acquisition" column opposite the appropriate dates.

4. Define the linear discriminant and limitors on each acquisition (up to four) in the verified Separation Window as follows:

(a) Draw a line on the scatterplot down the approximate center of the green arm.

(b) Place the template under the scatterplot and position it so that the linear discriminant and limitors are perpendicular to the line.

(c) Using the guidelines in Figure 42, slide the template along the line until the optimum boundary between the probable corn and soybean distributions is defined by the linear discriminant.

(d) Trace the linear discriminant and limitors on the scatterplot.

(e) On the Acquisition Summary Sheet, record the GRABS and Brightness coordinates of two distinct points on the linear discriminant (use the form "Brightness1, GRABS1, Brightness2, GRABS2"). Select points that are far apart in order to minimize the impact of possible recording errors.

5. Select acquisitions for BLOB according to the guidelines in Figure 43.

6. Record BLOB acquisitions on the Acquisition Summary Sheet by checking the "BLOB Acquisition" column opposite the appropriate dates. Circle the check mark if the acquisition is a pre-emergent acquisition for summer crops.

FIGURE 40.
Criteria For Verifying Corn/Soybean Separation

1. The majority of the points on the GRABS vs. Brightness scatterplot fall along a well-defined green arm.

2. At least two distributions are detectable along the green arm, the lowermost of which is the probable corn distribution and the uppermost is the probable soybean distribution.

3. A combination of bright pink, red or orange (probable soybeans) and dull brick red or orange (probable corn) signatures is detectable on the PFC Product 1.

FIGURE 41.
Crop Calendar Form Showing Adjusted Separation Window

```
                        FIGURE 42.
          Guidelines for Placing The Linear Discriminant


       1.  If  the  data are spread continuously along the green arm
  with only a single break or constriction, place  the  discriminant
  through that constriction.


       2.  If distributions are fairly well defined at either end of
  the  green  arm and a single scatter of points appears in between,
  place the discriminant and limitors so that the scatter  is  split
  between probable corn and probable soybeans.


       3.  If  two  or  more  distributions are detected between the
  definite corn  (lowermost)  and  definite  soybeans  (uppermost)
  distributions,  place  the  discriminant and limitors to split the
  distribution that  lies  directly  above  the  corn  distribution.
  Soybeans  have  a  less  compact distribution than corn, extending
  farther up and down the green arm.


       4.  If  several  possibilities  exist  for  placing  the
  discriminant,  be  conservative.   That is, place it closer to the
  corn end of the green arm than the soybean end since soybeans  are
  more likely to appear in the corn distribution than vice versa.


       5. Do not, however, allow  the  limitors to intersect the
  dense interiors of the definite corn and soybean distributions.
```

```
┌─────────────────────────────────────────────────────────────────┐
│                        FIGURE 43.                                 │
│            Blob Acquisition Selection Guidelines                  │
│                                                                   │
│     1.  Acquisitions to be used for BLOB must meet the following  │
│  data quality criteria:                                           │
│     (a)  Acquisitions  must  have  good  field definition. Heavily│
│          vegetated acquisitions must have good segment-wide field │
│          definition.  Summer crop pre-emergence and  post-harvest │
│          acquisitions  must  have  good  field  definition in the │
│          vegetated areas and relatively homogeneous signitures in │
│          the bare soil areas relative  to  the  fields  that  are │
│          vegetated on those acquisitions.                         │
│     (b)  Avoid  cloud-covered  and  hazy  acquisitions.  Several  │
│          popcorn clouds are  acceptable  if  the  acquisition  is │
│          important and meets other quality control criteria.      │
│     (c)  Use  acquisitions  that are registered to within one pixel│
│          of one another whenever possible.  Do not select  a  set │
│          of   acquisitions   in   which   the   total   range  of │
│          misregistration   exceeds   two   pixels   unless    the │
│          acquisitions   are   essential   and   no   reasonable   │
│          alternatives exist.                                      │
│                                                                   │
│     2.  The minimum data set needed for  processing  consists  of │
│  one acquisition with good segment-wide field definition.         │
│                                                                   │
│     3.  A maximum of four acquisitions may be selected.  However, │
│  do  not  select more than one acquisiticn that falls in the summer│
│  crop pre-emergence or post-harvest time frames.                  │
│                                                                   │
│     4.  The optimum data set for BLOB consists of  at  least  one │
│  verified  Corn/Soybean  separation acquisition and one acquisition│
│  from either the summer crop pre- to  early  emergence  period  (SC│
│  Biowindow  1  and  early 2) or maturity to post-harvest period (SC│
│  Biowindow 5 or late 4).                                          │
│                                                                   │
└─────────────────────────────────────────────────────────────────┘
```

```
                    FIGURE 43.   (continued)
              Blob Acquisition Selection Guidelines


     5.  If possible, select one acquisition from each of the
following categories:
     (a)  The acquisition with the best Corn/Soybean separability
          (i.e., the distributions at the extreme upper and lower
          ends of the green arm are the most clearly defined with
          the fewest points of scatter in between).  If a
          separation acquisition of sufficient quality is not
          available, choose an acquisition from Composite Crop
          Group Separaion Subwindow E, D3, D2, D1, C3, or F1 (in
          that order).
     (b)  An acquisition on which summer crops are not spectrally
          emerged or are just barely emerged but other crop groups
          are emerged.  The B composite subwindows provide the
          best candidates.  If no acquisitions are available in
          those subwindows, use early C1 or late A3 if the desired
          vegetated/non-vegetated condition is represented.  If
          nothing else is available, use an earlier A, G, F2, or
          later C acquisition to satisfy this requirement.
     (c)  An additional separation acquisition.  Choose this
          acquisition to represent the range of crop development
          within the verified Separation Window.  For example, if
          the acquisition selected in (a) came from the middle of
          the Separation Window, a second acquisition should be
          selected from later in the window to catch late-
          developing soybeans.  If a second separation acquisition
          of sufficient quality is not available, choose the
          acquisition that will make the greatest contribution to
          field definition of those remaining in Summer Crop
          Biowindows 2, 3, and 4.


     6.  A fourth acquisition may be selected at the discretion of
the analyst team to cover a special situation that has been
observed in the segment.  For example, an extra acquisition might
be chosen from late in Summer Crop Biowindow 2 if differential
green-up between probable corn and probable soybeans is detected.
Do not choose a fourth acquisition unless it will provide
information to enhance blob purity.
```

FIGURE 44.
Completed Acquisition Summary Sheet

6.7 CLUSTERING

Machine Function (Step M6):
- **CLUSTER**

Purpose:
- To spatially and spectrally stratify the pixel data into field-like units (BLOB algorithm) and into spectral classes (BCLUSTER algorithm).

Inputs:
- Segment name
- List of acqusitions for BLOB (but note that BLOB statistics will be computed for all acquisitions).

Outputs:
- (BLOB and BCLUSTER descriptions stored into data base.)

How To Proceed:

1. Ensure that the memory size of the virtual machine is at least 2 megabytes. Place the computer into command mode (see section 4.1.1).

2. Enter the command:
CLUSTER

3. Enter the segment name (up to 16 non-blank characters).

4. Enter the number of acquisitions used for clustering (integer between 1 and 4).

5. Enter the list of acquisitions used for clustering (integer of the form yyddd).

6. Enter the date (yyddd) of the latest pre-emergent (summer crop) acquisition, or enter a '0' if there are no pre-emergent acquisitions.

7. Enter the desired number of clusters (integer between 1 and 100).

8. This command should now execute.

8. Place the BLOB and BCLUSTER reports in the Analyst packet.

6.8 SAMPLING AND GENERATION OF LABELING AIDS

Machine Function (Step M6 Continued):
- **SAMPLE**

Purpose:
- To select a subset of the BLOBS for labeling, and
- Generate labeling aids for the Analyst.

Inputs:
- Segment name
- Target number of blobs in the resulting sample
- List of Corn/Soybean separation dates
- List of lines that separate Corn/Soybean distributions for separation dates
- Identification of tape and file to receive data for PFC product that highlights selected blobs
- Seed for random number generator.

Outputs:
- Printed report giving the selected blobs in descending order of size, by DFS.
- Printed Analyst aid report giving information about each selected blob, for use in labeling, including:
  - (a) Separator between blob prints
  - (b) Blob statistics
  - (c) GRABS vs. Time plot
  - (d) GRABS vs. Brightness plot
  - (e) Greymap showing shape and TPC patterns in blobs.
- Printed label recording form (SAL Part V) with blob numbers and Stage 1 labels.

How To Proceed:

1. Ensure a tape is available that can receive output for transmission to the PFC.

2. Place the computer in command mode (see section 4.1.1).

3. Enter the command:
SAMPLE

4. Enter the segment name (up to 16 non-blank characters).

5. Enter the desired (target) number of sample blobs to select

(integer, between 10 and 100).

6. Enter the number of separation acquisitions
(integer, between 0 and 3). If 0, proceed with Step 9.

7. Enter the list of separation acquisitions
(integer, of form yyddd).

8. Enter the coordinates of two distinct points on the decision
line for each separation acquisition. Each quartet of numbers is
ordered (BRIGHTNESS1, GRABS1, BRIGHTNESS2, GRABS2), and should define
a line roughly perpendicular to to the "green arm".
(4 real numbers for each separation acquisition).

9. Enter the tape identification of a tape that is to receive a
PFC image
(up to 24 non-blank characters).

10. Enter the file number on this tape that is to receive the
PFC image
(integer greater than 0).

11. Enter the random number seed or 0 to invoke the default
seed. For statistical reasons, this should be a positive odd 6-digit
integer. If 0 is entered, the system will generate a number based on
the time of day.

12. This step should now execute.

13. Upon successful completion, place the report of selected
blobs in the Analyst packet.

14. Also upon successful completion, have a standard PFC Product
1 film product produced for the output file. It is permissible to use
one tape to receive the PFC images from several segments before
transporting to the PFC.

15. When the PFC products are ready, place them in the Analyst
Packet, and make the tape available for reuse.

6.9 LABELING

Analyst Function (Step A7):
- Labeling

Purpose:
- To verify or correct, using data from all machine-processed acquisitions, the Stage 1 crop group and crop type labels for each selected blob.

Inputs:
- PFC Products 1 and 3
- PFC overlay showing selected blobs
- Printed report listing selected blobs in descending order of interior size, by DFS stratum
- Printed Analyst aid report for each selected blob containing the following information:
    - (a) Greymap of blob showing shape, location and TPC's in interior
    - (b) GRABS vs. Brightness trajectory plot
    - (c) GRABS vs. Time plot
    - (d) Blob statistics, including the zone (A, B, C, or D) into which the blob mean falls on each separation acquisition
- Verified Summer Crop Spectral Biowindow definitions
- Printed label recording form (SAL, Part V), listing selected blobs and associated Stage 1 labels.
- GRABS vs. Time plot overlay, with GRABS = 6 decision threshold

Outputs:
- Stage 2 labels and confidence codes for selected blobs
- Additional Analyst documentation

Comments:
- This step is an individual Analyst function
- Selected blobs are to be examined in descending order of interior size within each DFS stratum, beginning with Summer Crops
- Any blob that does not follow a readily identifiable ("definite") pattern may be reserved to be labeled after all definite blobs have been identified.
- One or more of the following labels will be associated with each blob: SC (Summer Crops), C (Corn), S (Soybeans), and O (other).
- Stage 1 labels are derived from crop group stratification

(Section 6.4) and placement of the linear discriminant (Section 6.6). Stage 2 labels result from application of the decision logic in this section.

- Mixed blobs will be assigned more than one Stage 2 label. In order to be counted as part of the mixture, a category must represent at least _one_ _third_ of the blob interior. At most, three labels may be assigned to any given blob.
- A sample Label Recording Form is shown in Figure 49.

How To Proceed:

1. On the GRABS vs. Time plot overlay, draw in and label the boundaries of the five verified Summer Crop Spectral Biowindows.

2. Verify or correct the Stage 1 label of each sample blob according to the procedure below. Examine blobs in the order in which they appear on the Label Recording Form. Unless otherwise indicated, label the area defined by the blob interior on BLOBed acquisitions.

(a) Place the Summer Crop Biowindow overlay on the BRABS vs. Time plot and execute the crop group decision logic in Figure 45.

(b) If the outcome of Figure 45 is "Summer Crop" or "Summer Crop, Other" and at .least one separation acquisition is available, execute the crop type decision logic in Figure 46. If the outcome is "Other" or no separation acquisition is available, do not process further.

(c) Blobs that are difficult to analyze may be reserved to be labeled after all definite blobs have been identified. This should always be done if comparative labeling is required (questions 20, 22, 29, 31, 34, 36, 39, and 41) and a sufficient number of definite blobs has not yet been identified.

(d) If the decision logic results in crop group and/or crop type labels that are different from the printed Stage 1 labels, enter the corrections in the "Stage 2 Labels" columns on the recording form; otherwise leave these columns blank. Multiple labels must be entered for mixed blobs. Use two labels to indicate an approximate 50/50 mixture (e.g., C/S). Use three labels to indicate an approximate 1/3 / 1/3 / 1/3 mixture (e.g., C/S/O) or a 2/3 / 1/3 mixture (e.g., C/C/S).

(e) Circle one of the confidence codes on the recording form, according to the guidelines in Figure 48.

(f) On the Decision Logic Record Sheet (SAL, Part VI), trace each unique path taken through the decision logic.

(g) Enter the blob number on the Decision Logic Record sheet that illustrates the analysis path followed for that blob.

3. Record an overall segment confidence code (guidelines TBD).

FIGURE 45.
Crop Group Decision Logic
(see diagram at end of figure)

1. According to the blob greymap, is the blob interior greater than five pixels in total size and more than a single pixel wide or long? If "yes", go to 4; if "no", go to 2.

2. Use the PFC products and the blob overlay to determine whether the blob interior defines the same field or landscape feature on all acquisitions. Examine the following acquisitions with special care: (a) BLOBbed acquisitions, (b) separation acquisitions, and (c) any acquisition on which the GRABS temporal profile abruptly rises or drops. Is the blob interior properly registered on all acquisitions? If "yes", go to 4; if "no", go to 3.

3. Check the "Misreg." Column on the recording form and circle misregistered acquisitions on the GRABS vs. Time plot. Resume the decision logic at question 4, using GRABS mean values where possible. Substitute other information (as indicated under corresponding questions in Figure 47) from the proper field for GRABS values on the misregistered acquistions. If misregistration between BLOBbed acquisitions makes it difficult to determine which field is being defined by the blob interior, refer to the full blob.

4. Does the blob greymap indicate that either of the following conditions is satisfied?
   (a) All of the pixels in the blob interior belong to non-Summer Crop Temporal Pattern Classes (TPCS's) that are not alternately "A" subclasses of Summer Crops.
   (b) Any Summer Crop or alternate Summer Crop TPC's that appear in the blob interior are associated with pixels that are relatively few in number and are scattered through the blob, particularly along the edge (i.e., they are not concentrated in a group that might define a separate field or feature). If "yes", go to 10; if "no", go to 5.

```
FIGURE 45.  (continued)
Crop Group Decision Logic
```

5. Does the blob greymap indicate that <u>either</u> of the following conditions is satisfied?
   (a) All of the pixels in the blob interior belong to Summer Crop TPC's that are not alternatively "A" subclasses of non-Summer Crop strata.
   (b) Any non-Summer Crop or alternative non-Summer Crop TPC's that appear in the blob interior are associated with pixels that are relatively few in number and are scattered through the blob, particularly along the edge (i.e., they are not concentrated in a group that might define a separate field or feature). If "yes", go to 12; if "no", go to 6.

6. Does the blob greymap indicate that there are any definitely non-Summer Crop TPC's in the blob interior? If "yes", go to 7; if "no", go to 9.

7. Do the pixels belonging to the Summer Crop stratum appear to define a field or landscape feature that is discernably different on the PFC Product 1 from that defined by pixels belonging to non-Summer Crop strata and/or those that might belong to either group? (ignore roads unless the <u>full</u> blob appears to be dominated by the road). If "yes", go to 8; if "no", go to 10.

8. Apply the crop group decision logic in Figure 47 to each component of the potential mixture. Are <u>both</u> of the following conditions satisfied?
   (a) One or more component is identified as a Summer Crop and one or more component is identified as Other.
   (b) The area associated with each category (Summer Crops and Other) occupies roughly a third or more of the blob interior. If "yes", go to 24 (mixed Summer Crop and Other); if "no" and answer to question 6 was "no", go to 12.

FIGURE 45. (continued)
Crop Group Decision Logic

9. Does <u>either</u> of the following situations exist? (ignore roads unless the <u>full</u> blob appears to be dominated by the road).
(a) The pixels that definitely belong to the Summer Crop stratum define a field or landscape feature that is discernably different on the PFC Product 1 from that defined by pixels that might alternatively belong to non-Summer Crop strata.
(b) Two or more fields or landscape features may be observed on the PFC within the area defined by pixels that might alternatively belong to non-Summer Crop strata. If "yes", go to 8; if "no", go to 12.

10. Is the blob vegetated (i.e., does the GRABS mean value exceed 6) on at least one acquisition? If "yes", go to 11; if "no", go to stop (Other).

11. Is the GRABS mean value greater than 6 on all acquisitions? If "yes", stop (Other); if "no", go to 12.

12. Does the GRABS vs. Time profile indicate that there is a single continuous vegetated phase (mean values above 6) that is preceded and/or followed by unvegetated phases (mean values below 6)? If "yes", go to 13; if "no", go to 16.

13. Is the vegetated phase (or main vegetated phase, if the answer to question 12 was "no") represented as a relatively "smooth" curve on the GRABS vs. Time plot? (i.e., the GRABS mean value increases to some maximum and then decreases again; the green canopy profile does not fluctuate sharply up and down). If "yes", go to 14; if "no", go to 21.

14. Are <u>all</u> the following conditions satisified?
(a) If acquisitions fall in Summer Crop Biowindow 1 (SC1), all are unvegetated.
(b) All SC3 acquisitions are vegetated.
(c) If acquisitions fall in SC5, all are unvegetated.
(d) The maximum GRABS mean values coincide with late SC2, SC3 or early SC4 (<u>not</u> early SC2). If "yes", go to 15; if "no", go to 22.

FIGURE 45. (continued)
Crop Group Decision Logic

15. Are the maximum GRABS mean values moderately to very high (i.e., greater than approximately 20)? If "yes", go to 24; if "no", go to 23.

16. Does the GRABS vs. Time profile indicate <u>one dominant</u> vegetated phase that is preceded and/or followed by a minor vegetated phase of substantially lower amplitude and shorter duration? If "yes", go to 13; if "no", go to 17.

17. Use the PFC products and the blob overlay to determine if cloud cover, haze, shadow, data dropout or temporary standing water (or misregistration in larger blobs not previously checked for misregistration) accounts for the drop in the GRABS mean value between vegetated phases. Would the GRABS vs. Time profile indicate a single continuous vegetated phase if it weren't for these phenomena? If "yes", go to 18; if "no", go to 19.

18. Check the appropriate column on the recording form ("Misreg." For misregistered acquisitions and/or "Missing Data" for temporary water, cloud, shadow, etc.) and cicle the problem acquisitions on the GRABS vs. Time plot. Resume the decision logic at question 13 if the last question answered was 17 or at question 14 if the last question answered was 21. Exclude acquisitions with missing data, and substitute other information (as indicated under corresponding questions in Figure 47) from the proper field for GRABS values on misregistered acquisitions. If misregistration between BLOBbed acquisitions makes it difficult to determine which field is being defined by the blob interior, refer to the <u>full</u> blob.

19. Does the GRABS mean value drop below or to within a few counts of 6 at any time during SC1 or SC2? If "yes", go to 20; if "no", stop (Other).

FIGURE 45. (continued)
Crop Group Decision Logic

20. Carefully analyze this indefinite blob. Check for possible correlation between dates of expected alfalfa cuttings and dips in the GRABS vs. Time profile. Compare the blob's GRABS vs. Time profile, GRABS vs. Brightness trajectory and imagery appearance to a representative sample of blobs definitely identified as Summer Crop and Other. Does the blob appear to be a Summer Crop on acquisitions following the dip in SC1 or SC2? If "yes", go to 24 (Summer Crop); if "no", stop (Other).

21. Use the PFC products and the blob overlay the determine if cloud cover, haze, shadow, data dropout or temporary standing water (or misregistration in larger blobs not previously checked for misregistration) accounts for the fluctuation of the GRABS mean value within the vegetated phase (or main vegetated phase). Would the GRABS vs. Time profile represent a "smooth" crop curve if it weren't for these phenomena? If "yes", go to 18; if "no", go to 19.

22. Does the GRABS vs. Time profile represent one of the following variant summer crop patterns?
  (a) The GRABS mean value is above 6 on acquisitions early in SC1 but falls below 6 on at least one acquisition later in SC1 or early in SC2; conditions (b), (c), and (d) in question 14 are all met.
  (b) The GRABS mean value is above 6 on acquisitions late in SC5 but falls below 6 on at least one acquisition earlier in SC5 or late in SC4; conditions (a), (b), and (d) in question 14 are all met.
  (c) The GRABS mean value is slightly (no more than 5 counts) above 6 on an acquisition very late in SC1 but is below 6 on acquisitions earlier in the window; conditions (b), (c), and (d) in question 14 are all met.
  (d) The GRABS mean value is slightly above 6 on an acquistion very early in SC5 but falls below 6 on later acquisitions in the window. Conditions (a), (b), and (d) in question 14 are all met. If "yes", go to 15; if "no", stop (Other).

Analyst step: LABELING 6.9

FIGURE 45. (continued)
Crop Group Decision Logic

23. Compare the overall shape of the GRABS vs. Time profile and GRABS vs. Brightness trajectory and the appearance of the blob on the PFC Product 1 to a representative sample of blobs definitely identified as Summer Crop and Other. Based on this comparison, does the blob still appear to be a Summer Crop rather than Other (particularly pasture or hay)? If "yes", go to 24 (Summer Crop); if "no", stop (Other).

24. Is at least one separation acquisition available? If "yes", go to 25; if "no", stop.

FIGURE 45. (continued)
Crop Group Decision Logic

Analyst step: LABELING 6.9
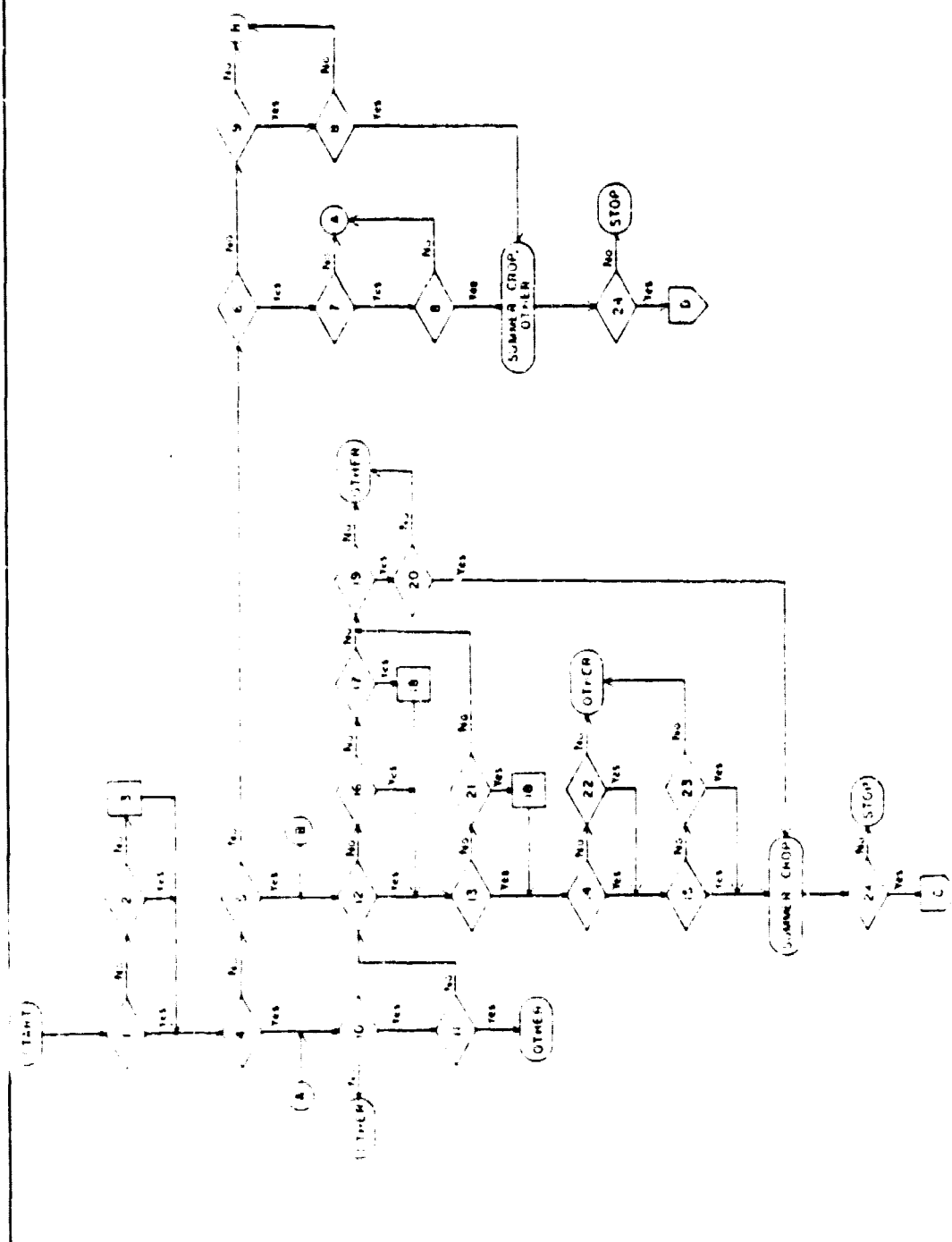
```
FIGURE 46.
Crop Type Decision Logic
(see diagram at end of figure)
```

25. Does the PFC Product 1 of each <u>separation</u> acquisition indicate that the blob interior is homogeneous, i.e., that it is occupied by a single crop type? (ignore roads unless the <u>full</u> blob appears to be dominated by the road). If "yes", go to 26; if "no", go to 35.

26. Is the area defined by the blob interior properly registered on at least one separation acquisition? (assume proper registration unless earlier examination of the blob interior indicated otherwise). If "yes", go to 27; if "no", go to 41.

27. Does the blob mean fall in zone D (relative to the linear discriminant and limitors) on any properly registered separation acquisition? If "yes", stop (Soybeans); if "no", go to 28.

28. Does the blob mean fall in zone C on any properly registered separation acquisition? If "yes", go to 29; if "no", go to 30.

29. Compare the labeling target (blob interior or mixture component) to a representative sample of blobs definitely identified as Corn and Soybeans. If the labeling target is the entire blob interior, compare GRABS vs. Time profiles, GRABS vs. Brightness trajectories, and PFC Product 1 signatures; should the numeric data and the image appearance seem to conflict, use numeric data only (particularly the GRABS profiles). If the labeling target is a mixture component, use the image appearance only. Does the labeling target more closely resemble definite Corn than definite Soybeans? If "yes", Corn; if "no", Soybeans. Stop.

30. Does the blob mean fall in zone B on any properly registered separation acquisition? If "yes", go to 31; if "no", go to 32.

FIGURE 46. (continued)
Crop Type Decision Logic

31. Compare the labeling target (blob interior or mixture component) to a representative sample of blobs definitely identified as Corn and Soybeans. If the labeling target is the entire blob interior, compare GRABS vs. Time profiles, GRABS vs. Brightness trajectories, and PFC Product 1 signatures; should the numeric data and the image appearance seem to conflict, use numeric data only (particularly the GRABS profiles). If the labeling target is a mixture component, use the image apearance only. Does the labeling target more closely resemble definite Soybeans than definite Corn? If "yes", Soybeans; if "no", Corn. Stop.

32. Do the maximum GRABS mean values first occur late in SC3 or early in SC4 (i.e., does the blob peak relatively late)? If an approximate peak cannot be inferred with confidence, answer "no". If "yes", go to 31; if "no", go to 33.

33. Is the area defined by the blob interior misregistered on any separation acquisition? (assume proper registration unless earlier examination of the blob interior indicated otherwise). If "yes", go to 34; if "no", stop (Corn).

34. On each misregistered separation acquisition, compare the PFC Product 1 appearance of the labeling target (blob interior or mixture component) to a representative sample of blobs definitely identified as Corn and Soybeans. Does the target more closely resemble definite Soybeans than definite Corn on any misregistered separation acquisition? If "yes", Soybeans; if "no", Corn. Stop.

35. Is the PFC Product 1 appearance of the blob interior a combination of bright and dull green-canopy signatures (i.e., does the potential mixture appear to be restricted to the Summer Crop group)? If the decision logic in Figure 47 has already been applied to this blob, answer "yes" without further examination. If "yes", go to 36; if "no", go to 37.

FIGURE 46. (continued)
Crop Type Decision Logic

36. Compare the PFC Product 1 appearance of each Summer Crop component of the potential mixture to a representative sample of blobs definitely identified as Corn and Soybeans. Are both of the following conditions satisfied?
    (a) One or more component resembles definite corn, and one or mor component resembles definite Soybeans.
    (b) The area associated with each crop occupies roughly a third or more of the blob interior. If "yes", stop (mixed Corn and Soybeans); if "no", go to 26.

37. Apply the crop group decision logic in Figure 47 to each component of the potential mixture. Are both of the following conditions satisfied?
    (a) One or more component is identified as a Summer Crop, and one or more component is identified as Other.
    (b) The area associated with each category (Summery Crops and Other) occupies roughly a third or more of the blob interior. If "yes", go to 38 (mixed Summer Crop ad Other); if "no", go to 36.

38. Based on previous analysis of this mixed blob, are both of the following conditions satisfied?
    (a) There is more than one Summer Crop component.
    (b) Each Summer Crop component occupies roughly a third of the blob interior. If "yes", go to 39; if "no", go to 40.

39. Compare the PFC Product 1 appearance of each Summer Crop component to a representative sample of blobs definitely identified as Corn and Soybeans. Does one component resemble definite Corn and the other resemble definite Soybeans? If "yes", stop (mixed Corn, Soybeans, Other); if "no", go to 40.

FIGURE 46. (continued)
Crop Type Decision Logic

40. To identify the Summer Crop (or dominant Summer Crop) component, execute the remaining decision logic beginning with question 26. Use the blob mean as representative of the Summer Crop component unless otherwise instructed. Is the outcome Soybeans? If "yes", mixed Soybeans and Other; if "no", mixed Corn and Other. Stop.

41. On each separation acquisition, compare the PFC Product 1 appearance of the labeling target (blob interior or mixture component) to a representative sample of blobs definitely identified as Corn and Soybeans. Does the target more closely resemble definite Soybeans than definite Corn on at least one separation acquisition? If "yes", Soybeans; if "no", Corn. Stop.

FIGURE 46. (continued)
Crop Type Decision Logic
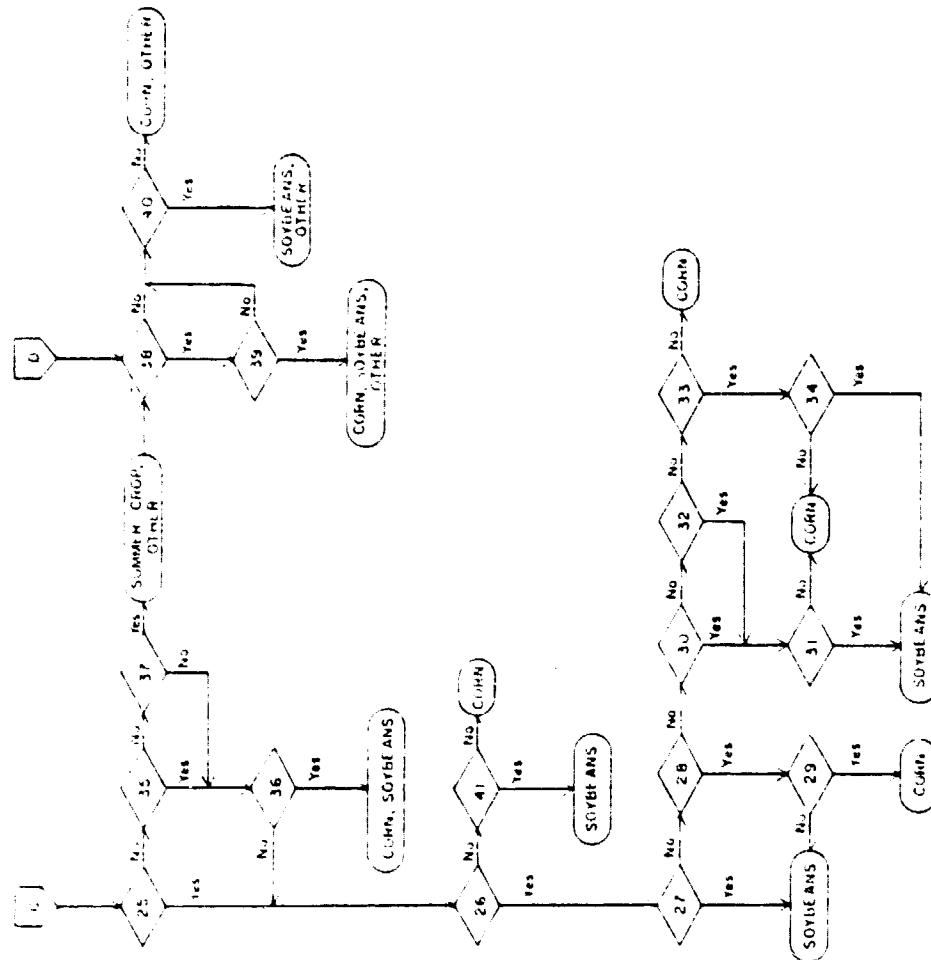
FIGURE 47.
Crop Decision Logic For Mixed And Misregistered Blobs
(see diagram at end of figure)

10. Does the labeling target appear to be vegetated on the PFC Product 1 on at least one acquisition (i.e., is it some shade of red ranging from maroon and brownish-red through bright pink, red and orange)? If the Product 1 signature is insufficient to distinguish between bare soil and early emergence, check the appropriate bit in the TPC binary string (is it a 1?) or the PFC Product 3 (is the target some shade of red?). If "yes", go to 11; if "no" stop (Other).

11. Does the labeling target appear to be vegetated on all acquisitions? If "yes", stop (Other); if "no", go to 12.

12. Do the PFC Product 1's from all available acquisitions indicate a single continuous vegetated phase (shades of red) that is preceded and/or followed by unvegetated phases (shades other than red, e.g., blue-green, black or gray bare soil signatures and white or yellowish-white stubble signatures)? If "yes", go to 13; if "no", go to 16.

13. Does the vegetated phase appear to follow a crop development pattern (i.e., does the amount of red on the PFC Product 1 increase steadily to some maximum and then pass through maroon, blood red, green, gold or yellow signatures that indicate approaching maturity)? If "yes", go to 14; if "no", go to 21.

14. Does the PFC Product 1 indicate that all of the following conditions are satisfied?
   (a)   All Summer Crop Biowindow 1 (SC1) acquisitions are unvegetated (see Question 12).
   (b)   All SC3 acquisitions are vegetated (see Question 10).
   (c)   All SC5 acquisitions are unvegetated.
   (d)   The labeling target is NOT bright red in acquisitions in early SC2.
If "yes", stop (Summer Crop); if "no", go to 22.

---

16. Does there appear to be a single dominant vegetated phase that is preceded and/or followed by a minor vegetated phase of shorter duration and sparser canopy/lower vigor (i.e., does there appear to be volunteer vegetation in the field that is plowed down before planting or emerges after the field is harvested)? If "yes", go to 13; if "no", go to 17.

17. Does cloud cover, haze, shadow, data dropout or temporary standing water account for the absence of a single continuous sequence of PFC Product 1 vegetation signatures over available acquisitions (i.e., would the imagery indicate a single continuous vegetated phase if it weren't for these phenomena)? If "yes" go to 18; if "no", go to 19.

18. Check the "Missing Data" column on the recording form. Resume the decision logic at question 13 if the last question answered was 17 or at 14 if the last question answered was 21.

19. Does the PFC Product 1 indicate bare soil (see Question 12) or very early emergence (e.g., dark purple, light pink, light red) on any acquisition in SC1 or SC2? If "yes", go to 20; if "no" stop (Other).

20. Carefully analyze this indefinite mixture component. Check for possible correlation between dates of expected alfalfa cuttings and dips in the GRABS vs. Time profile. Compare the image appearance to a representative sample of blobs that have been definitely identified as Summer Crops and Other. Does the component appear to be a Summer Crop on acquisitions following the bare soil/early emergence acquisition(s) in SC1 or SC2? If "yes", Summer Crop; if "no", Other. Stop.

21. Does cloud cover, haze, shadow or temporary standing water account for the absence of a clear crop development pattern over available acquisitions? If "yes", go to 18; if "no", go to 19.

```
FIGURE 47.   (continued)
Crop Decision Logic For Mixed And Misregistered Blobs
```

22. Do the PFC Product 1's from all available acquisitions
indicate the presence of one of the following variant summer crop
patterns?

(a) Bare soil acquisitions in SC1 or SC2 are preceded by
     acquisitions showing some red in the field; conditions
     b) and c) in Question 14 are met (volunteer vegetation
     in the field prior to field preparation).

(b) Some red appears in the field late in SC5 but it appears
     to be harvested on a previous SC4 or SC5 acquisitions;
     conditions a) and b) in Question 14 are met (volunteer
     regrowth in the field).

(c) The field has a very slight amount of red in it on an
     acquisition very late in SC1; conditions b) and c) in
     Question 14 are met (early-emerging summer crop or an
     error in the SC1 window definition).

(d) The blob is still red early in SC5 but appears to be
     harvested later; conditions a) and b) in Question 14 are
     met (late- harvested summer crop or an error in the SC5
     window definitin).

(e) Emergence is not detectable early in SC3 but acquisitions
     later in SC3 are a shade of red; conditions a) and c) in
     Question 14 are met (probably late-planted soybeans).

(f) The field has a turning signature (green, gold, yellow)
     late in SC3 but is some shade of red on an acquisition
     after the close of WSG or SSG 4 (whichever is later);
     conditions a) and c) in Question 14 are met (probably
     early-maturing corn).   If "yes", Summer Crop; if "no",
     Other. Stop.

FIGURE 47. (continued)
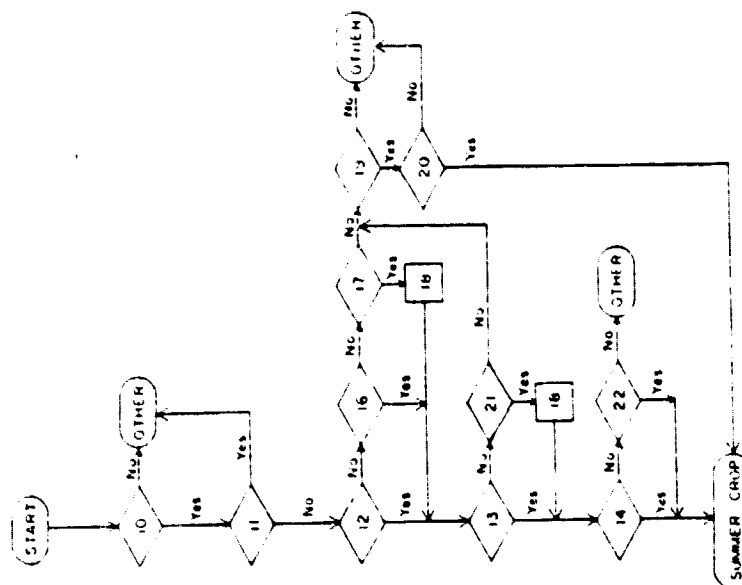Crop Decision Logic For Mixed And Misregistered Blobs

```
┌─────────────────────────────────────────────────────────────┐
│                         FIGURE 48.                          │
│                 Confidence Code Definitions                 │
│                                                             │
│                                                             │
│    5.   I have high confidence that this label is correct.  │
│                                                             │
│    4.   This label seems correct,  but  I  have  some       │
│         significant uncertainty.                            │
│                                                             │
│    3.   I  have no opinion as to the accuracy of this       │
│         label (other labels appear equally probable).       │
│                                                             │
│    2.   This label seems incorrect, but I  have  some       │
│         significant uncertainty.                            │
│                                                             │
│    1.   I  have  high confidence that this label is         │
│         incorrect, but the procedure requires it.           │
│                                                             │
└─────────────────────────────────────────────────────────────┘
```

FIGURE 49.
Label Recording Form

6.10   LABEL ENTRY AND ESTIMATION

Machine Function (Step M8):
- ESTIMATE

Purpose:
- To produce a segment-wide estimate of the acreages of corn, soybean, and other.

Inputs:
- Segment name
- Level of estimation possible (e.g., is there sufficient information to make complete estimates)
- Labels for all blobs selected for labeling (by machine step SAMPLE), and their associated confidence values.

Outputs:
- A printed report giving the segment crop acreage estimates.

Comments:
- This is the last step of the procedure.

How To Proceed:

1. Place the computer in command mode (see section 4.1.1).

2. Enter the command:
ESTIMATE.

3. Enter the segment name (up to 16 non-blank characters).

4. Enter the level of estimation: 0 if there is insufficient information to produce meaningful estimates; 1 if there is only sufficient information to estimate summer crop acreage; 2 if there is sufficient information to estimate corn and soybean acreage.

5. If the level entered is zero, skip to Step 7.

6. Enter the labels for all selected blobs, in the order listed in the printed report produced by machine command SAMPLE. The labels may be entered on separate lines, and/or separated by commas. Each label consists of up to 20 characters containing the blob number, a space, the one-character crop types, a space, and a confidence factor. The blob number is optional, and if present is used to ensure correct

correspondence of labels to blobs. The crop type characters allowed
depend on the level as follows:

LEVEL	CHARACTER	CROP
0	none	(no labeling is to be done)
1	S	Summer crop
	0	Other than summer crop
2	C	Corn
	S	Soybeans
	0	Other, not corn or soybeans

The confidence factor is a digit between 1 and 5 indicating how
confident the Analyst is regarding the label (1 = not confident, 5 =
very confident).

For example, a input line might be:
    123 C 4, 47 0 1
meaning that blob 123 is labeled "Corn" with a fairly high confidence,
and blob 47 is labeled "Other" with a very low confidence.

The Analyst may enter pure labels as above, or mixed labels as
follows. Equal mixtures of crops are denoted by supplying all crop
code characters together. For example if the Analyst is confident
that blob 88 is roughly a 50%-50% mixture of corn and soybeans, the
following entry should be made:

    88 CS 5

Mixtures other than equal-proportional cannot be denoted.

When labels are entered interactively on a terminal, the user
will be prompted for labels in groups of 10. This enables the user to
enter and confirm entries in groups before the information leaves the
area of immediate view.

In batch mode, labels must also be supplied in groups of ten.
However, the use of interactive mode is suggested due to the error
recovery available.

7. The command should now execute. Place the printed proportion
estimation report into the Analyst packet.

7
EXTERNAL SYSTEMS

In this section the manner in which the classification system interfaces with other program elements is further discussed. The elements with which an interface exists are presented in Figure 50. A brief discussion for each element follows.

7.1 DATA PREPARATION

This program element is responsible for collection of segment-specific non-electronic data required by the procedure into a prepared packet, for collecting non-segment-specific data into an Analyst reference library, and for providing raw Landsat acquisition tape information. The information to be provided is discussed in Section 6.1 and Appendix E.

7.2 CROP CALENDAR AND WEATHER

This project element is responsible for providing crop calendar information required by the procedure. This information is to be included in the packet, as described in Appendix E.

7.3 EXPERIMENT DESIGN

This project element has the responsibility to formulate the questions that the pilot experiment is to answer, and to allocate samples (segments) and treatments (e.g., parameters, Analysts) to optimally address the questions within resource constraints.

FIGURE 50.
Interfaces To U.S. Corn/Soybean Classification System

Program Element	Inputs to System	Outputs from System
Preparation	Packet contents, Landsat imagery	
Crop and Weather	Crop calendar information	
Experiment Design	Specification of: goals, segments to process, parameter settings	
Operations Management	Control	Status queries
Quality Assurance	Error detection and control	Access to database, Printed QA reports
Sampling and Aggregation		Access to database, (final segment proportion estimate)
Accuracy Assessment		Access to database, Printed reports

7.4   OPERATIONS MANAGEMENT

This project element supervises the day-to-day running of the pilot experiment, and as such is an integral part of it. As discussed in Section 3.3, the manager has access to electronically stored status information. Furthermore, management can arrange to have minor modifications made that affect tradeoffs in resource use, as discussed in Section 3.4. Section 3 also presents a number of other topics of interest to management.

The procedure does not provide an electronic means of recording the status of segments within an Analyst step, status of Analyst assignments, packet locations, or intermediate PFC product production. It is anticipated that manual procedures will be developed by management to handle these items.

7.5   QUALITY ASSURANCE

This project element provides the vital function of verifying the qualiity and accuracy of execution of the pilot procedure. A quality assurance engineer will be able to access a wide variety of information handled by the system. This includes all information in the data base, all information in the packet and in SAL, the status and tracking log, all information that the command ASK (see Section 3.3) can produce, and the standard quality assurance reports produced routinely by the system.

It is the responsibility of this project element to develop the quality assurance procedures, independently from operations and from implementation. It is felt that this independence is important to verify quality independent of pressures from schedules and pride.

Examples of possible quality assurance efforts include:

- Cross checking of labels indicated in the Analyst packets (in SAL) versus those input into the machine.
- Verifying that the printed SCREEN report does not show too much cloudiness (bad acquisition selection?).
- Noting that TPC acquisitions were entered in chronological order.
- Identifying cases of too many blobs formed (bad acquisitions?).
- Scanning the status log error messages (were there warning messages that should not have been ignored?). (Are error messages of a certain kind abnormally prevalent so that some general corrective action is needed?)
- Looking for unusual patterns in the output reports.
- Are all required entries in SAL being made?

7.6   SAMPLING AND AGGREGATION

This project element is the recipient of the segment crop proportion estimates which are the final products of the classification system. These estimates are analyzed statistically and are aggregated to larger political/geographical units.

The data is to be accessed from the data base according to the method outlined in Appendix I. The principle data of interest are the CHARLIE entities:

"ESTIMATE_LITTLE_BLOBS_WEIGHTED" -- the final proportions.

"NO_OF_CROP_TYPES" -- the number of crop types (2 or 3).

"LIST_OF_CROP_TYPES" -- crop types: corn/soybean/other or
            summer-crop/other

7.7   ACCURACY ASSESSMENT

This project element represents a principle source of learning required to advance the remote sensing technology for future experiments, and as such is vital to the success of the overall program. For this reason, the classification procedure was designed to fully support accuracy assessment. It is the function of accuracy assessment to technically examine the procedure, and the individual components of the procedure, in order to understand sources of error and the propagation of this error through the system.

Principally for this reason, most intermediate data within the system is retained in the database for subsequent analysis. Mechanisms for obtaining this data from the data base are provided, and these are discussed in Appendix I.

APPENDIX A
DEFINITIONS

This section consists of a list of terms used in this manual whose meaning may not be understood from context.

- Accuracy Assessment . . . .   see section 7.7
- aid . . . .   product generated to assist analyst
- Analyst packet. . . . . . .   packet of materials used by analyst
- batch, batch mode . . . . .   mode of computer processing where user is not interacting with the system
- bcluster. . . . .   procedure which groups blobs which are spectrally similar
- big blob. . . . .   blob with at least 1 interior pixel
- blob. . . . .   group of spatially contiguous and spectrally similar pixels forming a field-like shape
- CHARLIE . . . .   Collateral Holding And Retrieval Library for Information Extraction
- classification. . . . . . .   the process of assigning labels to pixels in a segment
- controlled tape or disk . .   a tape or disk which is logged in to the baseline procedure software system
- crop group stratification .   the stratification of pixels or blobs into crop groups
- DFS . . . .   Delta Function Stratification or crop group stratification
- EODLS . . . .   Earth Observation Division Laboratory System
- GRABS . . . .   GReenness Above Bare Soil
- IBM 3031. . . . .   computer of the IBM 370 family
- image access key. . . . . .   16 character name assigned to each image
- interactive mode. . . . . .   mode where user responds to system prompts
- LARS. . . . .   Laboratory for Applications of Remote Sensing
- little blob . . . .   blob with no interior pixels
- machine . . . .   computer on which software system executes
- megabyte. . . . .   1,048,576 bytes
- Midzuno sampling . . . . .   unbiased sampling technique
- multitemporal . . . .   more than 1 date
- packet. . . . .   analyst packet
- PFC . . . .   Production Film Converter

- Products 1 and 3. . . . . . .   PFC products emphasizing field definition and crop development, respectively
- report. . . . .   printed or printable computer generated product
- segment . . . .   portion of full Landsat frame (5 by 6 nautical miles in LACIE)
- Segment Analysis Log. . . .   non-electronic log for recording progression of segment analysis
- status log. . . . .   electronic log maintaining computer processing status
- Tasselled Cap . . . .   transformation performed on LANDSAT data to reduce dimensionality
- TPC . . . .   Temporal Pattern Class
- unsupervised clustering . .   clustering without regard to any strata to which the blobs may have been assigned

APPENDIX B
SUMMARY OF COMMANDS

      This section provides a concise summary of the commands that may be executed by the machine. Figure 51 gives a list of commands with a brief indication of function. Following this is Figure 52 which

```
                            FIGURE 51.
                     Available Machine Commands
    COMMAND              PURPOSE


    standard processing functions:

    DATAPREP        Merge and window the raw Landsat acquisitions
    PREPROCESS      External effects correction and feature extraction
    DFS             Assimilate analyst-supplied crop group strata
    SCATTER         Form  spectral   distribution   displays  for  each
                    acquisition
    CLUSTER         Form blobs and form spectral clusters
    SAMPLE          Statistically sample and produce labeling aids
    ESTIMATE        Combine analyst labels to  form  a  crop  proportion
                    estimate


    miscellaneous related functions:

    CLEAR           Recover after an error
    TAPEDISK        Force a file to be on disk (within data base)
    DISKTAPE        Free a file to be on tape (within data base)
    TRANSMIT        Write a file onto a tape external to the data base
    USERINIT        Initialize the user access file
    TAPELOG         Logs an empty tape into the data base
    ASK             Provides status information
```

defines each input parameter required. This figure presents only parameters that are required in batch mode, since any additional inputs (such as confirmations) for interactive mode are requested with clear prompting messages on the terminal. The "M" (mode) column of Figure 52 indicates the entry mode -- Character, Integer, Real, or Logical. The "S" (source) column indicates who is responsible for the value of the parameter: A=Analyst, E=experiment design, M=management, U=user, P=data prep, S=software, "value"=fixed entry.

```
                              FIGURE 52.
                 Input Parameters For Processing Commands

     PARAM    DIM    M   S    DESCRIPTION


       ----- command "ASK" ----- see Section 3.3

     request   -     C   MU   one    of:   HELP,   COMMANDS,   STATUS,
                              HISTORY, DATA, LOG, or END
     subreq    -     C   MU   (only for requests HISTORY and DATA)
                              for  HISTORY,  one of: OUTLINE, RECENT,
                              FULL
                              FOR DATA, one of: LIST or ITEM
     segment   -     C   M    (only for requests HISTORY, DATA, and
                              LOG)
                              segment  use  name  or  "END"; repeated
                              until "END" occurs

     Note: these inputs are repeated until request "END" is made

       ----- command "CLEAR" ----- see Section 4.5.2

     segment   -     C   M    segment use name
     command   -     C   U    name of command to clear

       ----- command "CLUSTER" ----- see Section 6.7

     segment   -     C   M    segment use name
     nacqb     -     I   A    number of acquisitions for BLOBbing
     acqb      nacqb I   A    list  of  acquisitions  for  BLOBbing,
                              yyddd
     latest    -     I   A    latest  preemergence  acquisition date,
                              yyddd
     nclust    -     I   E    target number of clusters to form
```

```
                        FIGURE 52.   (continued)
                  Input Parameters For Processing Commands


    ----- command "DATAPREP" ----- see Section 6.3


segment   -       C   M    segment use name
nacq      -       I   A    number of acquisitions, overall
acq       nacq    I   A    acquisition list, yyddd
window    6       I   E    subscene,  whole  scene  specified   by
                           1,117,1,1,196,1
tapen     nacq    I   P    list    of    tapes    containing    raw
                           acquisitions
filen     nacq    I   P    list  of  tape  file  numbers  for  the
                           acquisitions
density   nacq    I   P    list of tape recording densities



    ----- command "DISKTAPE" ----- see Section 4.6


segment   -       C   M    segment use name
key 2     -       C   S    second portion of data key, e.g., image
                           name (16 characters)


    ----- command "DFS" ----- see Section 6.5


segment   -       C   M    segment use name
ntpc      -       I   A    number  of  TPC's  in  this  (each)  DFS
                           category
tpclist   ntpc    C   A    list  of  TPC's  in  this  (each)   DFS
                           category  (integers  with  optional A or
                           B)
Note: ntpc and tpclist are repeated for each of  the  strata  (4
strata)
```

```
┌─────────────────────────────────────────────────────────────────────┐
│                     FIGURE 52.   (continued)                          │
│                Input Parameters For Processing Commands               │
│                                                                       │
│     ----- command "ESTIMATE" ----- see Section 6.10                   │
│                                                                       │
│  segment   -      C   M    segment use name                           │
│  level     -      I   A    level  of information; 2=enough to make    │
│                            C/S estimates                              │
│  labels    nsamp  C   A    labels, entered in lots of 10, of form:    │
│                            "n 1 c" where n=optional  blob  number,    │
│                            l=crop     label    or    mixed    label,  │
│                            c=confidence (1-5)                         │
│                            nsamp=number of samples drawn              │
│                                                                       │
│                                                                       │
│     ----- command "PREPROCESS" ----- see Section 6.3                  │
│                                                                       │
│  segment   -      C   M    segment use name                           │
│  smeth     -      C   E    screening method: "none", "spatial", or    │
│                            "global"                                    │
│  xmeth     -      C   E    XSTAR  method:  "none", "spatial",  or      │
│                            "global"                                    │
│  nacqt     -      I   A    number of acquisitions for TPC             │
│  satnum    nacqs  I   M    satellite numbers for each acquisition     │
│  sunang    nacqs  R   M    sun angle for each acquisition             │
│  acqt      nacqt  I   A    list of acquisitions for TPC, yyddd        │
│                                                                       │
│                                                                       │
│     ----- command "SAMPLE" ----- see Section 6.8                      │
│                                                                       │
│  segment   -      C   M    segment use name                           │
│  nsamp     -      I   E    approximate  desired  number  of sample    │
│                            blobs                                       │
│  nacqs     -      I   A    number of separation acquisitions          │
│  acqs      nacqs  I   A    list of separation acquisitions in  the    │
│                            form 'yyddd'                               │
│  decision 4*nacqs                                                     │
│                   R   A    4 reals per acquisition giving 2 points    │
│                            on a decision line                         │
│                                                                       │
└─────────────────────────────────────────────────────────────────────┘
```

```
                         FIGURE 52.    (continued)
                  Input Parameters for Processing Commands

ptape      -        C   U    tape   name   (number) of tape to receive
                            PFC image
pfile      -        I   U    file of tape to receive PFC image
seed       -        I   F.   random number seed-positive odd integer


    ----- command "SCATTER" ----- see Section 6.5


segment    -        C   M    segment use name
ntpcp      -        I   A    number of TPC's in  list  of  those  to
                            plot, or 0 for standard
tpcp      ntpcp  I   A    (only  if  ntpcp    0) list of TPC's to
                            plot


    ----- command "TAPEDISK" ----- see Section 4.6


segment    -        C   M    segment use name
key 2      -        C   S    second portion of data key, e.g., image
                            name (16 characters)


    ----- command "TAPELOG" ----- [not available to all users]



    ----- command "TRANSMIT" ----- [not available to all users]



    ----- command "USERINIT" ----- [not available to all users]
```

APPENDIX C
SUMMARY OF ANALYST PROCEDURES

This appendix lists, in order of performance, all Analyst activities in the baseline procedure.

Section 6.2 DATA SCREENING AND SELECTION

6.2.1 Initial Screening of Segment Acquisitions
1. Recording of available acquisitions on the Acquisition Summary Sheet
2. Visual screening of each available acquisition for:
   a. Heavy cloud cover
   b. Heavy haze
   c. Bad data
   d. Obvious misregistration
3. Deletion of screened-out acquisitions from the summary sheet.

6.2.2 Verification and Adjustment of Crop Calendar
1. Plotting of preliminary Spectral Biowindows from phenological crop calendar data for:
   a. Summer crops
   b. Winter small grains
   c. Spring small grains
2. Determination of expected crop proportions from county historical crop statistics.
4. Verification or adjustment of the Spectral Biowindows from the PFC Products.
5. Plotting of Crop Group Separation Windows.
6. Plotting of Composite Crop Group Separation Subwindows.

6.2.3 Selection of Acquisitions for Machine Processing
1. Selection of Temporal Pattern Class (TPC) acquisitions.
2. Recording of selected acquisitions on the crop calendar form.
   a. Summer crops
   b. Winter small grains
   c. Spring small grains
   d. Pasture/trees/permanent vegetation
4. Definition of the candidate Corn/Soybean Separation Window.
5. Addition of potential separation acquisitions to the acquisition list on the crop calendar form.
6. Addition of potential BLOB acquisitions to the acquisition list on the crop calendar form.
7. Selection of addition acquisitions, if necessary.
8. Recording of machine-processing and TPC acquisitions on the Acquisition Summary Sheet.
9. Recording of associated Composite Crop Group Separation

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Subwindows.

Section 6.4 CROP GROUP STRATIFICATION (DFS)

1. Assignment of pure non-trivial TPC's to crop group strata.
2. Assignment of "A" Subclass TPC's to crop group strata.
3. Recording of stratum assignments on the Crop Group Stratum Assignments Sheet.
4. Selection, if necessary, of additional TPC's for scatterplot generation.

Section 6.6 SPECIFYING BLOB AND SEPARATION ACQUISITIONS

1. Verification of Corn/Soybean separability on candidate separation acquisitions.
2. Adjustment of Separation Window boundaries to exclude unverified acquisitions.
3. Recording of verified separation acquisitions on the Acquisition Summary Sheet.
4. Definition of linear discriminant and limitors on each separation acquisition.
5. Selection of BLOB acquisitions.
6. Recording of BLOB acquisitions on the summary sheet

Section 6.9 LABELING

1. Evaluation of sample blob Stage 1 labels through application of a detailed decision logic.
2. Adjustment of blob labels on the Label Recording Form, as required.
3. Recording of blob-specific confidence codes.
4. Recording of an overall segment confidence code.

APPENDIX D
CROP CALENDAR VERIFICATION AND ADJUSTMENT GUIDELINES

D.1   INTRODUCTION AND UNDERLYING CONCEPTS

D.1.1   PURPOSE OF CROP CALENDAR ANALYSIS

The crop calendar verification and adjustment step in the Corn and Soybean Baseline Area Estimation Procedure directly supports acquisition selection for temporal pattern class (TPC) extraction. TPC extraction, in turn, supports both the Crop Group Stratification section of the procedure, as well as the Target Labeling and Area Estimation section of the procedure. But mostly, crop calendar verification and adjustment and TPC extraction is of primary importance to the Crop Group Stratification and Sampling section of the procedure.

Crop Groups are stratified based upon the temporal differences in their growing seasons. The temporal differences between crop groups is measured and evaluated by extracting and analyzing the TPCs within a segment. It is possible to pre-determine for a segment the temporal difference between crop groups, if the crop calendar data for the general location of the segment is known. Crop calendar model data for corn, soybeans, and small grains will be available to support the pilot experiment. The model data will theoretically be adjusted to the specific segment to be analyzed. However, due to the importance of the stratification step in the area estimation procedure, the model data, which is as yet not extensively tested, must be verified and checked for reasonableness with the segment specific imagery and to transform it from a phenological crop calendar to a spectral crop calendar. If there are any obvious discrepancies between the model data and the segment spectral data, then the crop calendar model data needs to be adjusted, based on obvious indications from the segment data itself. Once the crop calendar data has been verified (and adjusted if necessary), then the acquisitions for TPC extraction are selected so that overlap between crop patterns is minimized and clean separations between crop groups occur. These spectral biowindows have been identified and defined based on spectral characteristics of the various crop groups. Acquisition selection criteria and priorities have been established to insure maximum crop group separation. However, the actual time period (specific calendar date) varies each year, and thus it is important to use properly verified and adjusted year-specific crop calendar data for acquisition selection for TPC extraction.

D.1.2 SPECTRAL BIOWINDOWS DEFINITIONS AND CONCEPTS

Before discussing the analysis steps in the crop calendar verification and adjustment procedure, it is first necessary to understand the spectral biowindows definitions and the concept behind these definitions. There are a total of 15 spectral biowindows - five for each of the three crop groups of interest (Summer Crops - SC, Winter Small Grains - WSG, and Spring Small Grains - SSG). Spectral biowindows 1, 3, and 5 (e.g., SC1, SC3. SC5,WSG1,WSG5, SSG1, SSG3, and SSG5) are considered absolute spectral biowindows. That is, virtually all (98-100%) of the fields within a given crop group within a given area (a segment) are expected to have GRABS values either totally above or below the decision threshold for green vegetation.[1] All (98-100%) of the fields within a given crop group are expected to be below the decision threshold in spectral biowindows 1 and 5, and above the decision threshold in spectral biowindow 3. Spectral biowindows 2 and 4 are considered transitional spectral biowindows. Fields of the specific crop groups within a given area (a segment) are expected to have GRABS values both above and below the decision threshold.

SC1 spectral biowindow represents a time when all summer crop fields within an area (in this instance - a segment), are below the decision threshold for detection of emerged green biomass. That is, all the "to be" summer crop fields within the segment within spectral biowindow SC1 are below the detection threshold[2] (i.e., appear as bare soil fields in the Landsat spectral data).

SC2 spectral biowindow represents a time when summer crop fields and fields which are "to be" summer crop within an area (segment) are "greening up"; that is, they are spectrally emerging above the detection threshold. SC2 is considered a transitional spectral biowindow because during this time period some summer crop fields within a segment are spectrally emerged and detectable while other summer crop fields within the segment are still not spectrally emerged and thus are below the detection threshold. Within the transitional SC2 spectral biowindow, summer crop fields can be either above the threshold of detection (represented by 1 in binary code) or below the

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[1] The detection threshold for green vegetation is considered to be at GRABS = 0, however, due to variability in sensor calibration, for the purpose of TPC extraction a decision threshold of GRABS = 6 has been established.
[2] Pixels with GRABS values less than 6, the decision threshold, are assigned a value of 0 in binary code.

threshold of detection (represented by 0 in binary code). Therefore, no single absolute code of 0 or 1 can be expected for summer crop fields within the SC2 spectral biowindow, but both 0 and 1 must be expected in SC2 for summer crop fields.

SC3 spectral biowindow represents a time when all summer crop fields within an area (segment) are above the detection threshold and appear vegetated in the Landsat spectral data. All summer crop fields within the segment during this "absolute" spectral biowindow can be represented by the single absolute binary code of 1.

SC4 spectral biowindow represents a time when summer crop fields within an area (segment) are "falling off", turning, or passing beneath the threshold of detection after reaching harvest maturity (Hanway scale of 10.5 for corn, Fehr Caviness Scale of 8.0 for soybeans). SC4 is considered a transitional spectral biowindow because during this time period some summer crop fields within the segment are still above the detection threshold, while other summer crop fields are below the detection threshold. Thus, in SC4, summer crop fields within a given segment can be either above or below the detection threshold, and a binary code of both 0 and 1 must be expected for summer crop fields within SC4.

SC5 spectral biowindow represents a time when all summer crop fields within an area (segment) are below the detection threshold. That is, all summer crop fields appear harvested or senescent in the Landsat spectral data. All summer crop fields within the segment during this "absolute" spectral biowindow can be represented by the single binary code of 0.

Definitions for the 15 spectral biowindows are given in Figure 25. The 15 spectral biowindows in this figure are defined according to ground biostages which are usually reported in crop calendar data. However, the concept of spectrally "absolute" and spectrally "transitional" biowindows is the same for the small grain crop groups as discussed above for the summer crop group. Again biowindows 1, 3, and 5 are spectrally "absolute" biowindows relatve to the specific crop group concerned, and biowindows 2 and 4 are spectrally "transitional" biowindows relative to the specific crop group concerned.

D.1.3   SEPARATION   WINDOWS   AND   SUBWINDOWS--DEFINITIONS   AND
CONCEPTS

Verification and adjustment of the crop calendar data with the
segment specific spectral imagery is initially worked for each of the
three crop groups separately. The verified and/or adjusted crop group
spectral biowindows are then combined into Crop Group Separation
Windows (GSW) and Composite Separation Subwindows (A through G).
There are three Crop Group Separation Windows which are defined by the
opening and closing of specific crop group spectral biowindows. See
Figure 26 for the definitions of the three Crop Group Separation
Windows. There are ten Composite Separation Windows (Figure 27) which
are defined by various combinations of the 15 Crop Group Spectral
Biowindows. The determination of the Crop Group Separation Windows
and Composite Separation Subwindows is necessary for the optimum
selection of acquisitions for TPC extraction, as combinations of
acquisitions from certain windows and subwindows will insure maximum
separation between crop groups.

Acquisition selection criteria and priorities for acquisitions
within these Separation Windows and Composite Separation Subwindows
are given in Section 6.2.

D.1.4   RELATIVE VS.   ABSOLUTE BIOWINDOW BOUNDARY PLACEMENT

Verification and adjustment of crop calendar data is done using
all the discrete Landsat acquisitions which are available for a given
segment in a given crop year. Verification of spectral biowindow
boundaries or adjustment of spectral biowindow boundaries is done
relative to the spectral data/acquisitions that are actually
available. What this means is that __exact__ (specific calendar date)
verification or adjusted placement of a spectral biowindow is not
possible since Landsat acquisitions are at best 18 days apart using
one satellite (or nine days apart using two satellites). However,
because of the discrete nature of the Landsat acquisitions, it is not
necessary to worry about exact date specific placement of spectral
biowindows boundaries. The pertinent point is that it is only
important to make sure that the spectral biowindow boundaries are
placed properly relative to the actual available acquisitions. In
other words, as long as the spectral biowindow boundaries are
correctly placed between the proper acquisitions, then the exact day
of the 18 possible days between sequential acquisitions on which the
boundary is placed is not relevant for the purposes of TPC acquisition
selection. The only important factor to be primarily concerned with
is whether each acquisition is in the proper spectral biowindow "bins"
according to the definitions of what should be spectrally and
biologically happening with the respective crop groups within the

respective Spectral Biowindows. Because of the important understanding of the crop calendar verification and adjustment procedure and in turn of the Stratification Procedure, an example of the relative (as opposed to absolute) verification and/or adjusted placement of a spectral biowindow boundary will be given below.

For example, for the summer crop group, one can determine - based on image analysis[1] and the spectral biowindow definitions, that acquisition "N" belongs in spectral biowindow SC2, with a specific calendar date "D". Furthermore, through similar means one can determine that acquisition N+1 (the next acquisition after N) belongs in spectral biowindow SC3. In addition, assume that acquisition N+1 occurs at calendar date D+18 days, that is 18 days after acquisition N. If Acquisition N is in spectral window SC2, and acquisition N+1 is in spectral biowindow SC3, then the true boundary between SC2 and SC3 must be somewhere between calendar dates D+1 and D+17. (One convention used in this analysis is the assumption that a spectral biowindow boundary does not fall on the same day as a Landsat acquisition; even if it did, an analyst could not determine this from the Landsat data itself.) (See Figure 29). Any date within the 16-day period D+1 to D+17 is the boundary between SC2 and SC3 since the placement of acquisition N in SC2 and acquisition N+1 in SC3 will be maintained regardless of the actual calendar date between days D+1 and D+17. Therefore, it does not matter that the exact boundary placement between SC2 and SC3 can not be verified or adjusted exactly to a specific calendar date; the important point is that the correct relative placement of the boundary between SC2 and SC3 can be verified or adjusted relatively with respect to the Landsat acquisitions.

D.2 ANALYSIS GUIDELINES FOR CROP CALENDAR VERIFICATION/ADJUSTMENT

D.2.1 PROCEDURAL GUIDELINES

The crop calendars must be verified and adjusted for each major crop group, which includes summer crops, winter small grains, and spring small grains. The verification and adjustment of crop calendars is worked separately for each crop group, proceeding with summer crops first (because these are our primary concern), then on to winter small grains, and to spring small grains in turn. Therefore, when the verification analysis has been completed, each Landsat acquisition will simultaneously belong to three spectral biowindows

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[1] Image analysis guidelines are given later in this appendix.

for each of the three major crop groups considered in the analysis. A fourth crop/land cover group, Alfalfa - Pasture - Permanent Vegetation, will also be considered relative to spectral biowindows; however, this will be discussed later under composite Separtation Subwindows.

In doing the verification and adjustment analysis, Image Product 3 is primarily used instead of Image Product 1 for analyzing boundaries between spectral biowindows 1 and 2, and 2 and 3. This is because within selected fields, the key feature that the analyst will be looking for is detectable young vegetation. It is important to be able to confidently detect emerging vegetation within the selected fields as soon as it reaches the threshold of detection. Since the spectral aid products will not be available at this point in the analysis, it becomes crucial to use the most spectrally "true" (undistorted) image product for this part of the analysis. For analyzing boundaries between spectral biowindows 3 and 4, and 4 and 5, Image Product 3 is still primarily used. Image Product 1, however should be checked for confirmation, and to make sure that nothing of significance in this part of the analysis was overlooked on Image Product 3 due to the lower contrast between features on that Product 3.

Due to the way the spectral biowindows are defined within the crop growing season, the boundary between adjacent spectral biowindows is always a boundary between an "absolute" situation (essentially all, or >95% fields within a crop group are in the same spectral state) and a "transitional" situation (some fields within a crop group are in one spectral state, some other fields within the same crop group are in a different spectral state). Thus, the crop calendar verification analysis is fairly simple to perform because within each crop group, the analyst need only consider which of two basic statements is true, then the other being false due to the exclusive nature of the spectral biowindow definitions.

The three possible spectral states are:
(a) No detectable green vegetation, not spectrally emerged, or apparent bare soil. (Grays on blacks on Product 3).
(b) Detectable green vegetation, spectrally emerged. (Some shade of red on Product 3.)
(c) Not detectable as green vegetation after a green vegetation phase was detected in an earlier acquisition. This includes post-harvest stubble conditions, sufficiently senescent vegetation states so that the GRABS value is below the threshold of detection (harvest maturity for corn-Hanway Scale 10.5, and soybeans - Fehr-Caviness Scale 8.0). (Yellowish-white, irridescent golden dark gray or black on Product 3.)

The statement pairs to be considered for verifying the crop

calendar date with respect to the actual Landsat acquisitions for a segment are given in Figure 53.

FIGURE 53.
Statement Pairs For Crop Calendar Verification

STATEMENT PAIRS FOR CROP CALENDAR VERIFICATION: SUMMER CROPS

Acquisition Being Considered for Placement In Spectral Biowindows	Statement Pairs to Consider for Summer Crops Spectral Biowindows	Spectral Biowindow It Statement is True
SC1 or SC2	a) less than 2% of summer crop fields are spectrally emerged.	1
	b) Greater than 2%, but less than 98% of summer crop fields are spectrally emerged.	2
SC2 or SC3	a) less than 98%, but greater than 2% of summer crop fields are spectrally emerged.	2
	b) Greater than 98% of summer crop fields are spectrally emerged.	3
SC3 or SC4	a) less than 2% of summer crop fields have started to turn.	3
	b) Greater than 2% of summer crop fields have started to turn.	4
SC4 or SC5*	a) less than 98%, but greater than 2%, of summer crop fields have reached harvest maturity.	4
	b) Greater than 98% of summer crop fields have reached harvest maturity.	5

*The boundary between SC4 and SC5 cannot be assessed with image products alone. Therefore the boundary between SC4 and SC5 should be accepted from the crop calendar data unless obvious conflicts arise due to necessary adjustments in the earlier spectral biowindow boundaries.

SUMMER CROP - CROP CALENDAR VERIFICATION ANALYSIS

FIGURE 53. (continued)
Statement Pairs For Crop Calendar Verification

STATEMENT PAIRS FOR CROP CALENDAR VERIFICATION: WINTER SMALL GRAINS

Acquisition Being Considered for Placement in Spectral Blowindow	Statement Pairs to Consider for Winter Small Grains Spectral Blowindows	Spectral Blowindow if Statement is True
WSG1 or WSG2	a) Less than 2% of winter small grains are spectrally emerged.	WSG1
	b) Greater than 2%, but less than 98% of winter small grains are spectrally emerged	WSG2
WSG2 or WSG3	a) Less than 98%, but greater than 2% of winter small grains are spectrally detectable as green vegetation after winter dormancy period.	WSG2
	b) Greater than 98% of winter small grains are spectrally detectable as green vegetation after winter dormancy period.	WSG3
WSG3 or WSG4	a) Less than 2% of winter small grains have started to turn.	WSG3
	b) Greater than 2%, but less than 98% of winter small grains have started to turn.	WSG4
WSG4 or WSG5	a) Less than 98% of winter small grains have been harvested.	WSG4
	b) Greater than 98% of winter small grains have been harvested.	WSG5

WINTER SMALL GRAINS - CROP CALENDAR DATA VERIFICATION ANALYSIS

FIGURE 53. (continued)
Statement Pairs For Crop Calendar Verification

STATEMENT PAIRS FOR CROP CALENDAR VERIFICATION: SPRING SMALL GRAINS

Acquisition Being Considered for Placement in Spectral Biowindow	Statement Pairs to Consider for Spring Small Grains Spectral Biowindows	Spectral Biowindows if Statement is True
SSG1 or SSG2	a) Less than 2% of spring small grains are spectrally emerged.	SSG1
	b) Greater than 2%, but less than 98% of spring small grains are spectrally emerged.	SSG2
SSG2 or SSG3	a) Less than 98%, but greater than 2% of spring small grains are spectrally emerged.	SSG2
	b) Greater than 98% of spring small grains are spectrally emerged.	SSG3
SSG3 or SSG4	a) Less than 2% of spring small grains have started to turn.	SSG3
	b) Greater than 2%, but less than 98% of spring small grains have started to turn.	SSG4
SSG4 or SSG5	a) Less than 98% of spring small grains have been harvested.	SSG4
	b) Greater than 98% of spring small grains have been harvested.	SSG5

SPRING SMALL GRAINS - CROP CALENDAR DATE VERIFICATION ANALYSIS

D.2.2   IMAGE INTERPRETATION GUIDELINES

General

The image interpretation for crop calendar verification and adjustment is done for crop groups as a whole. No crop type analysis is required in this step of the Corn/Soybean Baseline Area Estimation Procedures. Furthermore, within the crop group being considered, the interpretation for crop group is done for only a very small sample of fields. This is because the boundaries between spectral biowindows are defined at 2% (and 98%) of occurrence points which can easily be determined by sampling very few indicator fields. In other words, it is easy for the analyst to determine in the qualitative sense whether the minimum rate of spectral state occurrence of 2% has been reached, thus stratifying spectral biowindow definitions.

Indicator fields for the specific crop groups are selected and identified using the historical agricultural statistics data and the unverified crop calendar model data. Only fields which are identifiable as most probably of the crop group of interest are selected as indicator fields. Any fields which are doubtful as to crop group are not selected as indicator fields and should be ignored in this part of the analysis.

Summer Crops

Step 1. Using all available acquisitions, locate several indicator fields which are most probably summer crop fields. The characteristics of these probable summer crop fields are:
- (a) Vegetated (red on Image Product 3) sometime during the time period SC3.
- (b) Non-vegetated (not red on Image Product 3) prior to and during unverified spectral biowindow SC1.
- (c) Green-up (turn red after a not-red period) - spectral emergence should occur sometime during the time period of unverified spectral biowindow SC2 or early SC3.
- (d) Turned (turn golden, brown or black on Image Product 3) sometime during the time peiod of unverified spectral biowindow SC4 or late SC3.

Step 2. Using the historical agricultural statistics for the area in which the segment is located, determine the general proportion of the cropland area that has been planted to all types of summer crops in past years.

Step 3. Using the indicator fields selected in Step 1 as guides to the actual temporal pattern for summer crops, formulate a general impression of roughly what percentage of the segment in question appears to be planted to summer crops.

Step 4. Correlate this general impression of proportion of

summer crops from the segment with the historical agricultural statistics. They should roughly agree within ± 10-15%. If there is a great disparity between the proportion of summer crops impression from the segment and the historical agricultural statistics, recheck the general description of summer crop characteristics used to select the indicator fields. Make sure that you are confident in your selection of summer crop indicator fields. If you are confident in your identification of the general summer crop temporal- spectral pattern within the segment, then see if there are any other group of fields which display a temporal-spectral pattern which better fits the description of summer crops and whose general proportion of acreage within the segment better matches the historical agricultural statistics for summer crops. If no better matches for the description of Summer Crops is found, then accept the group of fields with the temporal-spectral pattern which best matches the description of summer crop, but note on the comment form that there is a large disparity between apparent proportion of summer crops within the segment and the proportion of summer crops expected from the historical agricultural statistics.

Step 5. Now that the general temporal-spectral pattern of summer crops within the segment is identified, the summer crop spectral biowindows can be verified and adjusted if necessary. Verification of the spectral biowindows is accomplished by observing the "green up" pattern and the "turning" or harvest pattern of summer crop fields as a group. Using selected indicator fields to see if the minimum 2% of occurrence of a particular spectral state has occurred yet, in order to meet the definitional requirements of the various spectral biowindows.

Verification and Adjustment of SC1/SC2 Boundary

Step 6. Looking at all acquisitions that fall in the unverified SC1, SC2, an early SC3 spectral biowindows, locate the latest acquisition on which there is virtually no spectral emergence (less than 2% of total summer crop acreage estimate from Step 3) of any summer crop fields. Check carefully, using indicator fields, to make sure that no more than 2% of the roughly estimated summer crop acreage can be observed to be spectrally emerged on the acquisition you are considering as the latest acquisition before summer crop spectral emergence significantly begins. Call this acquisition N. If the boundary between SC1 and SC2 falls after acquisition N, and before acquisition N+1, then the model data has been verified as correct, and the boundary between SC1 and SC2 as plotted from the crop calendar model data should be maintained and plotted on the Verified or Adjusted Summer Crop Calendar Plot.

If, however, the boundary between SC1 and SC2 as plotted from the crop calendar model data does not fall between acquisition N and N+1, then adjust the SC1/SC2 boundary to fall between these two acquisitions by plotting the adjusted boundary four days after

acquisition N on the Verified or Adjusted Summer Crop Calendar Plot.

Verification and adjustment of SC2/SC3 Boundary

Step 7. Looking at all acquisitions after and including acquisition N which fall in the unverified SC1, SC2, and SC3 spectral biowinows, locate the earliest acquisition on which virtually all (greater than 98% of total roughly estimated summer crop acreage from Step 3) summer crops have spectrally emerged. Check carefully using indicator fields to make sure that no more than 2% of the roughly estimated summer crop acreage can be found unemerged on this acquisition. Call this acquisition M. The boundary between SC2 and SC3 falls before acquisition M and after acquisition M-1, the last acquisition before M. If the boundary between SC2 and SC3 as plotted from the crop calendar model data falls between acquisitions M and M-1, then the model data has been verified as correct and should be unchanged on the Verified or Adjusted Summer Crop Calendar Plot.

If, however, the SC2/SC3 boundary from the model data does not fall between acquisitions M and M-1, then adjust the boundary to fall between these two acquisitions by plotting the adjusted SC2/SC3 boundary four days before acquisition M on the Verified or Adjusted Summer Crop Calendar Plot.

Verification and adjustment of SC3/SC4 Boundary

Step 8. Looking at all acquisitions after and including acquisition M which fall in the unverified SC3 and SC4 spectral biowindow, locate the latest acquisition on which virtually no summer crops (less than 2% of total roughly estimated summer crop acreage from Step 3) have started to turn. Check carefully, using indicator fields, to make sure that no more than 2% of the summer crops fields can be observed to have started turning on this acquisition. Call this acquisition P (there is no letter "O" due to possible confusions with zero). The boundary between SC3 and SC4 falls after acquisition P and before acquisition P+1. If the boundary between SC3 and SC4 as plotted from the crop calendar model data falls between these two acquisitions, then the model data has been verified as correct and should be unchanged on the Verified or Adjusted Summer Crop Calendar Plot.

If, however, the SC3/SC4 boundary from the model data does not fall between acquisitions P and P+1, then adjust the boundary to fall between the two acquisitions by plotting the adjusted SC3/SC4 boundary four days after acquisition P on the Verified or Adjusted Summer Crop Calendar Plot.

Verification and Adjustment f SC4/SC5 Boundary

Step 9. The boundary between SC4 an SC5 occurs when 98% of the summer crops within the segment have reached harvest maturity. At the present time no unique image appearance or other characteristics detectable and measurable on the image products have been identified with this biostage. Therefore it is not possible to verify or adjust the SC4/SC5 boundary as easily as the other summer crop spectral biowindows boundaries. Given this situation the default procedure is to accept as correct the SC4/SC5 boundary as plotted from the unverified crop calendar model data unless the following kinds of situations or conditions are observable or determinable within specific acquisitions or from EXCS year-specific statewide crop calendar data.

    (a) SC4/SC5 can not fall before adjusted SC3/SC4. Place SC4/SC5 at least four days after SC3/SC4.

    (b) If all summer crop fields have been plowed down to bare soil, this is a post-SC5 acquisition and the SC4/SC5 boundary definitely occurs before this acquisition.

    (c) The SC4/SC5 boundary cannot fall after the close of SC5 as determined from an ESCS year-specific <u>statewide</u> crop calendar.

    (d) The SC4/SC5 boundary cannot fall before the close of SC3 as determined from an ESCS year-specific <u>statewide</u> crop calendar.

Verification and Adjustment of the End of SC5 Boundary

Step 10. The end of SC5 occurs when 98% of the summer crops within the segment have been harvested. At the present time no guidelines on image characteristics for harvested summer crop fields have been established. Therefore it is not possible to verify or adjust the end of SC5 boundary as easily as some of the other summer crop spectral biowindow boundaries. Given this situation the default procedure is to accept as correct the end of SC5 boundary as plotted from the unverified crop calendar model data unless the following kinds of situations or conditions are observable or determinable within specific acquisitions or from ESCS year-specific statewide crop calendar data.

    (a) End of SC5 cannot occur before SC4/SC5. Place end of SC5 at least four days after SC4/SC5.

    (b) If all summer crop fields have been plowed down to bare soil, this is a post SC5 acquisition and the end of SC5 boundary definitely occurs before this acquisition.

    (c) The end of SC5 boundary cannot fall after the close of SC5 as determined from an ESCS year-specific <u>statewide</u> crop calendar.

    (d) The end of SC5 boundary should usually not fall before the SC3/SC4 boundary as determined from an ESCS year-specific statewide crop calendar.

Verification and Adjustment of the Beginning of SC1 Boundary

Step 11. Looking at all acquisitions that fall after the beginning of SC1 as determined from an ESCS year-specific statewide crop calendar and prior to and including acquisition N (see Step 6), locate the earliest acquisition on which plowing of summer crop fields can be observed. Call this acquisition L. The beginning of SC1 is prior to acquisition L and prior to SC1/SC2 boundary. It may be that no acquisition is available which meets the description of acquisition L above. In that case accept as correct the beginning of SC1 as determined from the Crop Calendar Model data if it falls at least four days prior to SC1/SC2. If not, adjust it to four days prior to SC1/SC2. If the beginning of SC1 as plotted from the unverified Crop Calendar Model data falls before acquisition L, and before verified and adjusted SC1/SC2, the model data has been verified as correct, and the boundary should be plotted on the verified an adjusted Summer Crop Calendar Plot.

Small Grains

The crop calendar verification and adjustment interpretation for winter and spring small grains is similar to the interpretation procedures described above for summer crop.

APPENDIX E
DESCRIPTION OF PACKET CONTENTS

Crop calendar information provided to the Analyst contains the following features

1. Data specific to the year of interest in addition to long-term average data. Normal crop calendars are valuable for obtaining a general overview of crop development, particularly when current year data are not available. However, year-specific trends in response to weather conditions are masked due to averaging. A current year crop calendar, derived from ground observations or model predictions, best represent actual crop development patterns detected in Landsat data by the Analyst.

2. Data specific to the local area of interest. As normal crop calendars mask year-to-year trends, crop calendars formulated over a broad area mask conditions at the local level. A crop calendar must be calibrated to the sample segment before it can be used by the Analyst to identify crops in that segment. If an accurae calibration cannot be provided through a model or actual biostage observations at that level, the AI must visually adjust the crop calendar himself. Refined laveling decisions depend on accurate segment-level crop calendar information.

3. Representation of all crops in the region. Crop calendars for crops other than those of interest (in this case, corn and soybeans), including hay and alfalfa cuttings, are required to definitely identify them as "other". An Analyst may encounter a temporal pattern that does not correspond entirely to the patterns expected for corn and soybeans but is not sufficiently different to exclude it from consideraion. If crop calendars for other crops are available, the Analyst can determine whether the pattern matches that of another, temporally similar, crop or is really a variant corn or soybean pattern.

4. Complete quantitative information for all crop biostages from planting through harvest. Quantitative information at some levels may be limited to the dates on which 50% of a crop reached each biostage. However, these data do not allow the Analyst to assess the rate at which the crop developed or the proportion of the crop that was in each biostage on a given date. Whenever possible, each crop biostage should be represented quantitatively from beginning to end.

5. An apropriate format for analysis by the AI. The crop calendar product should display maximum available biostage information in a format that is efficient for the Analyst to use. If detailed quantitative data are available, the cumulative "S-curve" format is preferred. The percentage of a crop in or beyond each biostage is plotted at frequent time intervals (one week or less). This format enables the Analyst to assess crop development rates and interpolate

between actual data points with greater confidence.

6. A meteorologically driven crop development stage estimator under development at LARS will be used to derive corn and soybean current year crop calendars for future corn/soybean pilots, due to the unavailability of real time agronomic obsevarations in foreign countries. Models for crops other than corn, soybeans and wheat are not yet being developed although there is a real requirement for their development before the Brazil and Argentina pilots. The corn/soybean model is to be completed in time for the U.S. pilot, but its accuracy will not have been evaluated prior to the pilot. Crop calendars derived from ESCS data will be used to simulate adjusted crop calendars for other crops as well as evalute the corn/soybean model.

If ESCS data are not available at the CRD level or are available only in the form of "50% dates", a detailed statewide crop calendar is also necessary. This will be adjusted to the CRD level by the Analyst with the aid of item (6), a product showing the average deviation of CRD-level crop development from statewide at the 50% point of each biostage.

All crop calendar products are to be included in the general Analyst information manual. In addition, appropriate copies of items (1) through (5) will go into segment-specific Analyst packets so that the Analysts may annotate them as necessary.

A detailed description of each product, including requested format and intended application, is provided in the following pages.

Product:
　　Current year crop calendar, adjusted to the segment level by a
　　meteorologically driven model.

Purpose:
　　The adjusted crop calendar may be viewed as a weather analysis
　　tool that translates year-to-date meteorological observations
　　into predicted crop development at the segment level. It serves
　　as a viable substitute for real time crop biostage observations.
　　The adjusted crop calendar will assist the Analyst in selecting
　　acquisitions for machine process ing, stratifying Landsat data
　　into crop/land use groups and labeling clusters and field-like
　　targets.

Description:
　　If the level of information provided by the model will support
　　it, a format similar to the "S-curve" format illustrated in
　　Figure 54 is preferred for displaying adjusted crop calendar
　　estimates. If not, the product developed for the wheat/barley
　　pilot, in which a single crop development stage estimate is
　　indicated at weekly intervals, would be acceptable.

Comments:
　　Adjusted corn and soybean crop calendars are required for each
　　Illinois, Indiana and Iowa sample segment in the U.S. Corn and
　　Soybean Pilot Experiment. Current year crop development
　　estimates are required for other crops as well. This requirement
　　will be satisified through ESCS data in the U.S. pilot. Adjusted
　　crop calendars for all confusion crops must be developed prior to
　　the Brazil and Argentina corn/soybean pilots, however, as there
　　do not appear to be any reliable alternatives for obtaining
　　current year estimates in these countries.

FIGURE 54.
Sample S-curve Format
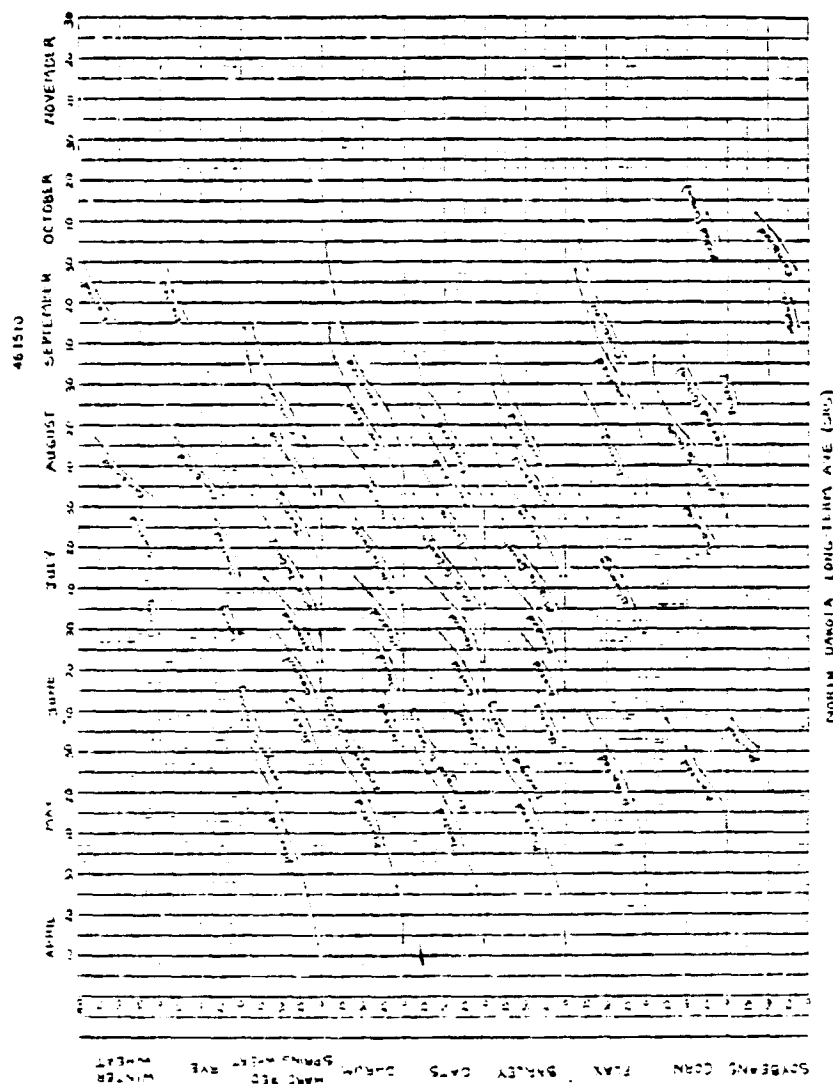
Product:
    Current year CRD-level crop calendar derived from ESCS data.

Purpose:
    Due to the unavailability of adjustable crop calendar models for
    crops other than corn, soybeans, and wheat, estimates of crop
    development for the U.S. Corn and Soybean Pilot must be obtained
    through other methods. One possible option is to use ESCS data
    as a substitute for model predictions.

Description:
    The format illustrated in Figure 54 is requested for crop
    calendar products (1) through (7). The proportion of a crop in
    or beyond each biostage is plotted against time at frequent
    intervals (preferably one week or less). Each crop biostage is
    thereby represented by an "S-curve" which describes the
    progression of that biostage over time. All major biostages
    should be included.

Comments:
    CRD-level crop calendars are requested for all CRD's in Illinois,
    Indiana and Iowa in which the sample segments are located.
    Actual generation of these products will depend on the
    availability of data. All major crops, including alfalfa and
    hay, should be represented. The final product should be in a
    form that may be inserted into a reference manual as well as
    segment-specific Analyst packets.

Product:
Current year statewide crop calendar derived from ESCS data.

Purpose:
If ESCS data are unavailable at the CRD level or are available only in the form of "50% dates", a current year statewide product is required to fill in the missing information on crop biostage progresssion (e.g., the dates when 10%, 25%, 90%, etc., of the crop is in or beyond that biostage). The statewide product will be adjusted to the CRD level by the Analyst.

Description:
The "S-curve" format illustrated in Figure 54 is requested for this product.

Comments:
Statewide data may be extracted from weekly ESCS crop and weather reports. Statewide crop calendars are required for Illinois, Indiana, and Iowa. All major crops, including alfalfa and hay, should be represented. The final product should be in a form that may be inserted into a reference manual as well as segment-specific Analyst packets.

Product:
    Statewide normal crop calendar.
    Year-specific statewide crop calendars for three previous years.

Purpose:
    These statewide crop calendars are primarily reference materials
    through which the AI becomes familiar with general crop biostage
    time frames and observed year-to-year variation. They provide an
    overall context for sample segment analysis.

Description:
    The "S-curve" format illustrated in Figure 54 is requested for
    these products.

Comments:
    Statewide crop calendars are required for Illinois, Indiana and
    Iowa. All major crops, including alfalfa and hay, should be
    represented. The final products should be in a form that may be
    inserted into a reference manual. The statewide normal product
    will also be included in segment-specific Analyst packets.

Product:
    CRD-level normal crop calendar.
    CRD- level year-specific crop calendars for three previous years.

Purpose:
    These products will serve as general reference information on
    normal crop development and year-to-year variation at the CRD
    level. In addition, the CRD level normal crop calendar can be
    calibrated to sample segment data by means of the adjusted corn
    and soybean crop calendars derived from year-to-date
    meteorological observations. This provides an alternative to
    using crop calendars to esimate current year development at the
    segment level of crops other than corn and soybeans.

Description:
    The "S-curve" format illustrated in Figure 54 is requested for
    these products.

Comments:
    CRD-level crop calendars are required for all Illinois, Indiana
    and Iowa CRD's in which sample segments are located. All major
    crops, including alfalfa and hay, should be represented. The
    final products should be in a form that may be inserted into a
    reference manual. The CRD normal product will also be included
    in segment-specific analyst packets.

Product:
   CRD-level crop calendar variation from statewide.

Purpose:
   This product provifes a summary of CRD-to-CRD crop calendar
   variation within a state. It will aid the Analyst in adusting
   the current year statewide crop calendar down to the CRD-level
   data are not avalable.

Description:
   CRD crop calendar variation is expressed as the difference in
   days between the average date on which 50% of a crop is in or
   beyond a given biostage at the state level and the corresponding
   date at the CRD level. A positive value indicates that the CRD
   is later than the statewide average while a negative value
   indicates that it is ahead of statewide. The statewide 50% date
   should be listed so that the Analyst may determine the
   corresponding CRD date (statewide plus indicated CRD deviation =
   CRD 50% date for a biostage). If year-specific data are
   sufficient, the range in year-to-year CRD deviation from
   statewide should also be included along with the year-to-year
   range in the statewide 50% date for the biostage. All major
   biostages should be represented for each major crop in the state.
   A possible format for this product is illustrated in Figure 55.

Comments:
   This product is requested for all three states (Illinois, Indiana
   and Iowa) and all major crops. The final form should be
   appropriate to go into a reference manual. It will not be
   included in segment-specific analyst packets.

FIGURE 55.
Sample CRD Crop Calendar Variation Format
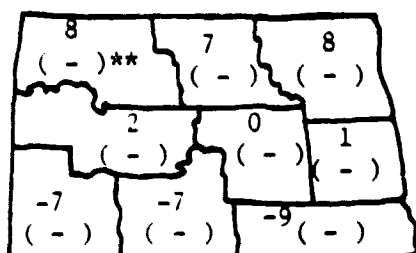
PLANTING OR BEYOND

Statewide Ave. 50% Date: 5/12
Range Statewide Year-to-Year:
5/1 - 5/28
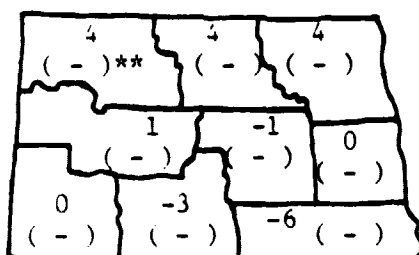
HEADING OR BEYOND

Statewide Ave. 50% Date: 7/7
Range Statewide Year-to-Year:
6/29 - 7/14
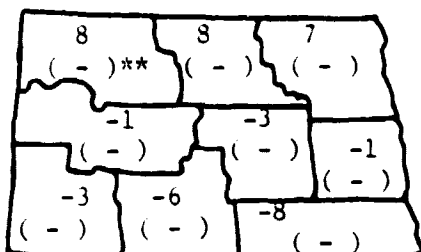
TURNING OR BEYOND

Statewide Ave. 50% Date: 8/3
Range Statewide Year-to-Year:
7/27 - 8/8
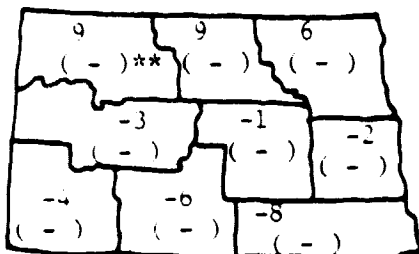
SWATHED OR BEYOND

Statewide Ave. 50% Date: 8/17
Range Statewide Year-to-Year:
8/9 - 8/26

*Statewide plus indicated CRD deviation = CRD 50% Date of Biostage
**Range CRD deviation year-to-year

Product:

CRD-level deviation of soybean and other summer crop development patterns from corn.

Purpose:

This product provides a summary of temporal variation among summer crops at the CRD level. It will aid the Analyst in (1) selecting appropriate acquisitions for machine processing and (2) separating summer crops when spectral amplitude criteria alone are not definite.

Description:

Deviation of other summer crop development from corn is exppressed at the CRD level as the difference in days between the average dates on which corn and the other crops reach the 50% point of comparable biostages (e.g., planting, flowering, maturity, harvest). A positive value indicates that the other crop is later than corn while a negative value indicates that it is ahead of corn. The corn 50% date for each biostage should be listed so that the Analyst may determine the corresponding date for the other crops (corn 50% date plus indicated deviation = 50% date for the other crop at a comparable biostage). All major corn biostages for which comparable biostages exist in other summer crops should be represented. An example of this product may be found in Figure 56.

Comments:

This product is requested for all three states (Illinois, Indiana and Iowa) and all major summer crops therein (soybeans, sunflowers, sorghum and sugar beets). The final form should be appropriate to go into a reference manual. It will not be included in segment-specific Analyst packets.

FIGURE 56.
Sample Form For Temporal Variation Among Summer Crops At CRD Level

CROP DATE MINUS HARD RED SPRING WHEAT DATE

Crop Stage:	50% Planted or Beyond			50% Headed or Beyond			50% Turning or Beyond			50% Swathed or Beyond		
Barley	1	2	1	0	-1	-2	-6	-6	-7	-10	-9	-8
	5	4	1	0	0	-3	-5	-4	-8	-6	-8	-9
	3	5	6	-1	0	-2	-5	-4	-7	-6	-6	-8
Oats	2	3	3	1	1	1	-5	-1	-2	-7	-5	-2
	6	7	5	0	2	0	-3	1	-3	-5	-5	-5
	3	6	7	0	1	1	-2	-2	-2	-4	-5	-4
Durum Wheat	1	2	0	1	0	0	2	2	1	0	0	2
	6	7	5	0	1	1	0	3	2	1	1	1
	4	2	2	0	0	1	2	1	2	1	0	1

Product:

General description of agrophysical unit (APU) climate.

Purpose:

To acquaint the Analyst with the significant climatic characteristics of the stratum to which a sample segment belongs. This is primarily an educational product that prepares the Analyst to make intelligent labeling decisions about a segment.

Description:

At minimum, this product should include a written summary of important climatic variables (temperature, precipitation, frequency of drought and thunderstorms, etc.) similar to that provided in the LACIE Universal Strata Descriptors (see Figure 57). Additional map, graphic or tabular data are not essential but would be desirable if readily available.

Comments:

A climate description is requested for each agrophysical unit. If APU descriptors cannot be obtained in time for U.S. Corn and Soybean Pilot, a climate description at the tri-state level (Illinois, Indiana, and Iowa) would be acceptable provided significant regional trends are noted.

FIGURE 57.
LACIE Universal Stratum Descriptor

UNIVERSAL STRATA DESCRIPTORS

Country: United States

State, CRD: Kansas, CRD 1,2,4,5; Nebraska, CRD 5,7,8;
Colorado, CRD 6

Full Frame Landsat Imagery Numbers:

Segments in Strata:

AGRICULTURAL LAND USE- General Description: Winter wheat is the principal crop. Grain sorghum, hay, small grains, and corn are other important crops. Wheat, grain sorghum, hay and the other small grains (oats, barley, and rye) are grown over the whole region. Corn is important in the northern part of the stratum.

Winter wheat in this region is produced almost exclusively on summer fallow. River bottomlands and terraces (Platte, Republican and Smoky Hill) have become important irrigated areas. Corn, hay, alfalfa and other small grains occupy much of the irrigated land.

CLIMATE- General Description: This stratum is a typical steppe climate with wide variations in precipitation from year to year. Evaporation generally exceeds precipitation during the summer months. The number of sub-normal years of precipitation outnumbers the above normal years about two to one. The mean monthly rainfall increases in the spring to a maximum in June. General storms provide the main source of precipitation during the spring months, while thunderstorms are the major factor during the summer months of the growing season. It is almost axiomatic that if inadequate moisture is received during the period March through June, drought conditions will prevail through the summer months with thunderstorms affecting only local relief. The frequency of thunderstorms normally increases to a maximum in July with a marked decrease in September. Hail is most frequent in May and June. Snow cover and snow moisture are important factors in the production of winter wheat, and residual soil moisture often offsets the effects of subnormal spring precipitation. Blizzards do occur. The heaviest snowfall is most likely to occur in March, although heavy snows can occur in every month from October through May. Temperatures follow the usual continental regime with January normally the coldest month and July the warmest. Winters are often moderated by persistent foehn winds but cold air outbreaks have been known to drop temperatures as much as 30° in a 24 hour period. Low relative humidity during the summer months makes most nights comfortable even in the hottest weather. Temperatures of 100° or greater are common in July and August.

GEOMORPHOLOGY- General Description: This is a nearly level to gently rolling sand and loess mantled tableland. Stream valleys are narrow and not deeply incised. Relief is in a few feet to a few tens of feet. The elevation increases from 2000 feet in the east to 4000 feet in the west.

Drainage Patterns: Major damage is to the east. The stratum is traversed by several rivers and their tributaries, including the Smoky Hill and the Republican. The local drainage is dendritic to parallel. Most of the stratum depends on low-to-moderate but erratic rainfall for crops and pasture. The Platte and Republican rivers provide water for irrigation only along their valleys. In the north abundant ground water is available for irrigation.

Native Vegetation: This stratum's original vegetation is grassland. In Kansas it is primarily bluestem and grama, and in Nebraska wheatgrass, bluestem, and needlegrass are dominant.

SOILS- General Description: These soils are on uplands and terraces and are developed from loess. They have a silt loam surface texture and a silty clay loam profile texture. The soil in the northern part of this stratum deviates from the above description. These soils are fine sand and silt texture with parent material of sandy aeolian sediment and silty alluvium. The alluvium derived soils are on floodplains and have a black surface color. Irrigation is practiced in the lower left quarter of stratum. Fifteen percent of the area within the stratum, located in the lower right quarter, are shallow soils, usually between 25-50 cm. These same soils occur on slopes ranging from 5-15 percent.

Product:
Temperature climagraph.
Precipitation climagraph.

Purpose:
To provide the analyst with a synopsis of normal and year-specific mean temperature and total precipitation at the segment level as an aid to (1) calibrating state and CRD level crop calendars to the segment and (2) evaluating unusual crop development patterns.
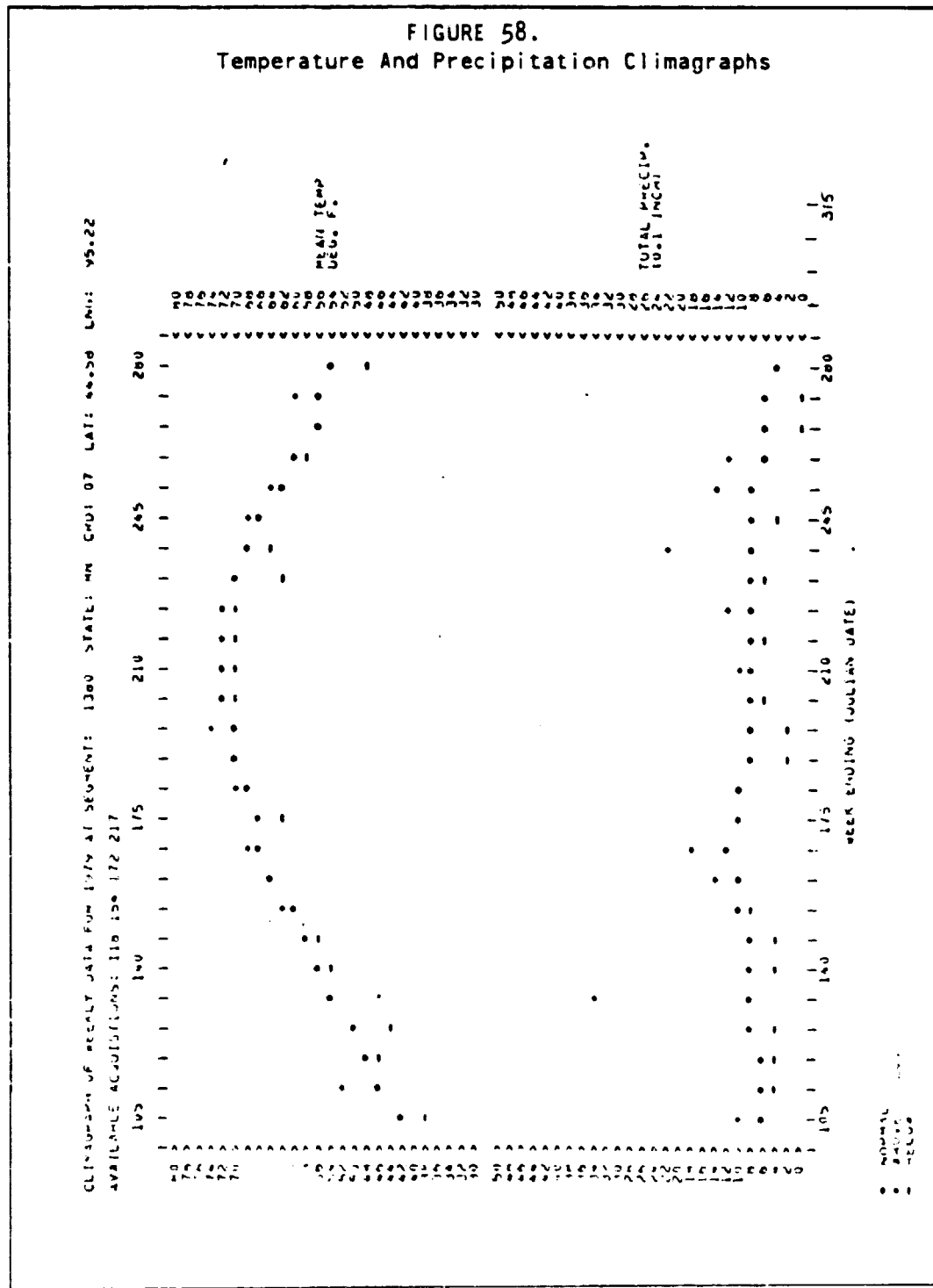

Description:
Normal and year-specific weekly mean temperature and total precipitation, interpolated to the segment level from surround meteorological stations, are plotted against Julian date. A format similar to that developed for the wheat/barley pilot is desirable (see Figure 58).

Comments:
Temperature and precipitation climagraphs are rquired for each Illinois. Indiana and Iowa sample segment in the U.S. Corn and Soybean Pilot.

FIGURE 58.
Temperature And Precipitation Climagraphs

Product:

Crop Moisture Index Climagraph.

Purpose:

The Crop Moisture Index (CMI) combines weekly temperature and precipitaton data into a measure of the degree to which crop moisture requirements were met during that week. This information is used by the analyst to assess crop growth and development patterns at the segment level for acquisition selection, stratification and labeling.

Description:

Year-specific weekly CMI values, interpolated to the segment level from surrounding meteorological stations, are plotted against Julian date. A format similar to that developed for the wheat/barley pilot is desirable (see Figure 59).

Comments:

A CMI climagraph is required for each Illinois, Indiana and Iowa sample segment in the U.S. Corn and Soybean Pilot.

FIGURE 59.
Requested CMI Climagraph Format
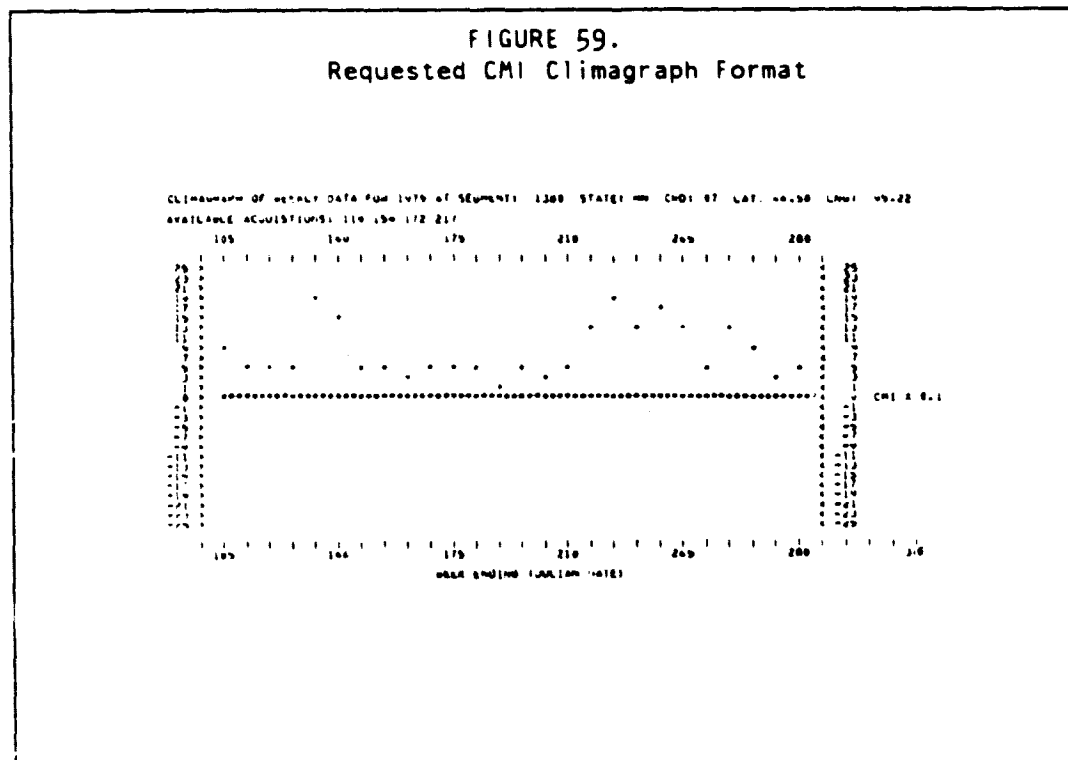
Product:
    Listing of reported significant ecological events by date and
    region.

Purpose:
    To inform the analyst of short-term, localized ecological events
    that are not visible in weekley meteorological averages but may
    have a significant effect on crop growth and development patterns
    in the segment.

Descr., on:
    Significant events such as heavy rains, hail damage and drought
    are listed by date of occurrence and extent of the region to
    which the report applies (e.g., state, CRD, county, local area).
    Information should be reported as near to the segment level as
    possible. A format similar to that developed for the
    wheat/barley pilot is desirable (see Figure 60).

Comments:
    This listing is required for each Illinois, Indiana and Iowa
    sample segment in the U.S. Corn and Soybean Pilot.

FIGURE 60.
Significant Ecological Event Report Format

CLIMAGRAPH OF WEEKLY DATA FOR 1979 AT SEGMENT: 1380   STATE: MN
                                    CRD: 07 LAT: 44.58 LNG 95.22

AVAILABLE ACQUISITIONS: 118 154 172 217

DATE AND REGION OF REPORTED SIGNIGICANT ECOLOGICAL EVENTS

175 MN ST HEAVY RAINS-STANDING WATER, EROSION DAMAGE,
          SOME HAIL DAMAGE
182 MN ST LARGE ACREAGE OF HAIL DAMAGED SOYBEANS REPLANTED
224 MN 07 HEAVY RAINS DELAYED SMALL GRAINS HARVEST
231 MN ST SHOWERS AND HEAVY DEWS DELAYED SMALL GRAIN HARVEST
238 MN ST RAIN, CLOUDS, HEAVY DEWS AGAIN SLOWED SMALL GRAIN HARVEST

APPENDIX F
DESCRIPTION OF ANALYST AIDS

This appendix describes the aids produced for the analysts, both computer generated and those from other sources.

F.1   PFC PRODUCT 1

This product is produced from the raw Landsat data by scaling channels 1, 2, and 4 so that each uses the full range of its respective color gun. This product generally provides enhanced field definition at the expense of reduced crop development information.

F.2   PFC PRODUCT 3

This film product is produced from raw Landsat data by scaling channels 1, 2, and 4 such that the widest possible range of the color guns is used while maintaining the correct proportions between the channels. This product is useful in seeing the multitemporal green development of fields, but may have poor field definition in comparison with the PFC Product 1.

F.3   TPC REPORT

TPC report as illustrated in Figure 61. The first page of the report lists the TPC's in numerical order, giving the number of pixels within the segment which belong to each TPC. The second page lists the same data again, but sorted in order of decreasing TPC size.

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/ 8 / - / 8 2

FIGURE 61.
TPC Report

TPC REPORT F.3

FIGURE 61. (continued)
TPC Report

F.4 STRATIFIED SCATTERPLOTS

Scatterplots (Figure 62) plotting GRABS vs Brightness are provided for each acquisition. The pixels plotted are normally only those in the pure summer crop TPC's. The plots are produced such that higher pixel counts are plotted with darker symbols and lower pixel counts are plotted with less dark symbols.

FIGURE 62.
Stratified Scatterplots
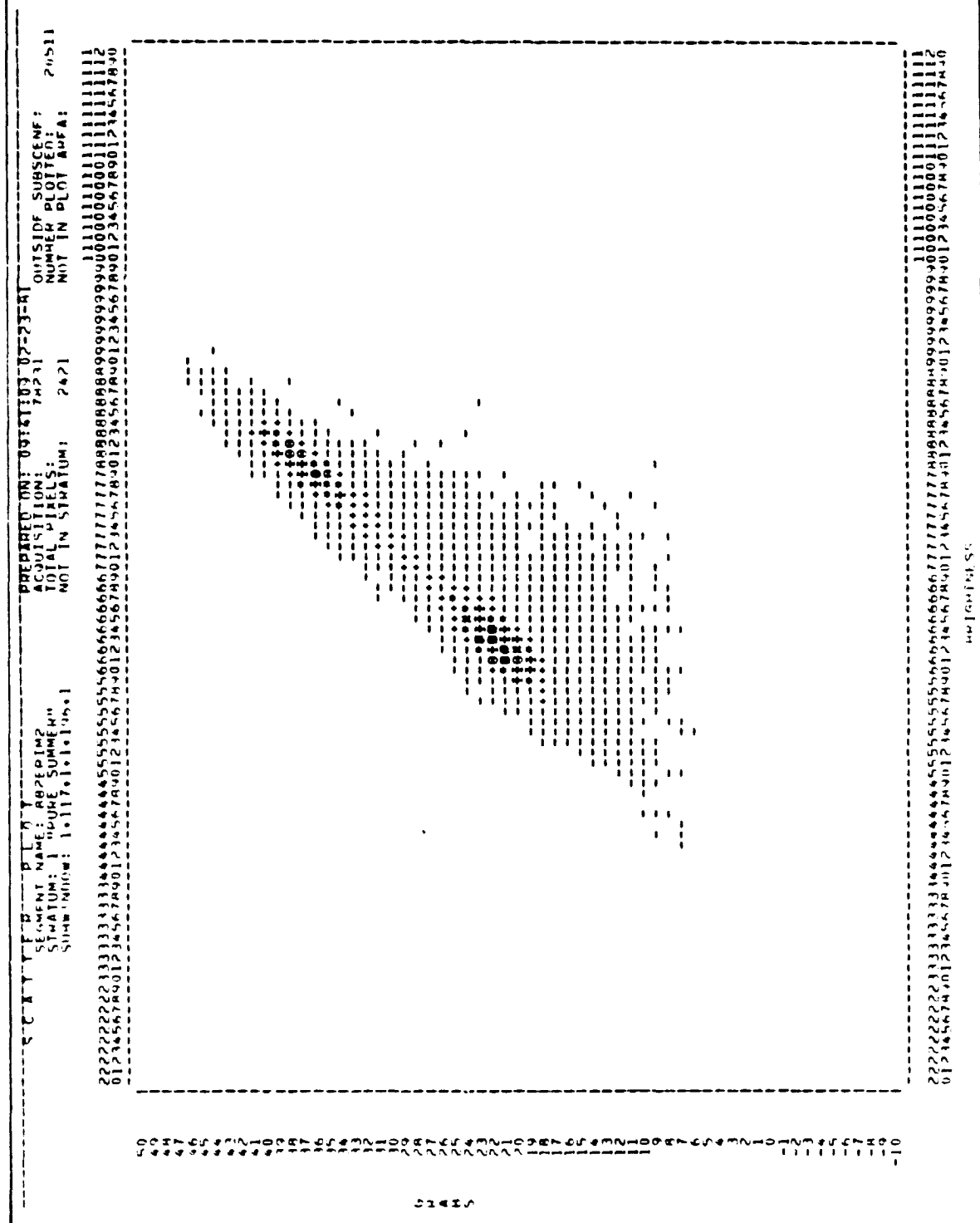
F.5   LINEAR DISCRIMINANT TEMPLATE

A template on clear acetate providing the linear discriminant and limitors is illustrated in Figure 63.

FIGURE 63.
Linear Discriminant Template
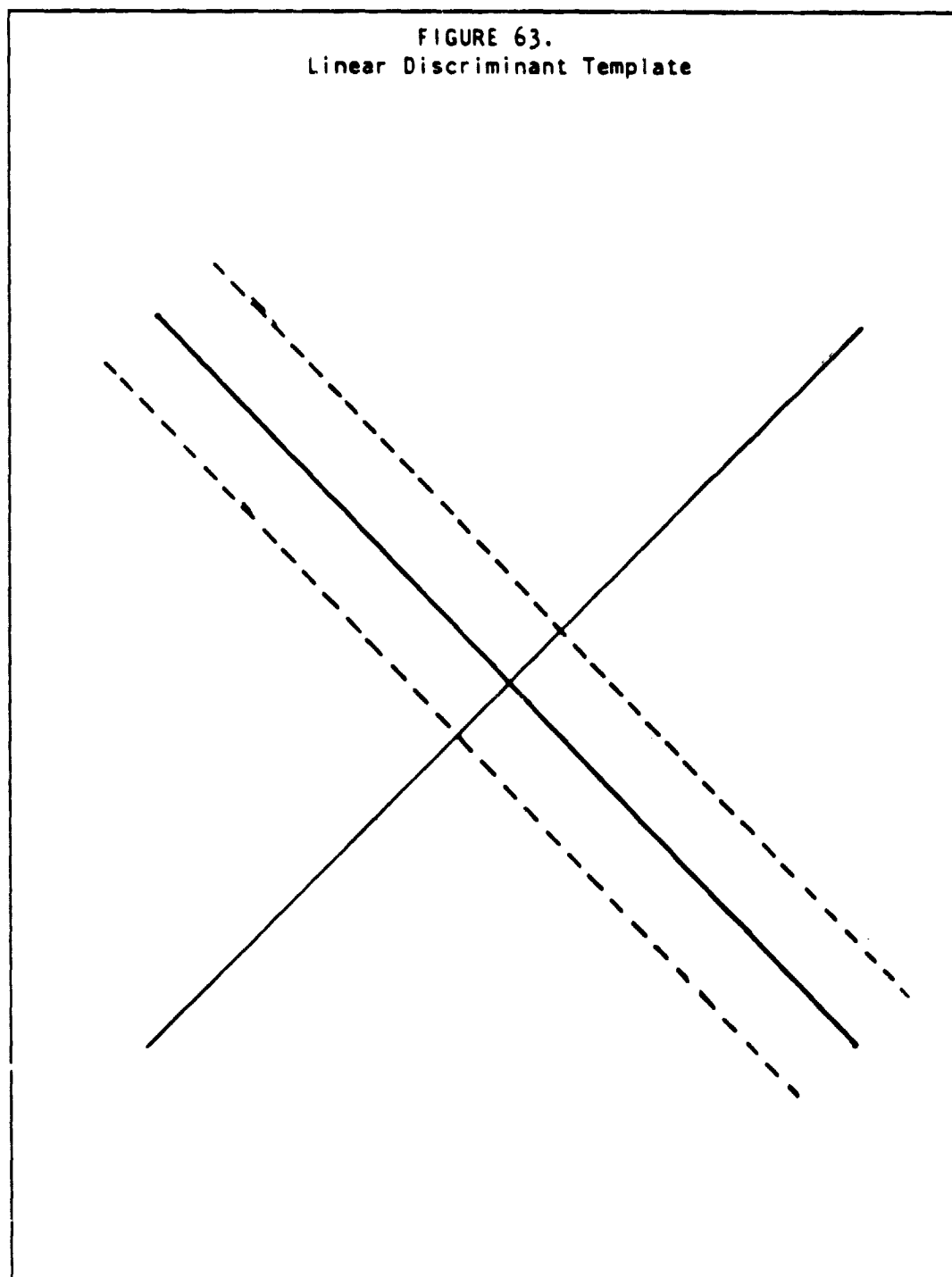
F.6   PFC SAMPLE BLOB OVERLAY

A PFC product outlining the selected blobs which may be overlaid on PFC products 1 and 3.

F.7   BLOB STATISTICS REPORT

The first page of this report lists the sampled blobs in descending order of interior pixel size by DFS (see Figure 64). The following pages of the report (see Figure 65) provide the for each sampled blob:

(a) The blob number.

(b) The TPC of the blob mean and the DFS to which it belongs.

(c) The number of total and interior pixels in the blob.

(d) The mean and standard deviation for GRABS and Brightness for the blob on all machine processing acquisitions.

(e) The zone of the blob mean for all separation acquisitions.

(f) The line and pixel values of the blob center.

(g) The line and pixel values of the rectangle which just encloses the blob.

(h) A map of the blob showing the TPC and DFS of each pixel in the blob (a different character for each TPC) and the edge pixels (indicated by '+'s).

(i) A temporal plot of GRABS vs Brightness of the blob mean with the first acquisition denoted by a '1', the second with a '2', and so on. Note that the tenth acquisition (if any) is denoted by a '0'.

(j) A ___ s Time plot of the blob mean and standard dev

FIGURE 64.
List Of Sampled Blobs

LIST OF BLOBS TO BE LABELED

SEGMENT NAME :HAZERIM2
REPORT GENERATED AT :10:17:57 02-21-81

BLOB	DES	IPC	CLUSTER	NO. OF PIXELS	NO. INT PIXELS	CENTER LINE NO.	CENTER POINT NO.
45	SUMMER	50	6	159	111	11.47	173.20
881	SUMMER	50	16	177	100	98.81	98.98
741	SUMMER	50	1	147	82	84.31	106.95
633	SUMMER	50	5	115	79	79.66	64.72
678	SUMMER	50	3	197	73	77.31	82.51
425	SUMMER	50	5	135	68	49.11	131.47
76	SUMMER	50	5	107	66	4.46	60.45
443	SUMMER	50	4	103	59	45.54	27.43
611	SUMMER	60	5	124	54	67.74	107.46
674	SUMMER	60	25	110	54	66.47	175.60
1026	SUMMER	60	1	84	54	111.10	150.77
321	SUMMER	60	9	92	50	34.40	95.79
303	SUMMER	60	9	84	49	98.15	157.08
367	SUMMER	50	3	94	48	28.28	117.80
457	SUMMER	50	1	85	48	52.56	66.01
251	SUMMER	50	9	81	42	25.94	152.56
142	SUMMER	50	3	83	39	19.71	112.63
517	SUMMER	50	1	68	39	57.71	18.07
613	SUMMER	50	10	69	38	72.46	136.16
550	SUMMER	50	3	82	37	62.83	103.80
503	SUMMER	60	E	68	36	55.59	117.66
602	SUMMER	60	5	56	32	44.00	175.29
636	SUMMER	50	5	54	31	72.22	128.61
818	SUMMER	50	3	73	31	49.82	89.55
46	SUMMER	50	3	63	31	3.90	171.49
351	SUMMER	50	13	63	28	104.63	54.70
530	SUMMER	50	1	59	28	54.90	68.44
144	SUMMER	60	1	57	28	18.07	158.51
45	SUMMER	60	6	59	27	6.71	4.34
333	SUMMER	60	1	52	27	34.38	62.56
431	SUMMER	50	10	53	22	48.98	39.83
457	SUMMER	50	25	58	22	34.12	171.05
314	SUMMER	50	6	45	21	98.31	5.73
742	SUMMER	50	6	48	21	81.02	188.35
44	SUMMER	50	1	53	21	4.13	54.91
1064	SUMMER	50	6	51	21	110.20	140.64
171	SUMMER	50	6	41	20	17.88	20.66
44	SUMMER	50	1	57	20	4.75	15.04
1082	SUMMER	50	4	38	19	112.08	159.08
225	SUMMER	50	2	47	19	21.68	119.38
25	SUMMER	50	4	35	18	4.09	104.14
432	SUMMER	50	1	44	17	49.20	73.11
441	SUMMER	50	10	45	16	52.78	175.18
636	SUMMER	50	6	42	16	46.52	108.79
117	SUMMER	50	5	36	16	14.59	34.92
646	SUMMER	50	5	37	15	72.24	122.51
42	SUMMER	50	1	33	15	45.79	156.78
750	SUMMER	50	13	44	16	4.48	34.41
411	SUMMER	50	10	44	16	81.45	41.00
1044	SUMMER	50	2	33	14	40.66	104.73
43	SUMMER	50	1	34	14	114.48	63.74
320	SUMMER	50	2	30	14	4.45	80.04
262	SUMMER	50	6	10	13	43.73	104.44
864	SUMMER	50	6	44	13	24.70	143.10
141	SUMMER	50	1	33	12	41.10	112.64
552	SUMMER	50	7	23	12	14.55	46.51
777	SUMMER	50	2	65	12	62.00	144.44
214	SUMMER	50	16	50	11	24.52	43.49
405	SUMMER	50	1	41	11	21.74	176.18
1043	SUMMER	50	2	25	9	44.45	83.05
1108	SUMMER	50	2	17	9	104.45	153.48
525	SUMMER	50	1	25	9	115.24	34.22
711	SUMMER	50	2	27	8	66.62	51.81
405	SUMMER	50	2	23	8	74.15	148.04
355	SUMMER	50	2	22	8	44.49	178.00
36	SUMMER	50	2	32	7	57.77	40.14
1047	SUMMER	50	16	33	7	107.47	81.47
675	SUMMER	50	1	25	7	66.09	88.42
304	SUMMER	50	1	22	7	25.39	46.10

FIGURE 65.
Blob Statistics

FIGURE 65. (continued)
Blob Statistics
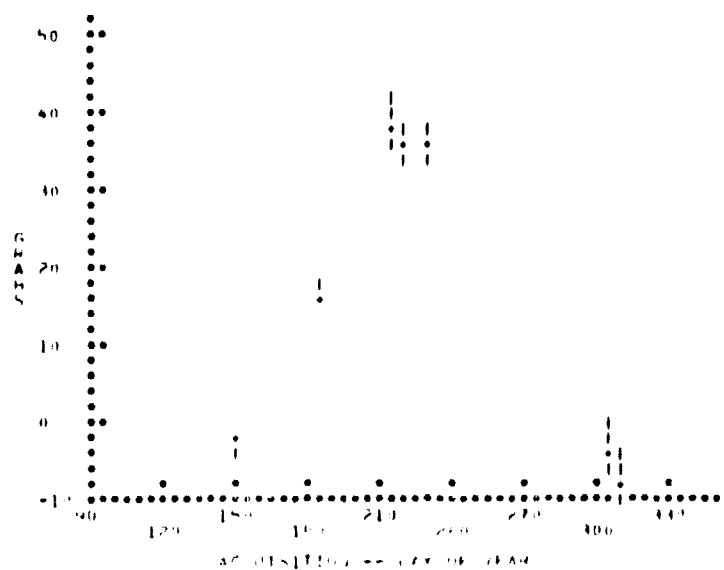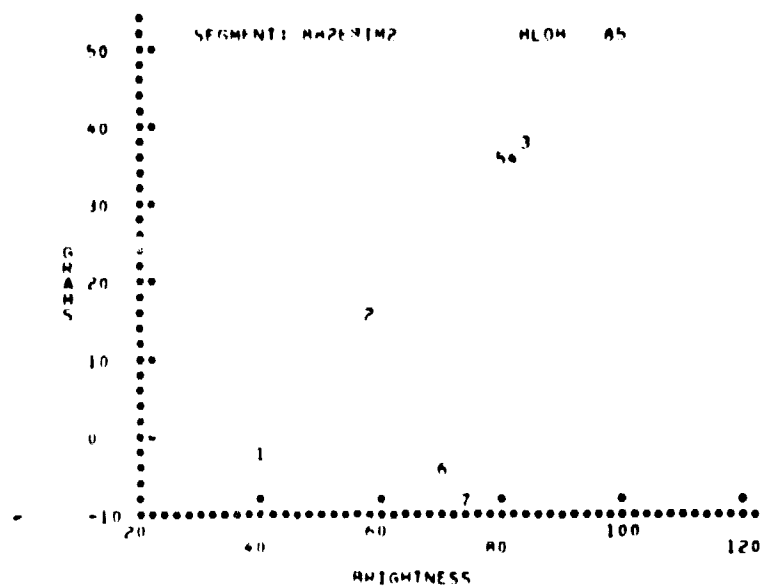
A template of clear acetate for indicating the crop biowindows on the GRABS vs. Time plots is illustrated in Figure 66.

FIGURE 66.
Crop Window Template
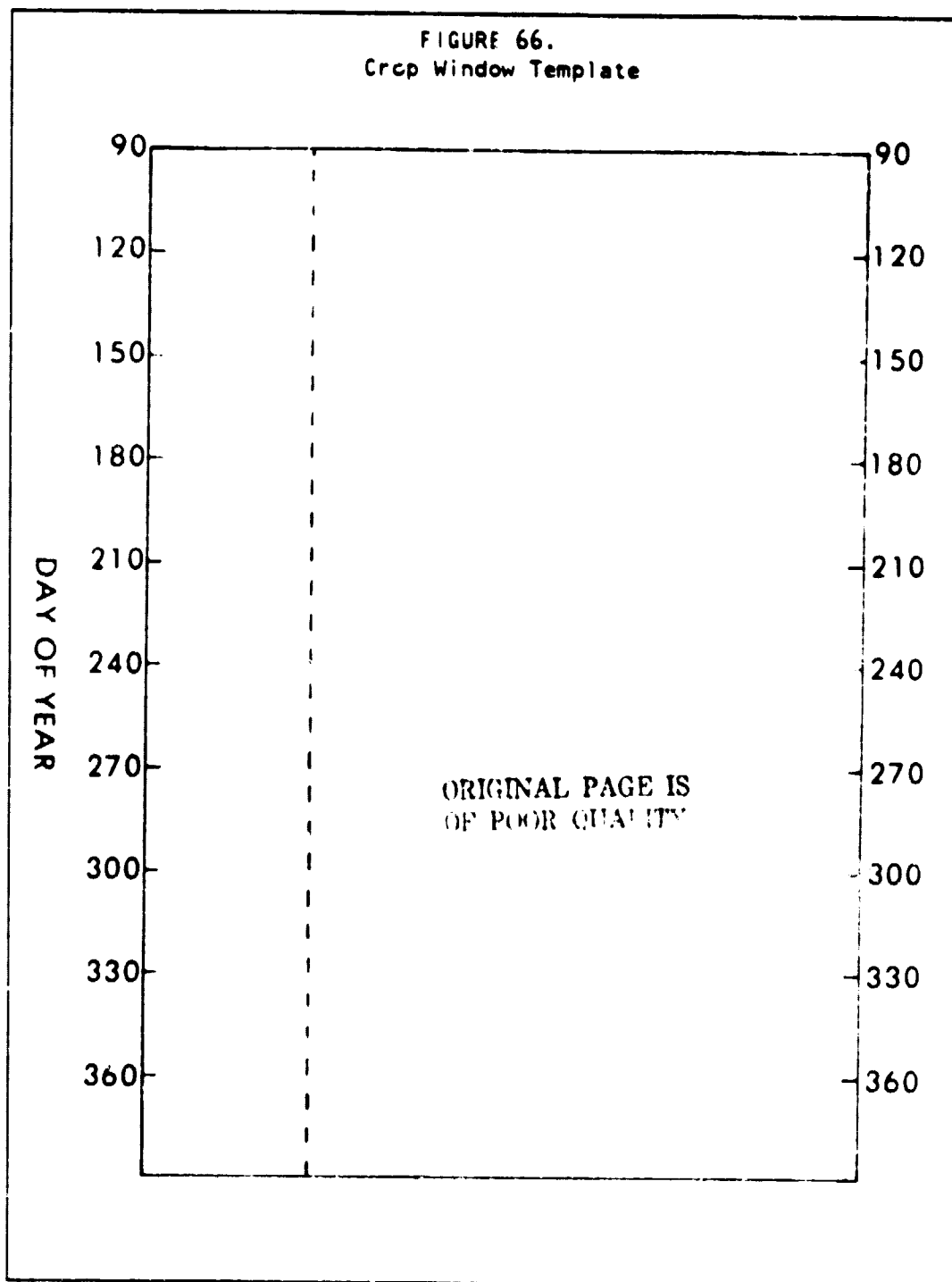
APPENDIX G
EXAMPLES OF COMPUTER GENERATED REPORTS

The report illustrated in Figure 67 is produced by the command DATAPREP.

FIGURE 67.
DATAPREP Report

PRECEDING PAGE BLANK NOT FILMED

C - 3

The reports illustrated in Figures 68 and 69 are produced by the command PREPROCESS.

FIGURE 68.
SCREEN Report

PRECEDING PAGE BLANK NOT FILMED

G. EXAMPLES OF COMPUTER GENERATED REPORTS

FIGURE 69.
TPC Report

FIGURE 69. (continued)
TPC Report

The report illustrated in Figure 70 is produced by the command DFS.

FIGURE 70.
DFS Report

The report illustrated in Figure 71 is produced by the command SCATTER.

FIGURE 71.
Scatter Plots
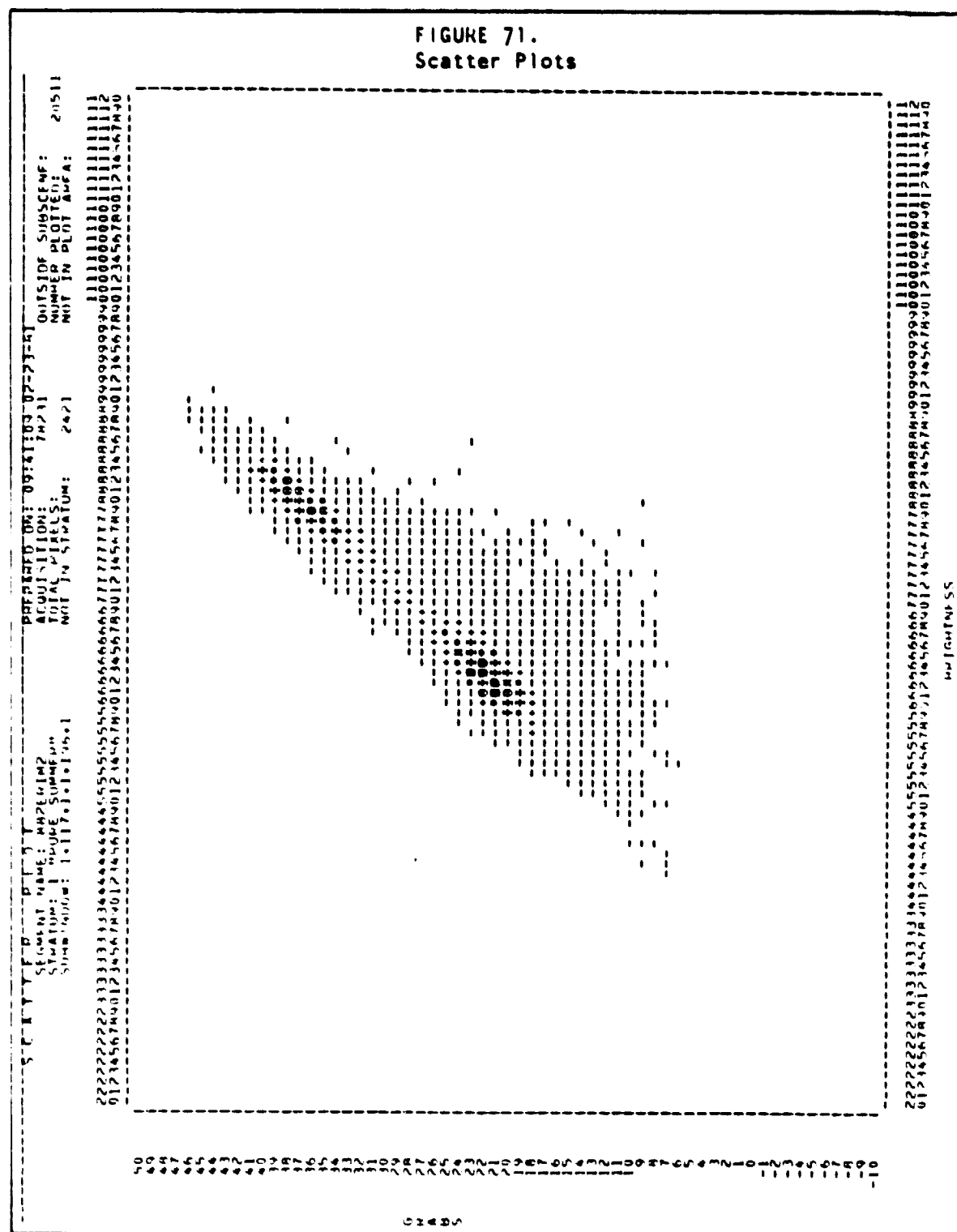
The report illustrated in Figure 72 is produced by the command CLUSTER.

FIGURE 72.
CLUSTER Report

```
B L O B   R E P O R T

SEGMENT NAME            :  AA2EWIM2
REPORT ISSUED ON        :  10:01:38  02-23-81
ACQUISITIONS            :  78150  74222  78231  78311
NUMBER OF BLOBS         :  1151
NUMBER OF PIXELS        :  22932
% INTERIOR PIXELS       :  45.90%
PIXELS IN GARBAGE BLOB  :  0
MAXIMUM BLOB SIZE       :  177
LARGEST BLOB            :  AA1
NUMBER OF LITTLE BLOBS  :  717
% SCENE IN LITTLE BLOBS :  15.59%


HISTOGRAM OF BLOBS BY BLOBSIZE

----------------------------------------------------------------------------------
HISTPT. # BLOBS= 1151. NPTS=   1150. RANGE=(  1.00,177.00)/  1.00. MEAN=   19.94

   MIDPT   CUMPCT  PCT    COUNT                       4 COUNTS PER SYMBOL
    1.00  0.129  0.129    148  |*************************************
    2.00  0.240  0.111    128  |*******************************
    3.00  0.318  0.078     90  |**********************
    4.00  0.384  0.066     76  |*******************
    5.00  0.435  0.050     58  |**************
    6.00  0.473  0.038     44  |***********
    7.00  0.500  0.027     31  |********
    8.00  0.524  0.024     28  |*******
    9.00  0.550  0.025     29  |*******
   10.00  0.564  0.015     17  |****
   11.00  0.584  0.020     23  |******
   12.00  0.604  0.020     23  |******
   13.00  0.614  0.010     11  |***
   14.00  0.628  0.014     16  |****
   15.00  0.646  0.018     21  |*****
   16.00  0.663  0.017     20  |*****
   17.00  0.677  0.013     15  |****
   18.00  0.683  0.007      8  |**
   19.00  0.693  0.010     11  |***
   20.00  0.711  0.018     21  |******
   21.00  0.717  0.005      6  |**
   22.00  0.728  0.011     13  |****
   23.00  0.739  0.011     13  |****
   24.00  0.749  0.010     11  |***
   25.00  0.753  0.004      5  |**
   26.00  0.762  0.009     10  |***
   27.00  0.765  0.003      4  |**
   28.00  0.773  0.008      9  |***
   29.00  0.783  0.010     11  |***
   30.00  0.790  0.007      8  |**
   31.00  0.797  0.007      8  |**
   32.00  0.801  0.004      5  |**
   33.00  0.808  0.007      8  |**
   34.00  0.812  0.004      5  |**
   35.00  0.817  0.004      5  |**
   36.00  0.819  0.003      3  |*
   37.00  0.823  0.003      4  |*
   38.00  0.827  0.004      5  |**
   39.00  0.831  0.004      5  |**
   40.00  0.834  0.003      3  |*
   41.00  0.841  0.007      8  |**
   42.00  0.843  0.003      3  |*
   43.00  0.847  0.003      4  |*
   44.00  0.853  0.006      7  |**
   45.00  0.858  0.005      6  |**
   46.00  0.863  0.004      5  |**
   47.00  0.866  0.003      4  |*
   48.00  0.872  0.006      7  |**
   49.00  0.875  0.003      3  |*
   50.00  0.878  0.003      4  |*
   51.00  0.881  0.003      4  |*
   52.00  0.884  0.003      4  |*
   53.00  0.888  0.003      4  |*
   54.00  0.890  0.003      3  |*
   55.00  0.893  0.003      3  |*
   56.00  0.896  0.003      3  |*
   57.00  0.899  0.003      4  |*
   58.00  0.902  0.003      4  |*
   59.00  0.906  0.004      5  |*
   60.00  0.907  0.001      1  |*
   61.00  0.910  0.003      3  |*
   62.00  0.912  0.003      3  |*
   63.00  0.917  0.004      5  |**
```

FIGURE 72. (continued)
CLUSTER Report

```
C L U S T E R   R E P O R T

SEGMENT NAME      :   HAZEHIM2
REPORT ISSUED ON  :   10:02:75  02-23-M1
ACQUISITIONS      :   7A150   7H222   79231   7A311
```

CLUSTER	CLUSTER CLASS	TOTAL NO. OF BLOBS	NUMBER OF BIG BLOBS	TOTAL NO. OF PIXELS	TOTAL NO. OF BIG BLOB PIXELS
1	SUMMER	78	78	4098	4098
5	SUMMER	71	71	3513	3529
9	SUMMER	67	67	2836	2836
6	SUMMER	47	47	2193	2193
3	SUMMER	43	43	2086	2086
10	SUMMER	14	14	781	781
19	SUMMER	13	19	607	607
13	SUMMER	10	10	437	437
25	SUMMER	6	6	365	365
3A	SUMMER	3	3	326	326
16	SUMMER	4	4	116	116
26	SUMMER	3	3	113	113
22	SUMMER	4	4	88	88
8	SUMMER	4	4	76	76
15	SUMMER	2	2	69	69
30	SUMMER	2	2	67	67
34	SUMMER	2	2	38	55
18	SUMMER	3	3	49	49
32	SUMMER	1	1	23	23
31	SUMMER	2	2	22	22
37	SUMMER	1	1	20	20
23	SUMMER	1	1	18	18
27	SUMMER	1	1	15	15
40	SUMMER	1	1	12	12
35	SUMMER	1	1	10	10
36	SUMMER	1	1	9	9
21	SUMMER	1	1	9	9
20	SUMMER	1	1	8	8
2	PASTURE	11	11	415	415
33	PASTURE	4	4	222	222
11	PASTURE	3	3	119	119
4	PASTURE	4	4	116	116
17	PASTURE	2	2	45	45
29	PASTURE	1	1	33	33
2A	PASTURE	1	1	31	31
14	PASTURE	1	1	26	26
24	PASTURE	1	1	20	20
7	PASTURE	1	1	19	19
12	PASTURE	1	1	17	17
41	PASTURE	1	1	14	14
10	PASTURE	1	1	10	10
0	UNCLUSTERED	126	9	3808	234

The report illustrated in Figure 73 is produced by the command SAMPLE.

FIGURE 73.
SAMPLE Report

LIST OF BLOBS TO BE LABELED

SEGMENT NAME
REPORT GENERATED AT

IBA2ERIM2
110:17:57 02-23-81

BLOB	DES	IPC	CLUSTER	NO. OF PIXELS	NO. INT PIXELS	CENTER LINE NO.	CENTER POINT NO.
85	SUMMER	60	6	159	111	11.47	173.20
881	SUMMER	60	18	177	100	99.81	98.98
741	SUMMER	60	1	147	82	84.31	106.05
698	SUMMER	60	5	116	79	79.66	68.72
678	SUMMER	60	9	107	73	77.31	82.51
626	SUMMER	60	9	135	68	49.11	131.47
76	SUMMER	60	5	107	64	9.46	60.95
448	SUMMER	60	3	103	59	49.59	27.43
611	SUMMER	60	6	104	55	67.74	107.46
574	SUMMER	60	25	110	54	68.47	175.60
1026	SUMMER	60	1	84	54	111.10	150.77
321	SUMMER	60	3	92	50	34.30	95.79
903	SUMMER	60	9	84	49	98.15	157.08
267	SUMMER	60	3	94	48	28.28	117.40
457	SUMMER	60	1	85	48	52.56	46.01
251	SUMMER	60	9	81	42	25.94	152.56
142	SUMMER	60	3	83	39	19.71	112.63
517	SUMMER	60	1	68	39	57.71	18.07
642	SUMMER	60	10	69	38	72.46	136.16
560	SUMMER	60	3	82	37	62.83	103.40
603	SUMMER	60	5	68	36	55.59	117.46
402	SUMMER	60	5	56	32	44.00	75.29
630	SUMMER	60	9	59	31	72.22	128.61
818	SUMMER	60	5	73	31	89.82	89.55
42	SUMMER	60	3	63	31	3.90	171.49
351	SUMMER	60	13	63	28	104.63	54.70
520	SUMMER	60	1	59	28	59.90	58.44
146	SUMMER	60	1	57	28	18.07	158.51
35	SUMMER	60	6	59	27	6.71	6.36
333	SUMMER	60	6	52	27	34.38	62.56
438	SUMMER	60	10	53	22	48.98	39.83
357	SUMMER	60	6	58	22	38.12	121.05
933	SUMMER	60	25	45	21	98.31	4.73
742	SUMMER	60	9	48	21	81.02	186.35
48	SUMMER	60	6	53	21	4.13	54.91
1053	SUMMER	60	1	51	21	110.20	190.49
171	SUMMER	60	6	41	20	17.88	20.66
44	SUMMER	60	1	57	20	4.75	15.04
1069	SUMMER	60	9	38	19	112.08	159.08
226	SUMMER	60	3	47	19	21.68	119.38
20	SUMMER	60	3	35	18	4.00	104.14
410	SUMMER	60	6	44	17	44.20	73.11
441	SUMMER	60	10	45	16	52.78	175.18
355	SUMMER	60	9	42	16	35.52	108.79
117	SUMMER	60	5	34	16	14.50	38.32
648	SUMMER	60	5	37	16	72.24	122.51
698	SUMMER	60	5	58	15	80.79	156.78
32	SUMMER	60	3	33	15	4.48	34.91
750	SUMMER	60	10	48	6	83.85	41.00
311	SUMMER	60	10	44	6	30.66	104.73
1094	SUMMER	60	6	33	6	114.88	63.79
19	SUMMER	60	1	34	6	3.85	80.06
344	SUMMER	60	25	33	13	43.73	104.68
260	SUMMER	60	9	30	13	24.70	183.10
846	SUMMER	60	3	48	13	91.10	112.56
131	SUMMER	60	5	33	12	14.45	96.61
566	SUMMER	60	5	23	12	62.00	194.46
777	SUMMER	60	1	45	12	83.02	92.49
219	SUMMER	60	19	50	11	21.74	176.16
900	SUMMER	60	19	41	9	94.85	83.05
1041	SUMMER	60	5	26	9	108.85	169.48
1109	SUMMER	60	5	17	9	115.29	194.29
528	SUMMER	60	1	26	9	58.62	53.41
711	SUMMER	60	6	27	8	79.15	148.08
845	SUMMER	60	5	23	8	90.39	128.09
425	SUMMER	60	5	23	8	47.77	30.16
26	SUMMER	126	8	32	7	2.28	81.38
1047	SUMMER	60	18	33	7	107.97	48.21
975	SUMMER	60	18	22	7	102.00	4.14
204	SUMMER	60	9	24	7	20.52	68.15

FIGURE 73. (continued)
SAMPLE Report

G. EXAMPLES OF COMPUTER GENERATED REPORTS

FIGURE 73.   (continued)
SAMPLE Report

The report illustrated in Figure 74 is produced by the command ESTIMATE.

FIGURE 74.
ESTIMATE Report

APPENDIX H
COMPLETE RUN-THROUGH EXAMPLE

This section consists of a simulation of the interaction with the machine portion of the procedure. The user inputs are taken from the appropriate sections of the Segment Analysis Log (SAL), Figures 75, 76, and 77, and the outputs generated are described in Appendix G.

In this section the prompts from the computer are in upper case, and the user entries are in lower case and preceded by a period (as in the standard CMS prompt). All commands are processed in interactive mode. To use batch mode, see section 4.1.2.

FIGURE 75.
SAL Acquisition Summary Sheet

SEGMENT ANALYSIS LOG

P. 4T II: ACQUISITION SUMMARY SHEET

Segment Name 127

Acquisition (YYDDD - Mo./Day)	Tape #	File #	Density	Machine Process	Composite Subwindow	TPC Acquisition	BLOB Acquisition	Separation Acquisition	Corn/Soy Discriminant $(BR_1, CR_1; BR_2, CR_2)$	Comments
78089 - MR30	7451	40	1600	✓						
78107 - AP17	"	41	=	✓	B₁	✓				
78152 - JN01	"	42	=	✓	B₂	✓				
78161 - JN10	"	43	=	✓	B₃	✓	(✓)			
78197 - JL16	"	44	=	✓	C₃	✓				
78207 - JL26	"	45	=	✓	E	✓				
78216 - AG04	"	46	=	✓	E	✓				
78243 - AG31	"	47	=	✓	E	✓	✓	✓	56,43; 81,19	
78252 - SP09	"	48	=	✓	F₁	✓	✓		55,43; 105,8	
78268 - SP26	"	49	=	✓	E₁					
78306 - NV02	"	50	=	✓	G	✓	✓			
78344 - NT10	"	51	=							Completely misregistered
78333 - NV29	"	52	=							
78350 - DC16	"	53	=							

FIGURE 76.
SAL Crop Group Strata Assignment Summary

PART IV: CROP GROUP STRATA ASSIGNMENT SUMMARY

	Pure TPC's		"A" Subclass TPC's					
	Class #		Class #		Assoc. Pure TPC	Alternatives		Scatter Plot?
	Decimal	Binary	Decimal	Binary		Assoc. TPC	Stratum	
Summer Crop	14	0001110	78	1001110	14			
			47	0101110	14	62	Pasture.	
			30	0011110	14	62	Pasture.	
			15	0001111	14			
Grain	96	1100000						
Pasture, Trees, etc.	127	1111111	124	1111100	136			
	126	1111110	31	0011111	63			
	63	0111111						
	62	0111110						
Non-Veg.	0	0000000	1	0000001	0			
Unknown	22	0010110						

FIGURE 77.
SAL Label Recording Form

H.1 DATAPREP

The data required for this command can be found in the Acquisition Summary sheet of SAL, columns "Acquisition", "Tape #", "File #", and "Machine Process". (See Figure 75).

```
.dataprep
ENTER SEGMENT NAME
.860mm
'860MM              '
 OK?
.ok
ENTER NUMBER OF LANDSAT MSS FILES YOU WISH TO MERGE
.9
        9
 OK?
.ok
ENTER ACQUISITION DATES:   'YYDDD'
.78107 78116 78152 78160 78197 78233 78251 78268 78304
  78107   78116   78152   78160   78197   78233   78251   78268   78304
 OK?
.ok
ENTER THE TAPE ID FOR EACH MSS FILE.
USE THE SAME ORDER AS ABOVE, SEPARATING WITH COMMAS.
.3680,3680,3680,3680,3680,3680,3680,3680,3680,3680
'3680                       ','3680                    ','3680
'3680                       ','3680                    ','3680
'3680                       ','3680                    ','3680
'3680                       '
 OK?
.ok
ENTER THE POSITION OF THE FILE ON THE TAPE
USE THE SAME ORDER AS ABOVE
.28,29,31,32,35,37,38,39,41
      28      29      31      32      35      37      38      39      41
 OK?
.ok
```

ENTER THE DENSITY FOR EACH TAPE. USE THE SAME ORDER AS ABOVE.
.<u>800,800,800,800,800,800,800,800,800</u>
'800 ','800 ','800 ','800 ','800 ','800 ','800 ','800 ','800 '
 OK?
.<u>ok</u>
IS THE DEFAULT WINDOW (1,117,1,1,196,1) DESIRED?
.<u>yes</u>
ALL INFORMATION HAS BEEN RECEIVED. DO YOU WANT TO PROCEED?
.<u>yes</u>
 10002 TAPE 3680 HAS BEEN REQUESTED ON UNIT 181   (TAPMOUNT)
TAPE 181 ATTACHED
 10003 TAPE READY...   EXECUTION CONTINUING   (TAPMOUNT)
 --- NO ERRORS DETECTED FOR SEGMENT 860MM   ---
PRT FILE 0193 TO RSCS   COPY 01 NOHOLD
R; T=131.19/150.34 21:26:01

     The report illustrated in Figure 67 will be printed and should be
placed in the analyst packet.

H.2   PREPROCESS

The data required for this command can be found in the Acquisition Summary sheet of SAL, columns "Acquisition" and "TPC Acquisition". (See Figure 75).

```
.preprocess
ENTER SEGMENT NAME
.860mm
'860MM          '
 OK?
.ok
SELECT SCREEN METHOD.
.spatial
'SPATIAL '
 OK?
.ok
SELECT XSTAR METHOD.
.spatial
'SPATIAL '
 OK?
.ok
ENTER NUMBER OF TPC ACQUISITIONS
.7
        7
 OK?
.ok
THE AVAILABLE ACQUISITION DATES ARE :
 78107  78116  78152  78160  78197  78233  78251  78268  78304
SELECT 7  TPC ACQUISITIONS FROM THE ABOVE LIST
.78107,78152,78160,78197,78233,78251,78268
 78107  78152  78160  78197  78233  78251  78268
 OK?
.ok
THE SELECTED ACQUISITION DATES ARE :
 78107  78152  78160  78197  78233  78251  78268
DO YOU WANT TO CHANGE THE SATELLITE NUMBERS OR SUN ANGLES?
.no
ALL INFORMATION HAS BEEN RECEIVED.  DO YOU WANT TO PROCEED?
.yes
 10002 TAPE 107000 HAS BEEN REQUESTED ON UNIT 181     (TAPMOUNT)
TAPE 181 ATTACHED
 10003 TAPE READY...    EXECUTION CONTINUING     (TAPMOUNT)
PRT FILE 0202  TO  RSCS     COPY 01 NOHOLD
 --- NO ERRORS DETECTED FOR SEGMENT 860MM          ---
R; T=865.02/900.49 22:30:16
```

The reports illustrated in Figures 68 and 69 will be printed
and should be placed in the analyst packet.

H.3 DFS

The data required for this command can be found in the Crop Group Stratum assignments sheet of SAL. (See Figure 76).

```
.dfs
ENTER SEGMENT NAME
.860mm
'860MM            '
 OK?
.ok
ENTER NUMBER OF TPCS (MAX = 104) TO BE ASSIGNED TO SUMMER
.11
     11
 OK?
.ok
ENTER  11 TPCS AND TYPES TO BE ASSIGNED TO SUMMER
.15,14,7,6,47a,31a,39a,46a,30a,23a,79a
'15     ','14     ','7      ','6      ','47A    ','31A    ','39A    ',
'46A    ','30A    '
 OK?
.ok
ENTER NUMBER OF TPCS (MAX =  93) TO BE ASSIGNED TO GRAIN
.1
      1
 OK?
.ok
ENTER   1 TPCS AND TYPES TO BE ASSIGNED TO GRAIN
.56
'56     '
 OK?
.ok
ENTER NUMBER OF TPCS (MAX =  92) TO BE ASSIGNED TO PASTURE
.8
      8
 OK?
.ok
ENTER  8 TPCS AND TYPES TO BE ASSIGNED TO PASTURE
.63,127,62,55a,60a,111a,95a,61a

'63     ','127    ','62     ','55A    ','60A    ','111A   ','95A    ','61A    '
 OK?
.ok
ENTER NUMBER OF TPCS (MAX =  84) TO BE ASSIGNED TO NON_VEG
.0
      0
 OK?
```

ERIM and UCB

.**ok**
ALL INFORMATION HAS BEEN RECEIVED. DO YOU WANT TO CONTINUE?
.**yes**
  --- NO ERRORS DETECTED FOR SEGMENT 860MM   ---
PRT FILE 0228 TO RSCS   COPY 01 NOHOLD
R; T=2.00/3.89 22:42:38

H.4 SCATTER

The data required for this command can be found in the Crop Group Stratum assignments sheet of SAL, column "Scatter Plot?". (See Figure 76).

```
.scatter
STORE COMPLETE
ENTER SEGMENT NAME
.860mm
'860MM                  '
 OK?
.ok
ENTER NUMBER OF TPC'S IN LIST TO PLOT
OR 0 FOR DEFAULT TPC LIST.
.0
       0
 OK?
.ok
DO YOU WANT STANDARD SCATTERPLOT OPTIONS?
.yes
ALL INFORMATION RECEIVED.  DO YOU WANT TO CONTINUE?
.yes
 --- NO ERRORS DETECTED FOR SEGMENT 860MM           ---
PRT FILE 0230  TO  RSCS     COPY 01 NOHOLD
R; T=108.91/117.85 22:47:52
```

H.5 CLUSTER

The data required for this command can be found in the Acquisition Summary sheet of SAL, column "BLOB Acquisition". And. "Machine Process". (See Figure 75).

```
.cluster
STORE COMPLETE
ENTER SEGMENT NAME
.860mm
'860MM
 OK?
.ok
ENTER NUMBER OF ACQUISITION DATES TO BE USED FOR BLOBBING:
.3
      3
 OK?
.ok
THE AVAILABLE ACQUISITION DATES ARE :
  78107  78116  78152  78160  78197  78233  78251  78268  78304
SELECT 3  BLOB ACQUISITIONS FROM THE ABOVE LIST
.78152,78251,78304
  78152  78251  78304
 OK?
.ok
THE SELECTED ACQUISITION DATES ARE :
  78152  78251  78304
WHICH OF THE BLOBBING DATES IS THE LATEST PREEMERGENT DATE?
.78152
  78152
 OK?
.ok
PREEMERGENT DATES :  78152
ENTER THE DESIRED NUMBER OF CLUSTERS
.40
     40
 OK?
.ok
ALL INFORMATION HAS BEEN RECEIVED.  DO YOU WANT TO PROCEED?
.yes
 10002 TAPE 107000 HAS BEEN REQUESTED ON UNIT 181     (TAPMOUNT)
TAPE 181 ATTACHED
 10003 TAPE READY...    EXECUTION CONTINUING     (TAPMOUNT)
 --- NO ERRORS DETECTED FOR SEGMENT 860MM            ---
PRT FILE 0245  TO  RSCS     COPY 01 NOHOLD
R; T=353.23/369.34 23:19:26
```

H.6   SAMPLE

The data required for this command can be found in the Acquisition Summary sheet of SAL, columns "Separation Acquisition" and "Corn/Soybean Discriminant".   (See Figure 75).

```
.sample
STORE COMPLETE
ENTER SEGMENT NAME
.860mm
'860MM                    '
 OK?
.ok
ENTER NUMBER OF SAMPLES TO BE SELECTED.
.60
     60
 OK?
.ok
ENTER NUMBER OF SEPARATION ACQUISITION DATES.
.2
      2
 OK?
.ok
THE AVAILABLE ACQUISITION DATES ARE :
  78107  78116  78152  78160  78197  78233  78251  78268  78304
SELECT 2  SEPARATION ACQUISITIONS FROM THE ABOVE LIST
.78233,78251
  78233  78251
 OK?
.ok
THE SELECTED ACQUISITION DATES ARE :
  78233  78251
ENTER COORDINATES OF THE DECISION LINES
FOR EACH SEPARATION ACQUISITION.
.45,50,120,6
.41.5,50,120,-2
 45.         50.         120.        6.        41.5        50.
120.        -2.
 OK?
.ok
```

```
ENTER THE ID OF A TAPE TO RECEIVE THE PFC PRODUCT.
.pfc12
'PFC12 '
 OK?
.ok
ENTER THE POSITION OF THE FILE ON THE TAPE.
THE FIRST FILE = 1, ETC.
7
      7
 OK?
.ok
ENTER AN ODD NUMBER > 10000 FOR RANDOM NUMBER SEED
OR ENTER 0 FOR DEFAULT SEED.
.0
      0
 OK?
.yes
ALL INFORMATION HAS BEEN RECEIVED.  DO YOU WANT TO PROCEED?
.yes
********************************************************************
* ERROR OF SEVERITY-00- DETECTED BY ROUTINE "ASAMPL    "
* FOR SEGMENT "860MM             "
*   103    SAMPLES ALLOCATED
********************************************************************
 10002 TAPE 107000 HAS BEEN REQUESTED ON UNIT 181     (TAPMOUNT)
TAPE 181 ATTACHED
 10003 TAPE READY...    EXECUTION CONTINUING     (TAPMOUNT)
 10002 TAPE PFC12 HAS BEEN REQUESTED ON UNIT 182      (TAPMOUNT)
TAPE 182 ATTACHED
 10003 TAPE READY...    EXECUTION CONTINUING     (TAPMOUNT)
 --- NO ERRORS DETECTED FOR SEGMENT 860MM             ---
PRT FILE 0250  TO  RSCS     COPY 01 NOHOLD
R; T=122.15/164.37 23:43:49
```

H.7   ESTIMATE

The data required for this command can be found in the Label Recording Forms of SAL, columns "Stage 2 Label(s)", "Crop Type" (or "Crop Group" if the level of labeling is 1), and "Confidence".   (See Figure 77).

```
.estimate
ENTER SEGMENT NAME
.860mm
'860MM                      '
 OK?
.ok
AT WHAT LEVEL WILL FIELDS BE LABELED?   (0, 1, 2)
.2
        2
 OK?
.ok
 103    FIELDS ARE TO BE LABELED
ENTER FIELD LABELS USING THE FORMAT :
BLOB# (SPACE) LABEL (SPACE) CONFIDENCE.
 'BLOB# (SPACE)' ARE OPTIONAL.
USE THE FOLLOWING SINGLE LETTERS TO DESIGNATE CROP TYPES :
C : CORN
S : SOYBEAN
0 : OTHER
  ENTER 10 LABELS BEGINNING WITH BLOB #    49
SEPARATE WITH COMMAS OR CARRIAGE RETURNS.
.49 s 5,c 5,c 5,c 5,c 5,cs 5,c 5,c 5,s 5,s 5
'49 S 5          ','C 5          ','C 5          ',C 5
'C 5             ','S 5          ','C 5          ',S 5
'C 5             ','S 5          '
 OK?
.ok
  ENTER    10 LABELS BEGINNING WITH BLOB # 1477
SEPARATE WITH COMMAS OR CARRIAGE RETURNS.
.oc 3,o 5,o 5,o 5,o 5,o 5,oc 2,os 3,o 4,s 3
'OC 3            ','O 5          ','O 5          ',O 5
'O 5             ','O 5          ','OC 2         ',OS 3
'O 4             ','S 3          '
 OK?
.ok
```

```
    ENTER    10 LABELS BEGINNING WITH BLOB #   373
SEPARATE WITH COMMAS OR CARRIAGE RETURNS.
.oc 3,o 5,o 5,o 5,o 5,o 5,oc 2,os 3,o 4,s 3
'OC 3              ','0 5              ','0 5              ',0 5
'0 5              ','0 5              ','OC 2             ',OS 3
'0 4              ','S 3             '
 OK?
.ok
    ENTER    10 LABELS BEGINNING WITH BLOB #    70
SEPARATE WITH COMMAS OR CARRIAGE RETURNS.
.oc 3,o 5,o 5,o 5,o 5,o 5,oc 2,os 3,o 4,s 3
'OC 3              ','0 5              ','0 5              ',0 5
'0 5              ','0 5              ','OC 2             ',OS 3
'0 4              ','S 3             '
 OK?
.ok
    ENTER    10 LABELS BEGINNING WITH BLOB #   666
SEPARATE WITH COMMAS OR CARRIAGE RETURNS.
.oc 3,o 5,o 5,o 5,o 5,o 5,oc 2,os 3,o 4,s 3
'OC 3              ','0 5              ','0 5              ',0 5
'0 5              ','0 5              ','OC 2             ',OS 3
'0 4              ','S 3             '
 OK?
.ok
    ENTER    10 LABELS BEGINNING WITH BLOB #  1467
SEPARATE WITH COMMAS OR CARRIAGE RETURNS.
.oc 3,o 5,o 5,o 5,o 5,o 5,oc 2,os 3,o 4,s 3
'OC 3              ','0 5              ','0 5              ',0 5
'0 5              ','0 5              ','OC 2             ',OS 3
'0 4              ','S 3             '
 OK?
.ok
    ENTER    10 LABELS BEGINNING WITH BLOB #  1458
SEPARATE WITH COMMAS OR CARRIAGE RETURNS.
.oc 3,o 5,o 5,o 5,o 5,o 5,oc 2,os 3,o 4,s 3
'OC 3              ','0 5              ','0 5              ',0 5
'0 5              ','0 5              ','OC 2             ',OS 3
'0 4              ','S 3             '
 OK?
.ok
    ENTER    10 LABELS BEGINNING WITH BLOB #   422
SEPARATE WITH COMMAS OR CARRIAGE RETURNS.
.oc 3,o 5,o 5,o 5,o 5,o 5,oc 2,os 3,o 4,s 3
'OC 3              ','0 5              ','0 5              ',0 5
'0 5              ','0 5              ','OC 2             ',OS 3
'0 4              ','S 3             '
 OK?
.ok
```

```
  ENTER   10 LABELS BEGINNING WITH BLOB # 1183
SEPARATE WITH COMMAS OR CARRIAGE RETURNS.
.oc 3,o 5,c 5,o 5,o 5,o 5,oc 2,os 3,o 4,s 3
'OC 3             ','O 5          ','O 5          ',O 5
'O 5              ','O 5          ','OC 2         ',OS 3
'O 4              ','S 3          '
 OK?
.ok
  ENTER   10 LABELS BEGINNING WITH BLOB # 1063
SEPARATE WITH COMMAS OR CARRIAGE RETURNS.
.oc 3,o 5,o 5,o 5,o 5,o 5,oc 2,os 3,o 4,s 3
'OC 3             ','O 5          ','O 5          ',O 5
'O 5              ','O 5          ','OC 2         ',OS 3
'O 4              ','S 3          '
 OK?
.ok
  ENTER    3 LABELS BEGINNING WITH BLOB # 1051
SEPARATE WITH COMMAS OR CARRIAGE RETURNS.
.s 3,c 2,o 2 'S 3            ','C 2          ','O 2
 OK?
.ok
ALL INFORMATION HAS BEEN RECEIVED.  DO YOU WANT TO PROCEED?
.yes
 --- NO ERRORS DETECTED FOR SEGMENT 860MM          ---
PRT FILE 0322  TO  RSCS    COPY 01 NOHOLD
R; T=3.46/6.82 01:05:28
```

APPENDIX I
HOW TO ACCESS DATA IN DATA BASE

This section is intended for persons with programming knowledge who need to write programs to access the data base maintained by the baseline procedure software.

There are two basic types of data in the data base, images and collateral data, and each has its own access mechanism.

I.1 ACCESSING CHARLIE ENTITIES

The collateral data is stored in a portion of the data base called CHARLIE (Collateral Holding And Retrieval Library for Information Extraction), a separate CHARLIE for each segment. The CHARLIE is created for a segment when processing of that segment begins. Data in CHARLIE may be displayed or printed with the ASK command (see section 3.3.1).

To retrieve data from a CHARLIE, two steps must be taken:

1. The CHARLIE must be 'opened' using the routine:
CALL COPEN (segname) where
* 'segname' is the 16-character left-justified name of the segment whose CHARLIE is to be opened.
This routine provides access to the CHARLIE for that particular segment.

2. The desired CHARLIE entity may now be retrieved from CHARLIE using the routine:
CALL CGET (item, pointer [,type [,length [,dimension [,dim1 [,dim2 [,dim3 [,dim4 [,dim5 [,dim6 [,dim7]]]]]]]]])
where:
* 'item' is the name of the entity (40 characters or less, left-justified, terminated with a blank),
* 'pointer' will contain on return the address of the data

The following optional parameters will be returned if included in the call to CGET:
* 'type' - the type of the data, one of 'INT ', 'REAL', 'LOG ', 'CHAR', OR 'COMP'
* 'length' - length specification of the data, in bytes (i.e. 4 byte real, etc.) note - this is the length of one element, not the entire array!
* 'dimension' - dimensionality of the item (0-7)
* 'dim1' - extent of first dimension
* 'dim2' - extent of second dimension

- 'dim3' - extent of third dimension
- 'dim4' - extent of fourth dimension
- 'dim5' - extent of fifth dimension
- 'dim6' - extent of sixth dimension
- 'dim7' - extent of seventh dimension

Now that the data entity has been copied from disk CHARLIE to virtual memory CHARLIE, it can be used in a standard FORTRAN program as follows:

The routine which actually manipulates the data should be a subroutine of the routine which called CGET so that the pointer may be interpreted correctly. The subroutine may then use the item as a standard FORTRAN variable or array. To call this subroutine, a special interface routine should be used. This routine builds a new parameter list to convert the pointer variable (from the call to CGET) to the address needed by the standard FORTRAN routine. The calling sequence for this interface routine is:
CALL C (subroutine_name, pointer) where:
- 'subroutine_name' is the name of the FORTRAN subroutine (declared EXTERNAL)
- 'pointer' is the variable returned by CGET.
If parameters which are not pointers are to be passed by routine 'C', they must be converted to pointers by the function routine 'PT'.
An example follows:
In this example, a routine gets a CHARLIE entity called 'EXAMPLE_ENTITY' and passes it to a routine to be printed. It is also assumed in this example that unit 5 has been assigned to the printer.

```
    EXTERNAL PRNTIT
    INTEGER*4 POINT, DIMENS, DIMEN1, DIMEN2, LENGTH, PT
    LOGICAL*1 TYPE(4)
    CALL SATOFF          (to suppress entries in the Status Log)
    CALL CGET ('EXAMPLE_ENTITY ',POINT, TYPE, LENGTH, DIMENS, DIMEN1,
    DIMEN2)
    CALL C(PRNTIT, POINT, PT(DIMEN1), PT(DIMEN2))

    RETURN

    SUBROUTINE PRNTIT (DATA)
    INTEGER*4 DIM1,DIM2
    REAL*4 DATA(DIM1,DIM2)

    DO 10 J=1,DIM2
    WRITE (5,100) (DATA(I,J) I=1,DIM1)
100 FORMAT (10F10.3)
10  CONTINUE

    RETURN
```

I.2 ACCESSING IMAGE DATA

Image data is stored separately from CHARLIE data as even one image is generally larger (more bytes) than the entire set of CHARLIE data for the segment. Since the images are stored separately, they have a different access mechanism than CHARLIE data.

Images are stored in a format described in Figure 78. Images may be transferred from the baseline procedure environment to "outside" tapes (tapes not controlled by the baseline procedure software) via the command TRANSMIT.

```
                          FIGURE 78.
                     External Image Format

      Images  are  saved  by  the baseline procedure software in an
 "external" format described below.  The image consists of four (4)
 header records followed by one data record for each scan line.

      Contents of Header Record 1:

              Length   Relative
 Item         (bytes)    Loc     Type          Description

 FNAME          16         1       C     Name identifying this  format
                                         ("ERSYS")

 VERS           24        17       C     Version identification of the
                                         routine  writing this format,
                                         such as "OERSYS V1.0 AUG80".

 KEY            48        41       C     Three   names   (image   name,
                                         image     subname,     image
                                         uniqueness     name)     that
                                         together  form  a  sufficient
                                         key to access this image from
                                         the database.

 NCHAN           4        89      I*4    Number of  channels  in  this
                                         image.

 NPIX            4        93      I*4    Number of pixels in each scan
                                         line.

 WINDOW         24        97      I*4    Six   integers  defining  the
                                         domain of the image:
                                            (1) first scan line number
                                            (2) last scan line number
                                            (3) scan line skip factor
                                            (4) first pixel number
                                            (5) last pixel number
                                            (6) pixel skip factor

 [Note: The scan line numbers in records 5 and  beyond  must  agree
 with  WINDOW(1)...WINDOW(3),  and  the number of pixels implied by
 WINDOW(4)...WINDOW(6) must agree with NPIX.]
```

FIGURE 78. (continued)
External Image Format

| LENGTH | 4 | 121 | I*4 | Length of a scan line logical record. This should always be 20 + NPIX + NPIX * NCHAN * 2 bytes. |

[Note: The number of physical records per scan line logical record will always be [LFVGTH/MAXLEN], rounded if necessary to the next highest integer.]

| MINLEN | 4 | 125 | I*4 | Minimum length of physical record. $16 \leq MINLEN \leq MAXLEN$ |

| MAXLEN | 4 | 129 | I*4 | Maximum length of physical record. $MINLEN \leq MAXLEN \leq 32767$ and $140 \leq MAXLEN$. MAXLEN must be even. |

[Note: MINLEN and MAXLEN exist so that systems that have record length restrictions can be serviced with this format. These variables, passed to the output writer, can be used to force all records to be shorter than a maximum, or to force all records to be the same length. They can also be used to minimize tape useage by reducing the number of I/O operations.]

| VIDEO | 4 | 133 | I*4 | Byte number (counting from i) of the start position of the pixel data in a scan line logical record. This should always be byte number [17 + NPIX]. |

| - | 4 | 137 | C | "HEND" |

FIGURE 78. (continued)
External Image Format

Contents of Header Record 2:

Item	Length (bytes)	Relative Loc	Type	Description
-	8	1	C	"MODE "
MODE	4*NCHAN	9	I*4	The mode of each channel: 1 if channel is floating point 0 if channel is integer
-	4	9+4*NCHAN	C	"MEND"

Contents of Header Record 3:

Item	Length (bytes)	Relative Loc	Type	Description
-	8	1	C	"TAG "
TAG	16*NCHAN	9	C	A name for each channel
-	4	9+16*NCHAN	C	"TEND"

```
                         FIGURE 78.   (continued)
                         External Image Format

        Contents of Header Record 4:

              Length   Relative
    Item      (bytes)    Loc     Type           Description

     -           8        1        C      "ACQDATE "

    ACQDATE   4*NCHAN      9       I*4     The acquisition date of  the
                                          data  in each channel, in the
                                          form "yyddd", where  "yy"  is
                                          the last 2 digits of the year
                                          and  "ddd"  is the day of the
                                          year.    If   the   date   is
                                          ambiguous (e.g., channel is a
                                          composite)  then  a  date  of
                                          zero is used.


     -           4     9+4*NCHAN   C      "AEND"

    [Note: TAG (from Header Record 3) and ACQDATE (from Header  Record
    4)  together  should  form an access key to the channels -- no two
    channels should have both the same ACQDATE and TAG.]
```

FIGURE 78. (continued)
External Image Format

Contents of a Scan Line Logical Record (record 5 and following):

Item	Length (bytes)	Relative Loc	Type	Description
-	4	1	C	"LINE"
LINE	4	5	I*4	Scan line number.
-	4	9	C	"DATA"
DATA	2*NCHAN*NPIX	13	I*2	A 2-byte integer for each channel of each pixel, stored spectrally interleaved (d ta values for all channels of a pixel are stored together).
-	4	13+2*NCHAN *NPIX	C	"MASK"
MASK	NPIX	17+2*NCHAN	C	One-byte 2's complement integer for each pixel: 0 - pixel data is good 1 - pixel data is bad -1 - pixel is outside of active region, and may have unpredictable values.
-	4	17+2*NCHAN *NPIX +NPIX	C	"DEND"

Pixel data (DATA) stored in this format are stored in 2-byte (16 bit) form. The manner of storage varies slightly depending whether the corresponding mode (MODE) is integer or floating point for a given channel. Integer mode data are stored in standard 2-byte signed integer for, and may range between -32768 and 32767. Floating point data are stored by multiplying by 100.0 and rounding the result to a 2-byte integer, giving a range of -327.68 to 327.67. This slightly exceeds the range of 1-byte data, and gives 2 decimal places of precision.

APPENDIX J
DATA BASE ELEMENTS

This section provides information about all data entities used in the pilot. Specifically it states:

(a)   Which command creates the entity.

(b)   The source of the entity's value.

(c)   The type and dimensionality of the entity.

(d)   In the case of images, the precursor image.

(e)   Why it exists and what it is used for.

(f)   A description of the entity.

The appendix is divided into two subsections:
- images (manipulated by image routines)
- CHARLIE entities (manipulated by CHARLIE routines)

J.1   IMAGE ELEMENTS

IMAGE "BLOBS"

TYPE: Integer*4, (number of pixels)
CREATOR: Command CLUSTER
SOURCE: Module BLOBER
INITIAL IMAGE: TASCAP, SCREEN

DESCRIPTION: The blob image contains the blob number assigned to each pixel. The blob numbers range from 0 for the garbage blob through NO_OF_BLOBS -1.

IMAGE "GRABS"

TYPE: Real*4 (NO_OF_ACQUISITIONS, number of pixels)
CREATOR: Command PREPROCESS
SOURCE: Module GRABS
INITIAL IMAGE: TASCAP

DESCRIPTION: The GReeness Above Bare Soil image is computed using a linear transformation of the Greenness and Brightness channels of the TASCAP image.

IMAGE "REALIM"

TYPE: Real*4 (NO_OF_ACQUISTIONS*4, number of pixels)
CREATOR: Command DATAPREP
SOURCE: Module REALIM
INITIAL IMAGE: MERGE (Merged raw data images from Universal format tapes)

DESCRIPTION: The MERGED image is converted from universal format to internal (real*4) format.

IMAGE "SCREEN"

TYPE: Integer*4 (NO_OF_ACQUISITIONS, number of pixels)
CREATOR: Command PREPROCESS
SOURCE: Module SCREEN
INITIAL IMAGE: SUNCOR

DESCRIPTION: This image will contain a screen code for each acquisition of each pixel. The screen codes are used as defined in the SCREEN_RESULTS_TABLE.

```
                    ┌─────────────────────────────────┐
                    │         IMAGE "STRIP"           │
                    └─────────────────────────────────┘

TYPE:           Integer*4 (number of pixels)
CREATOR:        Command CLUSTER
SOURCE:         Module STRIP
INITIAL IMAGE:  BLOB

DESCRIPTION:    The strip image contains a value for each pixel.  Strip
                values are 1 if the pixel is an interior pixel and 0 if
                it is a boundary pixel.
                A pixel is defined to be an interior pixel if:
                   1 - It is not in the garbage blob.
                   2 - Its mask value is zero.
                   3 - All rook move adjacent pixels satisfy
                         one of the following:
                       a) It is in the same blob
                       b) It is in the garbage blob.
                       c) It has a non-zero mask value.
                       d) It is outside the segment.
```

```
                    ┌─────────────────────────────────┐
                    │         IMAGE "SUNCOR"          │
                    └─────────────────────────────────┘

TYPE:           Real*4 (NO_OF_ACQUISITIONS*4, number of pixels)
CREATOR:        Command PREPROCESS
SOURCE:         Module SUNCOR
INITIAL IMAGE:  REALIM

DESCRIPTION:    Image corrected for satellite type and sun angle.
```

```
                    ┌─────────────────────────────────┐
                    │         IMAGE "TASCAP"          │
                    └─────────────────────────────────┘

TYPE:           Real*4 (NO_OF_ACQUISITIONS*4, number of pixels)
CREATOR:        Command PREPROCESS
SOURCE:         Module TASCAP
INITIAL IMAGE:  XSTAR

DESCRIPTION:    Tasselled Cap transformed data.
```

```
                    ┌─────────────────────────────────┐
                    │         IMAGE "TPC"             │
                    └─────────────────────────────────┘

TYPE:           Integer*4 (number of pixels)
CREATOR:        Command PREPROCESS
SOURCE:         Module GRABS
INITIAL IMAGE:  GRABS

DESCRIPTION:    Each pixel in the image contains a TPC bit  string  for
                the  acquisitions  specified in TPC_ACQUISITIONS.  Bits
```

are ordered (left to right) corresponding to the order
of the acquisition date. The bit strings are right
justified.

> ### IMAGE "XSTAR"

TYPE: Real*4 (NO_OF_ACQUISITIONS*4, number of pixels)
CREATOR: Command PREPROCESS
SOURCE: Module XSTAR
INITIAL IMAGE: SUNCOR

DESCRIPTION: This image is corrected for haze depending on the
                setting of the switch XSTAR_METHOD.

J.2 CHARLIE ENTITIES

ACQUISITIONS

TYPE: Integer*4 (NO_OF_ACQUISITIONS)
CREATOR: Command DATAPREP
SOURCE: User input
PURPOSE: Defines the overall set of acquisitions to be used throughout the procedure.

DESCRIPTION: Set of acquisition dates in the form YYDDD where YY is the year and DDD is the Julian date.

ACTUAL_SAMPLE_SIZE

TYPE: Integer*4
CREATOR: Command SAMPLE
SOURCE: Module ASAMPL
PURPOSE: Indicates the number of blobs actually sampled

DESCRIPTION: Reflects the number of blobs actually sampled (not necessarily the number of samples requested by the user).

BCLUSTER_WEIGHTS

TYPE: Real*4 (NO_OF_WEIGHTS)
CREATOR: Command SAMPLE
SOURCE: Module ASAMPL
PURPOSE: Allow the user to weight the selection of clusters for sampling

DESCRIPTION: Weights for each cluster to be used when allocating the number of samples each cluster is to receive. At present is configured to be 1.

BLOB_ACQUISTIONS

TYPE: Real*4 (NO_OF_BLOB_ACQUISITIONS)
CREATOR: Command CLUSTER
SOURCE: User input
PURPOSE: Specifies which acquisitions are to be used for blobbing and clustering.

DESCRIPTION: A subset of the set of all acquisitions (ACQUISITIONS) in form yyddd available for machine processing.

```
┌─────────────────────────────────────────┐
│            BLOB_CENTER_LINE              │
└─────────────────────────────────────────┘
```

TYPE: Real*4 (NO_OF_BLOBS)
CREATOR: Command CLUSTER
SOURCE: Module BCOMP
PURPOSE: Used to identify the location of a blob in a scene.

DESCRIPTION: The line coordinate (y coordinate) of the center of the
              blob mass.

```
┌─────────────────────────────────────────┐
│            BLOB_CENTER_POINT             │
└─────────────────────────────────────────┘
```

TYPE: Real*4 (NO_OF_BLOBS)
CREATOR: Command CLUSTER
SOURCE: Module BCOMP
PURPOSE: Used to identify the location of a blob in a scene.

DESCRIPTION: The point coordinate (x coordinate) of the center of
              the blob mass.

```
┌─────────────────────────────────────────┐
│              BLOB_EXTENT                 │
└─────────────────────────────────────────┘
```

TYPE: Integer*4 (4, NO_OF_BLOBS)
CREATOR: Command CLUSTER
SOURCE: Module BCOMP
PURPOSE: To aid in the ocular identification of labeling targets
              in the PFC overlay showing sampled blobs.

DESCRIPTION: The array defines a rectangle enclosing blob z where
                  BLOB_EXTENT(1, Z) = minimum y (scan line)
                  BLOB_EXTENT(2, Z) = maximum y (scan line)
                  BLOB_EXTENT(3, Z) = minimum x (pixel #)
                  BLOB_EXTENT(3, Z) = maximum x (pixel #)

```
┌─────────────────────────────────────────┐
│          BLOB_INDICES_IN_SAMPLE          │
└─────────────────────────────────────────┘
```

TYPE: Integer*4 (ACTUAL_SAMPLE_SIZE)
CREATOR: Command SAMPLE
SOURCE: Module ASAMPL
PURPOSE: Allows easy access to the statistics of a sampled blob.

DESCRIPTION: Set of indexes into the entity LIST_OF_BLOBS which
              identify the set of blobs selected as labeling targets.

```
┌─────────────────────────────────────┐
│          BLOB_MEANS_DISTANCE        │
└─────────────────────────────────────┘
```

TYPE: Real*4   (NO_OF_SEPARATION_ACQUISITIONS,
                ACTUAL_SAMPLE_SIZE)
CREATOR: Command SAMPLE
SOURCE: Module STAGE1
PURPOSE: Allows easy access to the statistics of sampled blobs.

DESCRIPTION: Distance from the decision line for each sampled blob
                for each separation acquisition.

```
┌─────────────────────────────────────┐
│            BLOB_MEANS_ZONE          │
└─────────────────────────────────────┘
```

TYPE: Character*1   (NO_OF_SEPARATION_ACQUISITIONS,
                ACTUAL_SAMPLE_SIZE)
CREATOR: Command SAMPLE
SOURCE: Module STAGE1
PURPOSE: Allows easy access to the statistics of sampled blobs.

DESCRIPTION: Zone (A, B, C, or D) each blob mean falls in for each
                separation acquisition.

```
┌─────────────────────────────────────┐
│           BLOB_PASS3_SWITCH         │
└─────────────────────────────────────┘
```

TYPE: Logical*4
CREATOR: Command CLUSTER
SOURCE: Command CLUSTER
PURPOSE: To specify whether the blobbing module should execute a
                third pass over existing blobs to merge similar blobs.

DESCRIPTION: A third pass will occur if BLOB_PASS3_SWITCH is TRUE.

```
┌─────────────────────────────────────┐
│          BLOB_SCREEN_SWITCH         │
└─────────────────────────────────────┘
```

TYPE: Logical*4
CREATOR: Command CLUSTER
SOURCE: Command CLUSTER
PURPOSE: To indicate whether the screen image will be used
                during blobbing.
                Note: This switch is configured to be FALSE for the
                pilot.

DESCRIPTION: If the boolean is TRUE then the screen image will be
                used.
                Note: This is presently configured to false.

BRIGHTNESS_MEAN

TYPE: Real*4 (NO_OF_ACQUISITIONS, NO_OF_BLOBS)
CREATOR: Command CLUSTER
SOURCE: Module BCOMP

DESCRIPTION: An array (i, j) where i is an index into the vector
              ACQUISITIONS and j is an index into the vector
              LIST_OF_BLOBS. Thus BRIGHTNESS_MEAN(i, j) is the
              brightness mean for acquisition ACQUISITIONS(i) of blob
              LIST_OF_BLOBS(j). The brightness mean is computed for
              all non-screened interior pixels of a blob (if the
              screen image is being used in blobbing).

BRIGHTNESS_VARIANCE

TYPE: Real*4 (NO_OF_ACQUISITIONS, NO_OF_BLOBS)
CREATOR: Command CLUSTER
SOURCE: Module BCOMP
PURPOSE: Used for clustering.

DESCRIPTION: A vector of statistical variances for all the
              acquisition dates of each blob.

CLUSTER_ASSIGNMENT

TYPE: Integer*4 (NO_OF_BLOBS)
CREATOR: Command CLUSTER
SOURCE: Module BCLUST
PURPOSE: Identity cf cluster to which a blob is assigned.

DESCRIPTION: A vector of indices into CLUSTER_CLASS, where the index
              is also the cluster number. A cluster number of 0
              indicates the blob was now clustered.

CLUSTER_BRIGHTNESS

TYPE: Real*4 (NO_OF_BLOB_ACQUISITIONS, NO_OF_CLUSTERS)
CREATOR: Command CLUSTER
SOURCE: Module BCLUST

DESCRIPTION: The Brightness value for each cluster for each blob
              acquisition.

```
                    ┌─────────────────────────────────────┐
                    │           CLUSTER_CLASS              │
                    └─────────────────────────────────────┘

TYPE:            Character*12 (NO_OF_CLUSTERS)
CREATOR:         Command CLUSTER
SOURCE:          Module BCLUST
PURPOSE:         A list of cluster classes.

DESCRIPTION:     List of names which will be the same as  the  DFS's  of
                 all  blobs  within  that  cluster with the exception of
                 UNKNOWN and TRIVIAL blobs  which  are  assigned  to  an
                 existing cluster if within the TAU threshold or else to
                 cluster "0" (not actually clustered).

                    ┌─────────────────────────────────────┐
                    │        CLUSTER_CLASS_LIST            │
                    └─────────────────────────────────────┘

TYPE:            Character*12 (NUMBER_OF_CLUSTER_CLASSES)
CREATOR:         Command SAMPLE
SOURCE:          Module ASAMPL
PURPOSE:         List of all cluster classes

DESCRIPTION:     This  list  will mirror DFS_TABLE with the exception of
                 the classes TRIVIAL and UNKNOWN which will  be  not  be
                 included.

                    ┌─────────────────────────────────────┐
                    │           CLUSTER_GRABS              │
                    └─────────────────────────────────────┘

TYPE:            Real*4 (NO_OF_BLOB_ACQUISITIONS, NO_OF_CLUSTERS)
CREATOR:         Command CLUSTER
SOURCE:          Module BCLUST

DESCRIPTION:     The  GRABS  value  for  each  cluster  for  each  blob
                 acquisition.

                    ┌─────────────────────────────────────┐
                    │         CLUSTER_NO_OF_PIX            │
                    └─────────────────────────────────────┘

TYPE:            Integer*4 (NO_OF_CLUSTERS)
CREATOR:         Command CLUSTER
SOURCE:          Module BCLUSTER
PURPOSE:         List of the number of pixels in each cluster.

DESCRIPTION:     The total number of pixels in each cluster.
```

COUNT_THRESHOLD_FOR_TRIVIAL_TPC

TYPE: Integer*4
CREATOR: Command DFS
SOURCE: Command DFS
PURPOSE: To identify the trivial TPC's.

DESCRIPTION: If a TPC contains less than this number of pixels, it is assigned to a trivial DFS.

DECISION_LINE

TYPE: Real*4 (4, NO_OF_SEPARATION_ACQUISITIONS)
CREATOR: Command SAMPLE
SOURCE: User input
PURPOSE: The coordinates of the linear discriminant used for labeling.

DESCRIPTION: A line which should be perpendicular to the green arm. Two points for each acquisition, each point specified by the x-coordinate followed by the y-coordinate.

DESIRED_NO_OF_CLUSTERS

TYPE: Integer*4
CREATOR: Command CLUSTER
SOURCE: Command CLUSTER
PURPOSE: Provides the capability to specify the number of clusters desired.

DESCRIPTION: The DESIRED_NO_OF_CLUSTERS will be used by the module BCLUST when forming clusters. However the number of clusters actually formed will be reflected in NO_OF_CLUSTERS.

DFS_OF_BLOB

TYPE: Character*12 (NO_OF_BLOBS)
CREATOR: Command CLUSTER
SOURCE: Module BDFS
PURPOSE: List of the DFS's of blobs.

DESCRIPTION: The DFS assignment of blob LIST_OF_BLOBS(j) is found using the TPC_OF_BLOB(j). If the TPC is in the TPC_TABLE and the DFS associated with this TPC is not TRIVIAL then that DFS is used. Otherwise, UNKNOWN will used.

```
                    ┌─────────────────────────────────────┐
                    │            DFS_OF_TPC               │
                    └─────────────────────────────────────┘
```

TYPE: Character*12 (TPC_TABLE_SIZE)
CREATOR: Command DFS
SOURCE: User input
PURPOSE: List identifying the DFS of each TPC.

DESCRIPTION: A list of 12-character Delta Function Stratum left
                justified with no embedded blanks and right padded with
                blanks.

```
                    ┌─────────────────────────────────────┐
                    │            DFS_TABLE                │
                    └─────────────────────────────────────┘
```

TYPE: Character*12 (NO_OF_DFS)
CREATOR: Command DFS
SOURCE: User input or DFS command
PURPOSE: Defines a list of valid Delta Function Stratum names.

DESCRIPTION: A list of 12-character left justified with no embedded
                blanks and right padded with blanks. The list must
                contain the DFS categories TRIVIAL and UNKNOWN.

```
                    ┌─────────────────────────────────────┐
                    │      ESTIMATE_BIG_BLOBS_ONLY        │
                    └─────────────────────────────────────┘
```

TYPE: Real*4 (NO_OF_CROP_TYPES)
CREATOR: Command ESTIMATE
SOURCE: Module AESTIM
PURPOSE: Allow the comparison of the two estimate methods: using
                big blobs only, and using all blobs (little and big).

DESCRIPTION: A vector of estimates using only big blobs.

```
                    ┌─────────────────────────────────────┐
                    │   ESTIMATE_LITTLE_BLOBS_WEIGHTED    │
                    └─────────────────────────────────────┘
```

TYPE: Real*4 (NO_OF_CROP_TYPES)
CREATOR: Command ESTIMATE
SOURCE: Module AESTIM
PURPOSE: Allow the comparison of the two estimate methods: using
                big blobs only, and using all blobs (little and big).

DESCRIPTION: A vector of estimates, where the estimate is computed
                using all blobs (little and big).

FIELD_LABELS

TYPE: Character*4 (ACTUAL_SAMPLE_SIZE)
CREATOR: Command ESTIMATE
SOURCE: User input
PURPOSE: List of labels assigned by user to selected targets.

DESCRIPTION: User provides labels according to the LEVEL_OF_LABELLING. If the level is:
    0 - no user input
    1 - s, o, so
    2 - c, s, o, cs, co, so, cso.

GAMMA

TYPE: Real*4 (NO_OF_ACQUISITIONS, z1, z2)
CREATOR: Command PREPROCESS
SOURCE: Module XGAMMA
PURPOSE: A 3 dimensional matrix of the gamma values computed using the XSTAR haze-correction algorithm.

DESCRIPTION: The 3 dimensional matrix takes on different meanings depending on the value of XSTER_METHOD.
(0) no haze-correction steps were performed,
(1) spatially varying XSTAR was performed,
(2) global XSTAR was used.
    Case 0 - GAMMA is (NO_OF_ACQUISITIONS, 1, 1) and has the values 0.0 for each acquisition indicating that no transformation was performed.
    Case 1 - In this case z1 represents the number of of 5-pixel blocks and z2 represents the number of 5 scan line blocks.
    Case 2 - In this case z1 and z2 are 1 since the entire scene is treated as one block. Hence GAMMA is (NO_OF_ACQUISITIONS, 1, 1).

GRABS_BRIGHTNESS_COVARIANCE

TYPE: Real*4 (NO_OF_ACQUISITIONS, NO_OF_BLOBS)
CREATOR: Command CLUSTER
SOURCE: Module BCOMP
PURPOSE: List of blob GRABS-Brightness covariances.

DESCRIPTION: The matrix GRABS_BRIGHTNESS_COVARIANCE(i, j) is the GRABS-Brightness covariance of acquisition i for blob LIST_OF_BLOBS(j).

```
                        ┌─────────────────────────────────────┐
                        │            GRABS_MEAN                │
                        └─────────────────────────────────────┘

TYPE:            Real*4 (NO_OF_ACQUISITIONS, NO_OF_BLOBS)
CREATOR:         Command CLUSTER
SOURCE:          Module BCOMP
PURPOSE:         List of blob GRABS means.

DESCRIPTION:     The matrix GRABS_MEAN(i, j) is the GRABS (GReeness
                 Above Bare Soil) mean for non_screened interior pixels
                 if the sceen image is used for blobbing else all
                 pixels. The mean is of acquisition ACQUISITIONS(i) for
                 blob LIST_OF_BLOBS(j).

                        ┌─────────────────────────────────────┐
                        │          GRABS_VARIANCE             │
                        └─────────────────────────────────────┘

TYPE:            Real*4 (NO_OF_ACQUISITIONS, NO_OF_BLOBS)
CREATOR:         Command CLUSTER
SOURCE:          Module BCOMP
PURPOSE:         List of blob GRABS variances.

DESCRIPTION:     The matrix GRABS_VARIANCE(i, j) is the variance of
                 acquisition ACQUISITIONS(i) for blob LIST_OF_BLOBS(j).

                        ┌─────────────────────────────────────┐
                        │       INITIALIZING_SUBWINDOW        │
                        └─────────────────────────────────────┘

TYPE:            Integer*4 (6)
CREATOR:         Command DATAPREP
SOURCE:          User input
PURPOSE:         Allow the user to specify a subset of the actual
                 segment to be processed in the procedure.

DESCRIPTION:     The elements of the vector have the following meanings:
                     (1) line begin
                     (2) line end
                     (3) line skip factor
                     (4) pixel begin
                     (5) pixel end
                     (6) pixel skip factor

                        ┌─────────────────────────────────────┐
                        │        INTERIOR_PIX_IN_BLOB         │
                        └─────────────────────────────────────┘

TYPE:            Integer*4 (NO_OF_BLOBS)
CREATOR:         Command CLUSTER
SOURCE:          Module BCOMP
PURPOSE:         List of the number of interior pixels in the blobs.

DESCRIPTION:     The vector INTERIOR_PIXEL_IN_BLOB(i) is the number of
                 interior pixels (an interior pixel is a pixel
                 surrounded on all four sides by pixels from the same
                 blob) in the blob LIST_OF_BLOBS(i).
```

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LABEL_CONFIDENCE

TYPE: Integer*4 (ACTUAL_SAMPLE_SIZE)
CREATOR: Command ESTIMATE
SOURCE: User input
PURPOSE: Allow the user to indicate the confidence of a target label.

DESCRIPTION: The vector will contain integer values from 1 to 5, where 1 is least confident and 5 is most confident.

LABEL_PERCENTS

TYPE: Real*4 (NO_OF_CROP_TYPES, ACTUAL_SAMPLE_SIZE)
CREATOR: Command ESTIMATE
SOURCE: Module LABCON
PURPOSE: Compute percentage of sampled blob in each crop type.

DESCRIPTION: The vector should contain only the following possible values: 0%, 33.33%, 50%, 66.67%, 100%.

LATITUDES

TYPE: Character*6 (NO_OF_ACQUISITIONS)
CREATOR: Command DATAPREP
SOURCE: Extracted from Universal data header by module IUNIV
PURPOSE: Verification and documentation

DESCRIPTION: Each latitude is in the form cdddmm where c represents north or south, dddmm is the latitude in degrees and minutes. For example N04002.

LEVEL_OF_LABELLING

TYPE: Integer*4
CREATOR: Command ESTIMATE
SOURCE: User input
PURPOSE: Identifies the level of labeling.

DESCRIPTION: The values of LEVEL_OF_LABELLING and their meanings are
             0 no labels
             1 differentiated between summer or other
             2 differentiated between corn or soy or other

```
                    ┌─────────────────────────────────┐
                    │         LINE_VARIANCE           │
                    └─────────────────────────────────┘

TYPE:           Real*4
CREATOR:        Command CLUSTER
SOURCE:         Command CLUSTER
PURPOSE:        Allow the user to parametrically vary blobbing.

DESCRIPTION:    The scalar LINE_VARIANCE is the reciprocal of the
                weight applied to the line of each pixel coordinate
                when assigning a pixel to a blob.

                    ┌─────────────────────────────────┐
                    │         LIST_OF_BLOBS           │
                    └─────────────────────────────────┘

TYPE:           Integer*4 (NO_OF_BLOBS)
CREATOR:        Command CLUSTER
SOURCE:         Module BCOMP
PURPOSE:        Provide a list of blobs.

DESCRIPTION:    The vector LIST_OF_BLOBS is the blob number associated
                with the index i.  The last blob in the list the
                garbage blob has a blob number of 0.
                Note: Due to efficiency considerations the numerous
                blob statistics are not ordedred by increasing blob
                number.  Therefore it is necessary to use this index to
                obtain the blob number of the ith entry in a blob table
                or list.

                    ┌─────────────────────────────────┐
                    │        LIST_OF_CROP_TYPES       │
                    └─────────────────────────────────┘

TYPE:           Character*12 (NO_OF_CROP_TYPES)
CREATOR:        Command ESTIMATE
SOURCE:         Command ESTIMATE
PURPOSE:        Defines the crop types that will be used in labeling.

DESCRIPTION:    A list of crop types that will be used for labeling
                blobs.

                    ┌─────────────────────────────────┐
                    │           LONGITUDES            │
                    └─────────────────────────────────┘

TYPE:           Character*6 (NO_OF_ACQUISITIONS)
CREATOR:        Command DATAPREP
SOURCE:         Extracted from the Universal data header by the  module
                IUNIV
PURPOSE:        Documentation and validation

DESCRIPTION:    Each  longitude is in the form cdddmm where c indicates
                East or West, where dddmm is the longitude  in  degrees
                and minutes.  For example E02006.
```

MERGED_REAL_IMAGE_WINDOW

TYPE: Integer*4 (6)
CREATOR: Command DATAPREP
SOURCE: Module SUBSET
PURPOSE: To record what portion of the full segment is being processed.

DESCRIPTION: The vector is in the form:
                (1) - line begin
                (2) - line end
                (3) - line skip factor
                (4) - pixel begin
                (5) - pixel end
                (6) - pixel skip factor

NO_OF_ACQUISITIONS

TYPE: Integer*4
CREATOR: Command DATAPREP
SOURCE: User input
PURPOSE: To record which acquisitions are being processed.

DESCRIPTION: The number of acquisitions in the data set which will undergo analysis.

NO_BLOB_ACQUISITIONS

TYPE: Integer*4
CREATOR: Command CLUSTER
SOURCE: User input
PURPOSE: Specify the number of acquisitions to be used for blobbing and clustering.

DESCRIPTION: This scalar must be between 1 and 4 inclusive.

NO_OF_BLOBS

TYPE: Integer*4
CREATOR: Command CLUSTER
SOURCE: Module BCOMP

DESCRIPTION: The total number of blobs formed for a segment. This includes big blobs (blobs with interior pixels), little blobs (blobs with no interior pixels), and the garbage blob which is assigned a blob number of 0.

```
                    ┌─────────────────────────────────────┐
                    │        NO_OF_CLUSTER_CLASSES         │
                    └─────────────────────────────────────┘

TYPE:           Integer*4
CREATOR:        Command SAMPLE
SOURCE:         Module ASAMPL

DESCRIPTION:    The number of cluster classes specified by the user   in
                the vector CLUSTER_CLASS_LIST.

                    ┌─────────────────────────────────────┐
                    │            NO_OF_CLUSTERS            │
                    └─────────────────────────────────────┘

TYPE:           Integer*4
CREATOR:        Command CLUSTER
SOURCE:         Module BCLUST

DESCRIPTION:    The number of clusters formed for a segment.

                    ┌─────────────────────────────────────┐
                    │          NO_OF_CLUSTER_RANGE         │
                    └─────────────────────────────────────┘

TYPE:           Integer*4
CREATOR:        Command CLUSTER
SOURCE:         Module BCLUST

DESCRIPTION:    Specifies      the      maximum      deviation      between
                NUMBER_OF_CLUSTERS and DESIRED_NO_OF_CLUSTERS.

                    ┌─────────────────────────────────────┐
                    │            NO_OF_CROP_TYPES          │
                    └─────────────────────────────────────┘

TYPE:           Integer*4
CREATOR:        Command ESTIMATE
SOURCE:         Command ESTIMATE

DESCRIPTION:    The number of  crop  types  used  by  the  analyst  for
                labeling.

                    ┌─────────────────────────────────────┐
                    │               NO_OF_DFS              │
                    └─────────────────────────────────────┘

TYPE:           Integer*4
CREATOR:        Command DFS
SOURCE:         User input or command DFS
PURPOSE:        Allow   the   user to specify the number of DFS in a list
                replacing the standard DFS list.

DESCRIPTION:    Equivalent to the number of entries in DFS_TABLE.
```

NO_OF_ITERATIONS

TYPE: Integer*4
CREATOR: Command CLUSTER
SOURCE: Module BCLUST
PURPOSE: Specify the number of times that the module BCLUST should iterate to find a distance threshold which will generate NO_OF_CLUSTERS within ± NO_OF_CLUSTERS_RANGE of DESIRED_NO_OF_CLUSTERS.

NO_OF_PREEMERGENT_ACQUISITIONS

TYPE: Integer*4
CREATOR: Command CLUSTER
SOURCE: User input
PURPOSE: Specifies the number of preemergent acquisitions.

NO_OF_SAMPLES_PER_CLUSTER

TYPE: Integer*4 (NO_OF_CLUSTERS)
CREATOR: Command SAMPLE
SOURCE: Module ASAMPL

DESCRIPTION: The number of samples allocated to each cluster. If a cluster is assigned to the trash cluster then NO_OF_SAMPLES_PER_CLUSTER(i)=0 .

NO_OF_SAMPLES_PER_TRASH

TYPE: Integer*4 (NO_OF_CLUSTER_CLASSES)
CREATOR: Command SAMPLE
SOURCE: Module ASAMPL

DESCRIPTION: The number of samples allocated to each trash conglomerate.

NO_OF_SEPARATION_ACQUISITIONS

TYPE: Integer*4
CREATOR: Command SAMPLE
SOURCE: User input

DESCRIPTION: The number of separation acquisitions.

```
                        ┌────────────────────────────────────┐
                        │            NO_TPC_ACQS             │
                        └────────────────────────────────────┘

TYPE:           Integer*4
CREATOR:        Command PREPROCESS
SOURCE:         User input

DESCRIPTION:    The number of acquisitions in the set TPC_ACQS which is
                a subset of ACQUISITIONS.

                        ┌────────────────────────────────────┐
                        │           POINT_VARIANCE           │
                        └────────────────────────────────────┘

TYPE:           Command CLUSTER
CREATOR:        Command CLUSTER
SOURCE:         Module BLOBER
PURPOSE:        Allow the specification of the BLOBER parameter.

DESCRIPTION:    The scalar is the reciprocal of the weight  as  applied
                to  each  pixel point coordinate when assigning them to
                blobs.

                        ┌────────────────────────────────────┐
                        │      PREEMERGENT_ACQUISITIONS      │
                        └────────────────────────────────────┘

TYPE:           Integer*4 (NO_OF_PREEMERGENT_ACQUISITIONS)
CREATOR:        Command CLUSTER
SOURCE:         User input
PURPOSE:        List of preemergent acquisitions.

DESCRIPTION:    The set of preemergent  acquisitions  is  a  subset  of
                BLOB_ACQUISITIONS   which   in  turn  is  a  subset  of
                ACQUISITIONS.  This set of preemergent acquisitions  is
                treated differently during blobbing.  Normally blobbing
                is  done  using  the brightness and greeness values but
                for preemergent acquisitions only greeness  values  are
                used.

                        ┌────────────────────────────────────┐
                        │         RANDOM_NUMBER_SEED         │
                        └────────────────────────────────────┘

TYPE:           Integer*4
CREATOR:        Command SAMPLE
SOURCE:         User input
PURPOSE:        Seed for a pseudo-random number generator which is used
                to select blobs at random.

DESCRIPTION:    The scalar must be a positive odd number.
```

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REQUESTED_SAMPLE_SIZE

TYPE: Integer*4
CREATOR: Command SAMPLE
SOURCE: User input
PURPOSE: Allow the user to specify the number of desired samples.

SATELLITE_NUMBERS

TYPE: Integer*4 (NO_OF_ACQUISITIONS)
CREATOR: Command PREPROCESS
SOURCE: User, but may be defaulted to value from tape header saved in TAPE_SATELLITE_NUMBERS.
PURPOSE: Determines the type of satellite correction performed.

DESCRIPTION: The values possible for the vector and their meanings are:
    0 - Lacie calibration of Landsat 2
    1 - Landsat 1
    2 - Full frame calibration of Landsat 2
    3 - Landsat 3

SCREEN_METHOD

TYPE: Integer*4
CREATOR: Command PREPROCESS
SOURCE: User input
PURPOSE: Determines what type of haze-correction should be performed.

DESCRIPTION: The possible values for the scalar and their meanings are:
    0 - perform no screening
    1 - use spatially varying screen
    2 - use global screen

SCREEN_RESULTS_TABLE

TYPE: Integer*4 (11, NO_OF_ACQUISITIONS)
CREATOR: Command PREPROCESS
SOURCE: Module SCREEN
PURPOSE: To provide the screen results for verification or validation.

DESCRIPTION: The format of the SCREEN_RESULTS_TABLE(i, j) is as follows: the j index is acquisition, and the i index is the screen code plus one. The screen codes are from 0 to 10 with the following meanings:
    0 - good pixels

```
1 - water pixels
2 - cloud pixels
3 - garbled pixels
5 - cloud shadow over water
6 - cloud shadow
10 - diffuse cloud or dense haze
```

Thus SCREEN_RESULTS_TABLE(i, j) is the number of pixels of acquisition j which were assigned screen code i-1.

SEGMENT_NAME

TYPE: Character*16
CREATOR: Command DATAPREP
SOURCE: User input
PURPOSE: Used for error checking.

DESCRIPTION: The SEGMENT_NAME is redundant with the segment key.

SEPARATION_ACQUISITION

TYPE: Integer*4 (NO_SEPARATION_ACQUISITIONS)
CREATOR: Command SAMPLE
SOURCE: User input

DESCRIPTION: The set of separation acquisitions must be a subset of ACQUISITIONS.

SITE_NUMBERS

TYPE: Integer*4 (NO_OF_ACQUISITIONS)
CREATOR: Command DATAPREP
SOURCE: Extracted from the Universal data header by the module IUNIV
PURPOSE: Validation and verification.

DESCRIPTION: A vector of 4-digit site numbers.

SPATIAL_FINAL_THRESHOLD

TYPE: Real*4
CREATOR: Command CLUSTER
SOURCE: Command CLUSTER
PURPOSE: Allow the user to parametrically vary blobbing.

DESCRIPTION: The scalar SPATIAL_FINAL_THRESHOLD is the spatial distance threshold used by the module BLOBER for its second and third passes. In the second pass, a pixel which was deferred (not assigned to a blob) in the first pass will be assigned to an adjacent blob if the distance to that blob center is less than SPATIAL_FINAL_THRESHOLD and the spectral distance is

less than SPECTRAL_FINAL_THRESHOLD.

SPATIAL_HIGH_THRESHOLD

TYPE: Real*4
CREATOR: Command CLUSTER
SOURCE: Command CLUSTER
PURPOSE: Allow the user to parametrically vary blobbing.

DESCRIPTION: In the first pass of module BLOBER over a scan line of pixels, a pixel will start a new blob if the spatial distance to the closest blob exceeds SPATIAL_HIGH_THRESHOLD.

SPATIAL_LOW_THRESHOLD

TYPE: Real*4
CREATOR: Command CLUSTER
SOURCE: Command CLUSTER
PURPOSE: Allow the user to parametrically vary blobbing.

DESCRIPTION: In the first pass of module BLOBER over a scan line of pixels, if for a pixel the spatial distance to the closest blob is less than SPATIAL_LOW_THRESHOLD then it is added to that blob. Otherwise, it either starts a new blob or is deferred to the next pass.

SPECTRAL_FINAL_THRESHOLD

TYPE: Real*4
CREATOR: Command CLUSTER
SOURCE: Command CLUSTER
PURPOSE: Allow the user to parametrically vary blobbing.

DESCRIPTION: In the second pass of module BLOBER over a scan line of pixels, a pixel which was deferred from the first pass will be assigned to an adjacent blob if its spectral distance to that blob is less than SPECTRAL_FINAL_THRESHOLD and its spatial distance is less than SPATIAL_FINAL_THRESHOLD. It is used similarly in the third pass of module BLOBER over a scan line of pixels but now applied to the merging of adjacent blobs.

```
                  ┌─────────────────────────────────────────┐
                  │        SPECTRAL_HIGH_THRESHOLD          │
                  └─────────────────────────────────────────┘

TYPE:           Real*4
CREATOR:        Command CLUSTER
SOURCE:         Command CLUSTER
PURPOSE:        Allow the user to parametrically vary blobbing.

DESCRIPTION:    In the first pass of module BLOBER over a scan line of
                pixels, a pixel starts a new blob if the spectral
                distance to the closest blob exceeds
                SPECTRAL_HIGH_THRESHOLD.

                  ┌─────────────────────────────────────────┐
                  │        SPECTRAL_LOW_THRESHOLD           │
                  └─────────────────────────────────────────┘

TYPE:           Real*4
CREATOR:        Command CLUSTER
SOURCE:         Command CLUSTER
PURPOSE:        Allow the user to parametrically vary blobbing.

DESCRIPTION:    In the first pass of module BLOBER over a scan line  of
                pixels, a pixel is added to a blob, if the spectral
                distance from a pixel to the closest blob is less  than
                SPECTRAL_LOW_THRESHOLD and the spatial distance is less
                than SPATIAL_LOW_THRESHOLD then the pixel will be added
                to that blob.  Otherwise, the pixel will either start a
                new blob or be deferred to subsequent passes.

                  ┌─────────────────────────────────────────┐
                  │           SPECTRAL_VARIANCES            │
                  └─────────────────────────────────────────┘

TYPE:           Real*4 (2)
CREATOR:        Command CLUSTER
SOURCE:         Command CLUSTER
PURPOSE:        Allow the user to parametrically vary blobbing.

DESCRIPTION:    The reciprocals of the values of the vector are used in
                blobbing as weights for the TASCAP brightness and
                greeness channels.

                  ┌─────────────────────────────────────────┐
                  │          STAGE_1_CROP_GROUP             │
                  └─────────────────────────────────────────┘

TYPE:           Character*2 (ACTUAL_SAMPLE_SIZE)
CREATOR:        Command SAMPLE
SOURCE:         Module STAGE1
PURPOSE:        Maintain the Stage 1 labels for future access.

DESCRIPTION:    The DFS of the sampled blobs is saved as 'SC' if summer
                or '0 ' if not summer.
```

STAGE_1_CROP_TYPE

TYPE: Character*2 (ACTUAL_SAMPLE_SIZE)
CREATOR: Command SAMPLE
SOURCE: Module STAGE1
PURPOSE: Maintain the Stage 1 labels for future access.

DESCRIPTION: The Stage 1 crop type is determined if the Stage 1 crop group is SUMMER and at least 1 separation acquisition was defined. The following is used :
      'C ' (CORN) if the zone is A or B in <u>ALL</u> separation acquisitions
      'S ' (SOY) if the zone is C or D in <u>ANY</u> separation acquisition
      'O ' (OTHER) if the Stage 1 crop group is not SUMMER.
      ' ' (blank) if no separation acquisitions were defined.

STANDARD_DFS?

TYPE: Logical*4
CREATOR: Command DFS
SOURCE: User input
PURPOSE: A switch which allows the user to provide an alternate set of DFS names in place of the standard set of DFS.

DESCRIPTION: If the boolean is TRUE then the standard DFS table is used; else the user has supplied a replacement set. The standard DFS table is:
      SUMMER
      GRAIN
      PASTURE
      NON_VEG
      UNKNOWN
      TRIVIAL

STARTING_TAU

TYPE: Real*4
CREATOR: Command CLUSTER
SOURCE: Command CLUSTER
PURPOSE: Allow the user to parametrically vary clustering.

DESCRIPTION: The scalar is the initial value assigned to the spectal threshold used for clustering.

STRATA_ESTIMATES

TYPE: Real*4 (NO_OF_CROP_TYPES, NO_OF_CLUSTER_CLASSES)
CREATOR: Command ESTIMATE
SOURCE: Module AESTIM
PURPOSE: Verification and validation.

DESCRIPTION: Contains the fraction of the stratum that belongs to each crop type. The little blobs are assumed to be distributed among crops in the same proportions as the big blobs of the same BCLUSTER_CLASS

SUN_ANGLES

TYPE: Real*4 (NUMBER_OF_ACQUISITIONS)
CREATOR: Command PREPROCESS
SOURCE: User, but may be defaulted to value from tape header saved in TAPE_SUN_ANGLES.
PURPOSE: Used in sun angle correction.

DESCRIPTION: Solar elevation angles in degrees.

SUPERVISION_SWITCH

TYPE: Logical*4
CREATOR: Command CLUSTER
SOURCE: Command CLUSTER
PURPOSE: Allow the user to parametrically vary blobbing.

DESCRIPTION: If this boolean is TRUE then blobbing will be performed in a supervised mode using an image such as ground truth or DFS.
             Note: For the pilot this switch is configured to be FALSE.

TAPE_SATELLITE_NUMBERS

TYPE: Integer*4 (NO_OF_ACQUISITIONS)
CREATOR: Command DATAPREP
SOURCE: Extracted from the Universal header format by the module IUNIV.
PURPOSE: Determines the type of satellite correction performed.

DESCRIPTION: The values possible for the vector and their meanings are:
             0 - Lacie calibration of Landsat 2
             1 - Landsat 1
             2 - Full frame calibration of Landsat 2
             3 - Landsat 3

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TAPE_SUN_ANGLES

TYPE: Real*4 (NUMBER_OF_ACQUISITIONS)
CREATOR: Command DATAPREP
SOURCE: Extracted from the Universal data header by the module IUNIV
PURPOSE: Used in sun angle correction.

DESCRIPTION: Solar elevation angles in degrees.

TOTAL_PIX_IN_BLOB

TYPE: Integer*4 (NO_OF_BLOBS)
CREATOR: Command CLUSTER
SOURCE: Module BCOMP

DESCRIPTION: The total number of pixels (both interior and boundary) in a blob.

TOTAL_PIXELS_IN_ALL_BIG_BLOBS

TYPE: Integer*4
CREATOR: Command SAMPLE
SOURCE: Module ASAMPL
PURPOSE: Used to estimate crop proportions.

DESCRIPTION: The total number of pixels in all the big blobs in a segment.

TPC_ACQS

TYPE: Integer*4 (NO_TPC_ACQUISITIONS)
CREATOR: Command PREPROCESS
SOURCE: User input
PURPOSE: Specify the set of acquisition dates to be used for generating Temporal Pattern Classes.

DESCPIPTION: This set must be a subset of ACQUISITIONS.

TPC_INDEX

TYPE: Integer*4 (TPC_TABLE_SIZE)
CREATOR: Command PREPROCESS
SOURCE: Module TPCREP
PURPOSE: Used in the TPC report.

DESCRIPTION: This is a list of indexes into TPC_TABLE sorted by decreasing pixel count.

```
                    ┌─────────────────────────────────────┐
                    │         TPC_INDEX_SORT2             │
                    └─────────────────────────────────────┘
```

TYPE: Integer*4 (TPC_TABLE_SIZE)
CREATOR: Command DFS
SOURCE: Module SRTREP
PURPOSE: Used in the TPC report.

DESCRIPTION: This is a list of indexes into TPC_TABLE sorted on the
               DFS names of the TPC's.

```
                    ┌─────────────────────────────────────┐
                    │            TPC_OF_BLOB              │
                    └─────────────────────────────────────┘
```

TYPE: Integer*4 (NO_OF_BLOBS)
CREATOR: Command CLUSTER
SOURCE: Module BCLUST
PURPOSE: Verification and validation

DESCRIPTION: A list of the TPC for each blob generated using the
               GRABS_MEAN for that blob.

```
                    ┌─────────────────────────────────────┐
                    │             TPC_TABLE              │
                    └─────────────────────────────────────┘
```

TYPE: Integer*4 (TPC_TABLE_SIZE, 2)
CREATOR: Command PREPROCESS
SOURCE: Module TPCREP
PURPOSE: Verification and validation.

DESCRIPTION: Table of TPC occurence count for each TPC value. The
               table is ordered by increasing TPC values. The format
               of the table is:
                   (i, 1) - the TPC value
                   (i, 2) - the count of TPC's for that value.

```
                    ┌─────────────────────────────────────┐
                    │           TPC_TABLE_SIZE           │
                    └─────────────────────────────────────┘
```

TYPE: Integer*4
CREATOR: Command PREPROCESS
SOURCE: Module TPCREP
PURPOSE: Indicate the size of various TPC entities.

DESCRIPTION: The number of TPC's in TPC_TABLE.

TPC_THRESHOLD

TYPE: Real*4
CREATOR: Command PREPROCESS
SOURCE: Command PREPROCESS
PURPOSE: Allow the manipulation of the threshold.

DESCRIPTION: If a pixels GRABS value is greater than TPC_THRESHOLD
               then the correspnding bit of the TPC pattern is 1,
               otherwise it is 0. This is configured to be 6 for the
               baseline procedure.

TPC_TYPE_TABLE

TYPE: Character*1 (TPC_TABLE_SIZE)
CREATOR: Command DFS
SOURCE: User input

DESCRIPTION: The format of the table is:
                   ' '- temporal pattern is pure
                   A - temporal pattern is is one bit
                       different from the expected pattern.
                   B - temporal pattern is two or more bits
                       different from the expected pattern.

TRASH_OF_BCLUSTERS_WITH_ALLO_LT_1

TYPE: Integer*4 (NO_OF_CLUSTERS)
CREATOR: Command SAMPLE
SOURCE: Module ASAMP
PURPOSE: Specify which clusters have been assigned to a trash
               conglomerate.

DESCRIPTION: An index into CLUSTER_CLASS_LIST.

USED_PIX_IN_BLOB

TYPE: Integer*4 (NO_OF_BLOBS)
CREATOR: Command CLUSTER
SOURCE: Module BCOMP
PURPOSE:

DESCRIPTION: A vector containing the number of pixels used in the
               calculation of the variance and mean of a blob. If a
               blob (big blob) has interior pixels then this number
               will equal the number of interior pixels, otherwise it
               will be the total number of pixels in the blob.

```
                        ┌─────────────────────────────────┐
                        │         XSTAR_METHOD            │
                        └─────────────────────────────────┘
```

TYPE: Integer*4
CREATOR: Command PREPROCESS
SOURCE: User input
PURPOSE: Allow the user to specify whether haze-correction
                should be performed and if so what type.

DESCRIPTION: The meanings of the scalar are:
                    0 - do not perform haze-correction
                    1 - perform spatially varying haze-correction
                    2 - perform global haze-correction