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IMAGE 100 PROCEDURES MANUAL DEVELOPMENT

APPLICATIONS SYSTEM LIBRARY DEFINITION

AND

IMAGE 100 SOFTWARE DEFINITION

Contract NAS-9-14556 and Contract NAS-9-14557

(LASA-CR-144442) IMAGE 100 PROCEDURES
MANUAL DEVELOPMENT: APPLICATIONS SYSTEM
LIBRARY DEFINITION AND IMAGE 100 SOFTWARE
DEFINITION Final Report (Texas A&M Univ.)
256 p HC $8.50

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I. INTRODUCTION

The G. E. Image 100 System provides the framework around which to build a versatile tool for the development, testing, and evaluation of image analysis techniques used in support of current and future Earth Resources Programs. In order to effectively support current applications, the existing Image 100 System requires augmentation through the acquisition of additional hardware, the design and implementation of application-oriented software, and the development of procedural guidelines for efficient System utilization and management.

An augmentation plan for the Image 100 System should be developed to provide the following capabilities:

- A batch-processing mode for testing the effectiveness and applicability of newly-developed data analysis algorithms and techniques.
- A means whereby interactive image analysis techniques, which are directly applicable to Earth Resources data-processing requirements, can be developed.
- A means whereby data-analysts and analyst-interpreters can effectively interact.

Developmental work aimed at providing the above capabilities can be divided into the following general areas and associated tasks:

**Procedures Manual Development**

Tasks

1. Procedures Manual Outline

2. Development of the Procedures Manual by completing each section of the outline
Operating System Development (RSX 11D)

Tasks

1. Implement Operating System which provides batch/conversational and interactive modes
2. Maintain Operating System
3. Modify Operating System to accommodate advanced file-handling techniques

Image Analysis Library Development

Tasks

1. Identify computer programs which should be part of the Image Analysis Library
2. Document, prioritize implementation of, and procure programs for Image Analysis Library
3. Design Library programs so that they can be used effectively in interactive mode
4. Implementation of Image Analysis Library
5. Maintain Library

Interactive System Development

Tasks

1. Augment Interactive System which operates under Operating System (RSX 11D) with minimal modification of Operating System
2. Augment advanced file-handling capability for both batch/conversational and interactive modes
3. Interface with personnel developing Operating System
4. Maintain/Modify Interactive System
5. Study hardware/software configuration for advanced operational system

**Interactive Capabilities Development**

**Tasks**

1. Determine those interactive capabilities needed to support various Earth Resources Projects (LACIE, FAP, etc.)
2. Implement software to provide interactive capabilities under Interactive System using Image Analysis Library

### II. SUMMARY OF WORK PERFORMED

The work performed under the subject contracts is a portion of that described in the Introduction—Procedures Manual Development and Image Analysis Library Development, namely;

- Preparation of an Image 100 Procedures Manual Outline
- Identify and prioritize implementation of computer programs essential to earth resources data processing requirements (FAP, RAP, LACIE, RT&E, etc.)

The outline of an Image 100 Procedures Manual was developed which sets forth guidelines, of both a general and specific nature, that provide a basis for the preparation and updating of an Image 100 Procedures Manual. The scope of the outline was limited to definition of general features of a procedures manual together with special features of an interactive system. The outline is organized in a
"task to be performed" fashion, and the topical order is intended to be a logically ordered "table of contents." This work is discussed in more detail in the next section and Appendix A.

Computer programs were identified (source, purpose, availability, application, etc.) which should be implemented as part of an applications-oriented library for the Image 100. In addition, each identified program was assigned an implementation priority. Although the Image 100 System is an interactive system that will also operate in the batch mode, identification of computer programs was based only on the requirement that they be utilized in the batch processing mode. Computer program identification was limited to those having direct or anticipated application to earth resources data processing requirements. It should be noted that many of these programs are essential to the development of interactive data processing capabilities not currently available on the Image 100 System. The Image Analysis Library is discussed in more detail in Section IV and Appendix B.

III. PROCEDURES MANUAL DEVELOPMENT

This portion of work is concerned with developing an outline of a Procedures Manual for the Image 100 System. By Image 100 System we mean the PDP 11/45 general purpose computer, special image analysis hardware (the G.E. Image 100) and all associated software. Even though the scope of this task is mainly limited to the development of a Procedures Manual outline, we did author those sections
dealing with updating standards, program documentation standards, and
library documentation standards. Also, we authored a JCL Cookbook
for FORTRAN IV users.

The purpose of a procedures manual is to provide information
necessary to effectively use the system. This includes descriptions,
operating procedures, maintenance procedures and so on (much of
which is furnished by the manufacturers of the hardware), but must
also include standards for documentation, maintenance and augmentation
of system hardware and software. We feel that work performed in
furnishing suitable documentation for a given program is more than
offset by the long term reduction in effort in use of the program.
Thus we pay particular attention in this outline to setting a
flexible but high standard for documentation for programs at each
developmental level.

In formulating documentation standards, an effort was made to
utilize existing widely-accepted documentation guidelines. While not
properly a part of a procedures manual, the information we located
may be of use to some programmers in their attempt to understand and
follow the standards for documentation set here. We found the
following documents to be particularly helpful:

NASA Handbook, NHB 2411.1 July 1971
"Computer Program Documentation Guideline"

Goddard Space Flight Center, X-540-72-114 Feb. 1972
"A Programmer's Guide to the Goddard Space Flight Center
Computer Program Library"

"Automated Data System Documentation Standards Manual"
Some sort of committee or working group should be formed to decide what is acceptable (well-documented, tame) enough to be implemented into the Image Analysis Library or into the Interactive system. At the present time, the Image Analysis Library is a collection of forms which identify programs of possible use and a list of functional requirements. As a useful program is located and implemented, it can pass through the following stages:

1. Identified (by a Computer Program Identification Form)
2. Compatible Library Unit (card deck and documentation of a program compatible with the PDP 11/45 system)
3. Specially-designed Library Package (a collection of compatible units assembled into an efficient package)
4. Implemented Library Program (a completely documented program of general interest with object code kept on the system disk)
5. Interactive Unit

Library management information in the Goddard manual mentioned above may be a little elaborate for the Image Analysis Library, but it has not been ignored. However, we feel it would be premature to set final management standards for a library which does not yet exist.

IV. Image Analysis Library Development

This portion of work is concerned with the identification of, and establishing implementation priority for various software units which will comprise an Image Analysis Library to support Earth Resources data processing requirements.
we mean a collection of both general-purpose mathematical/statistical routines and special-purpose data-analysis/pattern recognition routines.

The Image Analysis Library has been partitioned, functionally, into the four libraries (and further into packages) as outlined in Appendix B. Identification forms were completed for various computer subroutines and programs and subsequently arranged by Package (See Appendix B). These completed forms represent an initial attempt at defining those routines which will eventually comprise an Image Analysis Library for the PDP 11/45. Care has been taken to insure that the identified programs represent what is generally thought of as the best available technique for performing a particular function. In a number of cases, several theoretically equivalent computer programs were available with minor to extensive variations in code. We have exercised our technical judgement in an attempt to minimize duplication among the programs appearing in Appendix B.

In some cases a particular functional requirement appears for which no computer program has yet been identified. In those cases we have tried to indicate where such programs can be found and identified by the individuals who have either developed or are developing the programs.

Each subroutine or program which has been identified is assigned an implementation priority according to the following priority definitions:
Priority I - Basic utility subroutine or program required for the implementation of existing image analysis techniques

Priority II - Existing image analysis techniques (requires majority of Priority I items)

Priority III - Subroutine or program required to support development and/or refinement of image analysis techniques

Priority IV - Image analysis techniques in research and development stage.
APPENDIX A

PROCEDURES MANUAL OUTLINE

COMMENTS ON PROCEDURES MANUAL OUTLINE

COMPLETED SECTIONS OF PROCEDURES MANUAL
PROCEDURES MANUAL OUTLINE

A. Hardware Documentation
   1. Hardware configuration
   2. Hardware description by unit
   3. Updating standards

B. Maintenance
   1. System log standards
   2. System manager's guide
   3. Hardware
      a. Installation
      b. Check List
      c. Preventive maintenance
      d. Failure
         (1) failure report forms
         (2) check list of repairs in progress
   4. Software
      a. System software
         (1) software performance summary
         (2) software problem report form
         (3) filing and updating standards
      b. Batch and conversational library
         (1) software performance summary
         (2) software problem report form
         (3) filing and updating standards
      c. Interactive software
         (1) software performance summary
         (2) software problem report form
         (3) filing and updating standards
      d. Software failure bulletin board
C. System Software Documentation

1. Overall system concept

2. System programs
   a. DOS Monitor
   b. BATCH - II
   c. FORTRAN IV
   d. LINK - II Linker
   e. LIBR - II Librarian
   f. PIP File Utility Package
   g. MACRO - II Assembler
   h. EDIT - II Text Editor
   i. ODT - II Debugging Program
   j. Others

3. Cookbooks
   a. Job control language - BATCH
   b. IMAGE 100 orientation

4. FORTRAN conversion problems

5. Concise summary of all error messages issued by system programs

6. Other system software

7. Updating standards

D. Library Documentation

1. Program documentation standards
   a. Batch and conversational
   b. Interactive special functions
2. Image Analysis Library
   a. Pre-analysis data processing library
   b. General mathematical library
   c. General statistical library
   d. Pattern recognition library
3. Interactive special functions
4. Updating standards

E. Interface
   1. Interface documentation standards
   2. Interface documentation by hardware unit
   3. Updating standards
COMMENTS ON PROCEDURES MANUAL OUTLINE
COMMENTS ON PROCEDURES MANUAL OUTLINE

In the development of this procedures manual outline, we tried to be as concise as possible. We make the following comments to guide efforts to supply the necessary information. In some instances, we were able to identify manuals which partly supply this information. Additional manuals and information, particularly relating to hardware maintenance and system software documentation, exist and need to be identified and adapted to fit the existing system configuration.

Documentation of hardware appears in the outline under major divisions A, B and E, as follows:

under A (Hardware Documentation), for each unit

1. General description
2. Detailed physical description
3. Power requirements
4. Operating environment
5. Normal operations
6. Principles of operation
7. Block diagrams
8. Electrical diagrams
9. Accessories

under B (Maintenance)

1. Unpacking and incoming inspection
2. Installation
3. Warranty information
4. Initial checkout procedures
5. Tools and test equipment required

6. Preventive maintenance (daily, weekly, quarterly, annually)

under E (Interface)

1. Initialization
2. Interface design
3. Interfacing procedures
4. Timing
5. Data flow
6. Control panel interface
7. Data lines
8. Code charts
9. Diagnostics
10. Hardware dependent software

Documentation of programs appears in the outline under major divisions B, C and D. By "program" we refer throughout this outline to all types of subroutines, functions, programs, program packages, utilities, compilers, subsystems and systems. Maintenance of programs is described in B, system programs are documented in C (System Software Documentation) and user created (library) programs are documented in D (Library Documentation).

Software other than programs or program documentation is represented throughout the outline. Hardware operations manuals appear in A, diagnostic software is documented in E, system operation and management information appears in B and initialization procedures for system programs and other software procedures are described in C.

Procedures manual management information is spread throughout the manual, mostly in the form of documentation and updating standards.

PM-6
While a reference copy of the entire procedures manual should be kept on file, it is clear that some elements need to be located where they can be more easily referenced. Documentation standards for the use and maintenance of a system library are set in D.

A. System Hardware Documentation

1. Hardware configuration (general description)
   a. Overview of hardware with floor plan
   b. Processor (including size of internal storage, cycle time)
   c. Storage media (tape units, disk units)
   d. Output devices
   e. Input devices
   f. Special Image Processing Hardware

2. Hardware description by unit

3. Updating standards

B. Maintenance

1. System log standards
   These standards specify what is to be kept in the system log, the frequency of entries, and those personnel required to make and review entries.

2. System manager’s guide
   DEC manual DEC-ll-OMGRA-A-D (BATCH-ll/DOS-ll System Manager's Guide) provides information needed to install and manage the operating system. Modifications in the operating system necessitated by special interactive requirements must be documented here. Non-standard system modules (device drivers
3. Hardware (by unit)

a. Installation
This section includes information on the installation and acceptance of the hardware unit; also included is information on warranty, service contracts and general time-limited service.

b. Checklist
By this we intend a quick check of the status of the system hardware which can be gone over (say) with each change of shifts.

c. Preventive maintenance
A daily, weekly and so on schedule of preventive maintenance should be established and followed by operations personnel.

d. Failure
(1) failure report forms
The failure report procedures currently in use appear to be based on those developed for a much larger and more general maintenance problem. It appears that time could be saved and quality control improved if a modification of the current form were made to accommodate the special needs of the Image Processing Lab. One form, the WITHOLD tag (Form 1055), seems to be quite effective.

(2) check list of repairs in progress
This list, now kept in the form of a bulletin board, should include parts on order, special equipment.
or personnel required, the interim status of the system and so on.

4. Software

The DEC document entitled Software Performance Summary contains an extremely attractive and easily maintained system for reporting, correcting, filing and updating software problems. We strongly recommend their method replace the current method in system software problem reporting, and that an adaption to the needs of the Image Analysis Library interactive software be made.

a. System software

(1) software performance summary
(2) software problem report form
(3) filing and updating standards

b. Batch and conversational library

(problems in the Image Analysis Library and associated documentation)

(1) software performance summary
(2) software problem report form
(3) filing and updating standards

c. Interactive software

(problems in the interactive software and associated documentation)

(1) software performance summary
(2) software problem report form
(3) filing and updating standards
d. Software failure bulletin board

Here we suggest the establishment of an informal bulletin board to alert all system users of software failures which have been noted. When a way to avoid the problem is known it may be included. Although this information may also be included in a.-c. above, it seems unlikely most system users would keep up with that rather formal documentation. The minor duplication of effort involved is negligible compared to the benefits.

C. System software documentation

As we view the present system configuration, essentially all system software is supplied by DEC. We identify here major components of system software and make a few suggestions for easier use of the system. We also suggest an Image 100 orientation manual.

1. Overall system concept
   (A general description of system architecture)

2. System programs

   In each of the system programs mentioned here, we have been able to identify a programmer's guide (a DEC document) but not the actual program documentation. For example, the FORTRAN IV compiler programmer's manual contains almost no information on how the compiler itself operates. The Procedures Manual should contain such material when it is available.

b. BATCH-11 (BATCH-11 Users Guide, DEC-11-OBUDA-B-D)


d. LINK-11 Linker, and
e. LIBR-11 Librarian (BATCH-11/DOS-11 Linker (LINK 11) and Librarian (LIBR-11), DEC-11-ULLMA-A-D)


g. MACRO-11 Assembler (BATCH-11/DOS-11 Assembler (MACRO-11), DEC-11-OMACA-B-D)


j. Others (Other system programs which are operational; it is clear this part of the outline is open for expansion as the system is added to.)

3. Cookbooks

a. Job control language - BATCH

By this we intend a folding pamphlet containing basic job control statements to compile, link and execute a FORTRAN IV program in the BATCH mode. As actual operating experience is gained with the BATCH system, it seems likely that revision of the pamphlet will be necessary.

b. IMAGE 100 orientation

A brief applications oriented description of use of the
IMAGE 100 system functions in actual application with color photographs of how the screen looks, examples of what choice of channels or passes is appropriate for various users; this information would be of great value to the operators in explaining to a new user what to expect, and would also serve to illustrate to potential users some of the actual applications.

4. FORTRAN conversion problems

The conversion of a program from one computer installation to another is never trivial, but, when the conversion involves change to a 16 bit machine from a machine with at least 32 bit words, the problems may seem almost insurmountable. This section of the outline should initially contain hints on probable problems in converting an operational FORTRAN IV program to the PDP 11/45 computer. In order to make this information as useful as possible, it should be made easy to revise and add to as experience is gained with actual conversion problems.

5. Concise summary of all error messages issued by system programs

A tabular summary of error messages enabling a user to discover which component of the system issued the message and its meaning should be available to both BATCH and Interactive users.

6. Other system software

7. Updating standards

D. Library Documentation

Since all programs must be tested for correctness and occasionally modified, adequate documentation is a must so that future users may know exactly what a particular program is supposed to accomplish and how.
1. Program documentation standards
   a. Batch and conversational
   b. Interactive special functions

2. Image Analysis Library
   a. Pre-analysis data processing library
   b. General mathematical library
   c. General statistical library
   d. Pattern recognition library

3. Interactive special functions
   These are interactive programs run from the IMAGE 100 console.

4. Updating standards

E. Interface

In a PDP 11/45 computer system, hardware units generally communicate
with the Central Processing Unit and each other through the Unibus high speed
data bus by direct interfacing (wires) or by data communication interfacing
(usually a telephone or other low-speed line with a modem unit on each end).
Each unit of hardware communicates with an interactive user or with the
computer operator through a control panel interface. Especially in an
interactive environment, programmers (and sometimes users) need to be
aware of technical details of how commands are decoded, how data is routed
and how correct timing is maintained. Subroutines and functions exist which
would allow a FORTRAN IV programmer to write interactive programs making
efficient use of interactive hardware capabilities if the programmer
understood how to use the interfacing software.

1. Interface documentation standards

   Each type of interface should be provided with a documentation
standard sufficient to allow the interface to be maintained and used.

2. Interface documentation by hardware unit

3. Updating standards
A.3 Hardware Documentation Updating Standards

B.4.a (3) System Software Maintenance--Filing and Updating Standards

B.4.b (2) Batch and Conversational Library Maintenance--Software Problem Report Form

B.4.b (3) Batch and Conversational Library Maintenance--Filing and Updating Standards

B.4.c (2) Interactive Software Maintenance--Problem Report Form

B.4.c (3) Interactive Software Maintenance--Filing and Updating Standards

C.3.a Job Control Language Cookbook

C.4 FORTRAN Conversion Problems

C.7 System Software Documentation Updating Standards

D.1 Library Documentation Standards

D.4 Library Documentation Updating Standards

E.1 Interface Documentation Standards

E.3 Interface Updating Standards
A.3 Hardware Documentation Updating Standards

Each change in the system hardware configuration shall be documented as follows:

<table>
<thead>
<tr>
<th>Change</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addition of a hardware unit</td>
<td>Appropriate information shall be added to the Procedures Manual. (For reference, the distribution of this information throughout is listed below.) Section A.1 (Hardware configuration) shall contain references to sections of the Procedures Manual containing information about the added unit immediately following the general description of the unit.</td>
</tr>
<tr>
<td>Removal of a hardware unit</td>
<td>No longer applicable information shall be indicated by means of vertical line along the outer margin with a dated comment describing the change as &quot;removed (date)&quot;. When several consecutive pages which would require this treatment can be fastened together securely only the first page need have the change indicated.</td>
</tr>
<tr>
<td>Modification or rearrangement</td>
<td>Changes induced shall be indicated by means of a vertical line along the outer margin with a dated comment describing the change as &quot;changed (date) (page reference)&quot; with a reference to currently applicable information. When possible, additions shall be physically near (in the Procedures Manual) the items they modify.</td>
</tr>
</tbody>
</table>
Reference information on distribution of hardware documentation:

<table>
<thead>
<tr>
<th>Item</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessories</td>
<td>A.2</td>
</tr>
<tr>
<td>Block diagrams</td>
<td>A.2</td>
</tr>
<tr>
<td>Code charts</td>
<td>E.2</td>
</tr>
<tr>
<td>Control operation</td>
<td>A.2</td>
</tr>
<tr>
<td>Control panel interface</td>
<td>E.2</td>
</tr>
<tr>
<td>Data flow</td>
<td>E.2</td>
</tr>
<tr>
<td>Data lines</td>
<td>E.2</td>
</tr>
<tr>
<td>Detailed physical description</td>
<td>A.2</td>
</tr>
<tr>
<td>Diagnostic software</td>
<td>E.2</td>
</tr>
<tr>
<td>Electrical diagrams</td>
<td>A.2</td>
</tr>
<tr>
<td>Floor plan</td>
<td>A.1</td>
</tr>
<tr>
<td>General description</td>
<td>A.1</td>
</tr>
<tr>
<td>Hardware dependent software</td>
<td>E.2</td>
</tr>
<tr>
<td>Initial checkout procedures</td>
<td>B.2.a</td>
</tr>
<tr>
<td>Initialization (interface)</td>
<td>E.2</td>
</tr>
<tr>
<td>Installation</td>
<td>B.2.a</td>
</tr>
<tr>
<td>Interface design</td>
<td>E.2</td>
</tr>
<tr>
<td>Interfacing procedures</td>
<td>E.2</td>
</tr>
<tr>
<td>Logic flow</td>
<td>A.2</td>
</tr>
<tr>
<td>Normal operation</td>
<td>A.2</td>
</tr>
<tr>
<td>Operating environment (physical)</td>
<td>A.2</td>
</tr>
<tr>
<td>Power requirements</td>
<td>A.2</td>
</tr>
<tr>
<td>Preventive maintenance</td>
<td>B.3.c</td>
</tr>
<tr>
<td>Principles of operation</td>
<td>A.2</td>
</tr>
<tr>
<td>Timing</td>
<td>E.2</td>
</tr>
<tr>
<td>Tools and test equipment required</td>
<td>B.3.c</td>
</tr>
<tr>
<td>Unpacking and inspection</td>
<td>B.3.a</td>
</tr>
<tr>
<td>Warranty information</td>
<td>B.3.a</td>
</tr>
</tbody>
</table>
B.4.a (3) System Software Maintenance—Filing and Updating Standards

B.4.b (2) Batch and Conversational Library Maintenance—Software Problem
Report Form

The maintenance of the Image Analysis Library requires the design and use of a new program problem report form, patterned after the system used by DEC (appearing in the Procedures Manual in B.4.a (2)). Each problem report takes the following overall form; each part will be explained in detail.

<table>
<thead>
<tr>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. TITLE</td>
</tr>
<tr>
<td>II. SUBTITLE</td>
</tr>
<tr>
<td>III. PROBLEM: USER:</td>
</tr>
<tr>
<td>IV. SOLUTION: PROGRAMMER:</td>
</tr>
<tr>
<td>V. CODING</td>
</tr>
</tbody>
</table>

PM-19
DATE: The date of the current version of the problem report.

I. TITLE
The title of the problem report refers to the component of the Image Analysis Library involved (for example, the Pattern Recognition Library)

II. SUBTITLE
This brief statement (which should fit on one line), gives the user a hint about the content of the problem report. The title and subtitle are to be used in a table of contents.

III. PROBLEM
A paragraph is used to describe the problem in general terms, perhaps with an example, warnings, etc. The name and organization of the user reporting the problem appear here.

IV. SOLUTION:
If there is a way to avoid the problem it is stated here.

V. CODING
This block is used for filing purposes. Below is a close-up view of the coding block

<table>
<thead>
<tr>
<th>PROGRAM NAME</th>
<th>PROGRAM NUMBER</th>
<th>SEQUENCE #</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADDITIONAL INFORMATION (SUBROUTINES, FUNCTION)</td>
<td>PAGE</td>
<td></td>
</tr>
<tr>
<td>NEW REPLACEMENT #</td>
<td>ORIGINAL DATE</td>
<td></td>
</tr>
</tbody>
</table>

PM-20
Problem reports are filed by program (subroutine, function) name. Each program in the Image Analysis Library is assigned a number when accepted. The sequence numbers are assigned by program problem; as each new problem report for that program is filed it is assigned the next highest sequence number. Any additional information which may help a user is recorded. If the problem report is new (for this problem) an 'x' is placed in the NEW block; if a replacement, the revision number is placed in the REPLACEMENT # box. The original date is the date of the first report on this problem.
B.4.b (3) Batch and Conversational Library Maintenance—Filing and Updating Standards

Program Problem Reports shall be filed by program name and indexed by function as an element in the Image Analysis Library. When a problem is fixed or the program withdrawn, or information is added, the problem report shall be removed or replaced by a revision.
Interactive use of the system is by users who may not be programmers.

To account for this, a slight redesign of the form in B.4.b (2) has been made:

```
I. MENU
II. OPTION/FUNCTION
III. SUBTITLE
IV. PROBLEM   USER:
V. SOLUTION   PROGRAMMER:
VI. CODING
```

PM-23
DATE: Date of the current version of the problem report.

I. MENU

The menu refers to a user-selected set of options grouped together by the interactive system.

II. OPTION/FUNCTION

This describes which option was selected from the list under the menu of (I) above.

III. SUBTITLE

This is a brief (one line) description of the problem.

IV. PROBLEM: USER:

This is a one paragraph description of the problem with an example of a failure followed by the name and organization; action of the user reporting the problem.

V. SOLUTION: PROGRAMMER:

If there is a way to avoid the problem it is stated here, followed by the name and organization of the programmer who devised the solution.

VI. CODING

This block is used for filing purposes. Below is a close-up view of the coding block.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>SEQUENCE #</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADDITIONAL INFORMATION</td>
<td>PAGE</td>
</tr>
<tr>
<td>OF</td>
<td></td>
</tr>
<tr>
<td>NEW REPLACEMENT #</td>
<td>ORIGINAL DATE</td>
</tr>
</tbody>
</table>

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Problem reports are filed by option name. Sequence numbers are assigned by option; as a new problem report for an option is reported, the next highest sequence number is assigned. If the problem report is new, an 'x' is placed in the NEW block; otherwise the revision number is placed in the REPLACEMENT # box.
B.4.c (3) Interactive Software Maintenance—Filing and Updating Standard

Problem reports shall be filed by option name and indexed by menu and function as an Interactive special function. When a problem is fixed or more information is added, the problem report shall be removed or replaced by a revision.
C.4 FORTRAN Conversion Problems

The principal difficulties which arise when conversion of a FORTRAN IV program from a different implementation to PDP 11/45 is attempted stem from word length differences, core size differences, JCL differences and actual compiler bugs. The purpose of this section of the Procedures Manual is to allow users to share experience gained in attempting conversion so that an overall saving in effort (and frustration) can be realized. Much of the following information is contained in the FORTRAN Manual and the Software Performance Summary.

INTEGER Size:

Since the word length of the PDP 11/45 is 16 bits, the maximum signed integer is $2^{15} - 1 = 32,767$. "Double Precision" integers are not supported.

BYTE (LOGICAL * 1) Variables and Arrays:

BYTE (or LOGICAL * 1) variables and arrays cannot be initialized in DATA statements. The compiler allows simple BYTE variables to be used in arithmetic statements but does not allow them in arithmetic IF statements. Comparison with Hollerith strings leads to unexpected results because Hollerith strings are treated as type INTEGER. A BYTE array element used as a subroutine argument sometimes causes an execution time addressing error.

ENCODE/DECODE Problems:

Core-to-core transfer under FORMAT control require care in that the area of core must be contiguous. Thus if INTEGER arrays are being processed, the program will have
to have been compiled with the /ON switch.

F FORMAT Problem:
Double precision variables are truncated when output
under F FORMAT control.

EQUIVALENCE Problem:
Alignment to even bytes is necessary in EQUIVALENCE statements.

DEFINE FILE Problem:
Multiple DEFINE FILE statements are not compiled correctly,
nor is a diagnostic message issued.

UNARY MINUS:
Unary minus is given precedence over exponentiation. Thus
-2**2 is treated as (-2)**2 instead of the standard -(2**2).

ENDFILE Problems:
ENDFILE cannot be the statement to be conditionally
executed in a logical IF. ENDFILE cannot be the first
executable statement in a subroutine.

Logical Unit Numbers as Subroutine Arguments:
The compiler does not recognize integer variables passed
as subroutine arguments as valid I/O logical unit numbers.
A dummy assignment to a local variable is necessary to fix the
problem.
C.7 System Software Documentation Updating Standards

As system software is updated or revised, changes shall be indicated in the Procedures Manual as follows:

<table>
<thead>
<tr>
<th>Change</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addition of a component of system software</td>
<td>Documentation and user information shall be included at the proper place.</td>
</tr>
<tr>
<td>Removal of a component of system software</td>
<td>No longer applicable documentation shall be indicated by a vertical line along the outer margin with a dated comment describing the change as &quot;removed (date)&quot;. When several consecutive pages which would require this treatment can be fastened together securely only the first page need have the change indicated.</td>
</tr>
<tr>
<td>Modification</td>
<td>Changes induced shall be indicated by a vertical line along the outer margin with appropriate dated comment and reference to corrected or updated documentation.</td>
</tr>
</tbody>
</table>
D.1 Library Documentation Standards

The sharing of computer programs by a number of users requires that their documentation be managed so as to insure uniformity without imposing an undue clerical burden. While documentation must be performed at the same time the program is being developed, a requirement that a formal standard be satisfied at all levels would be costly. We recognize four levels of documentation:

LEVEL 1 Minimal level
Level 1 documentation standards apply to single-use programs of minimal complexity. The documentation required shall be the completion of the first page of the computer program documentation form, a liberally commented listing and test case.

LEVEL 2 Internal level
Level 2 documentation standards apply to larger special purpose programs which appear to have no sharing potential. The documentation required shall be the completion of pages 1 - 4 of the computer program documentation form, a liberally commented listing and a test case.

LEVEL 3 Working document level
Level 3 documentation standards apply to programs which are intended to be shared, either as parts of the Image Analysis Library or as special functions for Interactive use. In addition to Level 2 documentation, all basic elements of good documentation must be prepared and kept in the Library.
LEVEL 4 Interactive use level

Level 4 documentation standards apply to programs which are intended to be used in an interactive mode. In addition to Level 3 documentation, page 5 of the computer program documentation form (which describes operation of the program in an interactive mode to a user who may not understand the program) must be completed.

Basic elements of good documentation:

Title page
Table of contents
Abstract - brief summary of function or purpose
Problem task description - technical description of problem to be solved or task to be accomplished
Method of solution - mathematical techniques used, logical sequencing within the program and data files created by the program

Program description:

Operating Environment - hardware and software requirements
Program specifications - a detailed description of the programming techniques used in writing the program; e.g. calling sequence, overlay structure, test plan, COMMON usage
Subprograms (other than library) - with appropriate level of documentation
Non ANSI FORTRAN IV library subprograms--names and brief description
Source code listing
Flow charts--general and detailed

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Operating instructions - description of procedure required to set up and run the program, including:

Deck setup - showing placement of control cards, source or object decks and data

Description of input - file, record and data element descriptions and formats including the origin of each data element

Description of output - file, record and data element description and formats of each data element including scratch or intermediate files

Restrictions or limitations - hardware or software restrictions, data ranges and capacities, program behavior when restrictions are violated

Accuracy characteristics - including dependence on machine word length or floating point arithmetic

Diagnostics emitted - including probable cause of program-generated messages

Test Cases

Special instructions - interactive mode

Symbols - a complete tabular list of all symbols and array names used in the program, defined with reference to the mathematical or technical writing notations and terms used in the problem description, with units given where applicable

Record of changes - arranged in columnar form providing spaces for the change number, date and individual making the change,
with a brief description of the reason for the change;
actual changes should be made in the document itself

References
### I/O Configuration

<table>
<thead>
<tr>
<th>File name, logical or physical unit no.</th>
<th>Device Type</th>
<th>Description/Remarks</th>
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</thead>
<tbody>
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</tbody>
</table>

**Known restrictions:**

**File description:**
Operating instructions:

Terminating conditions:

Timing:
References:

Revision or modification history:

<table>
<thead>
<tr>
<th>Rev. No.</th>
<th>Date</th>
<th>Programmer, Loc., Ext.</th>
<th>Reason</th>
</tr>
</thead>
</table>

Implementation level and material available

- [ ] Reference only
- [ ] Source listing
- [ ] Source deck
- [ ] System device (Device code, file name, ext.)
  - [ ] Object module
  - [ ] Load module
  - [ ] Additional documentation

Estimated time and cost for development:

<table>
<thead>
<tr>
<th>Manmonths</th>
<th>Machine hours</th>
<th>Total cost $</th>
</tr>
</thead>
</table>
Interactive user instructions

Menu

Option name

Load and start procedure

Expected wait time

User instructions

Error messages

Error recovery

Effect on system parameters

UIC

Protection code

Files created

COMMON variables

Image 100 hardware affected

Other
D.4 Library Documentation Updating Standards

Each program in the Image Analysis Library and each Interactive special function shall be documented with a revision or modification history in which a record is kept of the revision number, date, programmer and reason. Should a program which is on a public disk be withdrawn, notice shall be posted on the software failure bulletin board. Every possible step shall be taken to insure upward compatibility of program revisions or modifications.
E.1 Interface Documentation Standards

a. Hardware - CPU interface
The connection of hardware units to the central processing unit shall be described in detail including information on initialization, data flow, data lines, timing, interface design and interfacing procedures.

b. Hardware - control panel interface
The connection of control panel switches, keys and controls to the data flow and interface bit status shall be described in detail.

c. Hardware - software interface
In the documentation of each Interactive software unit, the action of hardware controls on software variables shall be described. Utility software which exists for the purpose of enabling users to poll the status of hardware units or hardware controls shall be documented fully here.
E.3 Interface Updating Standards

The updating standard for change in the hardware configuration is set in section A.3.

Changes in the utility software shall be documented following the standard for system software maintenance under the component name "UTILITY".
APPENDIX B

IMAGE ANALYSIS LIBRARY OUTLINE

COMPONENT PROGRAM IDENTIFICATION FORMS

IMPLEMENTATION PRIORITY SUMMARY
IMAGE ANALYSIS LIBRARY OUTLINE

A. PRE-ANALYSIS DATA PROCESSING LIBRARY

1. PREPROCESSING PACKAGE
   a. RADIOMETRIC CORRECTION
   b. SUN ANGLE CORRECTION
   c. HAZE CORRECTION
   d. MEAN LEVEL ADJUSTMENT
   e. GENERAL SCANNER UNIT CORRECTION (IMAGE 100)
   f. ERTS DISTORTION CORRECTION
   g. I/O OF VARIOUS FORMATS

2. REGISTRATION PACKAGE
   a. SINGLE PASS TO GEOGRAPHICAL MAP OR AERIAL PHOTO
   b. SEVERAL PASSES TO DESIGNATED PASS

3. TRAINING FIELD SELECTION PACKAGE
   a. IRREGULARLY SHAPED FIELDS
   b. HISTOGRAMS FROM LINEAR COMBINATIONS OF n CHANNELS
   c. GREY SCALE MAP PROGRAM
   d. CONTOUR PROGRAM

4. SIMULATED DATA GENERATOR PACKAGE
   a. RANDOM NUMBER GENERATOR—VARIOUS DISTRIBUTIONS
   b. SIMULATED ERTS DATA
B. GENERAL MATHEMATICAL LIBRARY

1. LINEAR ALGEBRA PACKAGE
   a. LU DECOMPOSITION
   b. MATRIX INVERSE
   c. CHOLESKY METHOD--SYMMETRIC POSITIVE DEFINITE
   d. GENERALIZED INVERSE
   e. EIGENVALUE PROBLEM: \( Ax = \lambda x \), \( A \) SYMMETRIC
   f. GENERALIZED EIGENVALUE PROBLEM: \( Ax = \lambda Bx \), \( A, B \) SYMMETRIC
   g. HOUSEHOLDER TRANSFORMATION
   h. SINGULAR VALUED DECOMPOSITION
   i. POLAR DECOMPOSITION
   j. MATRIX MANIPULATION ROUTINES (GENERAL)

2. OPTIMIZATION PACKAGE
   a. LINEAR PROGRAMMING
   b. QUADRATIC PROGRAMMING
   c. GRADIENT--STEEPEST DESCENT
   d. FLETCHER POWELL DEFLECTED GRADIENT
   e. NEWTON'S METHOD AND VARIATIONS
   f. CONSTRAINED LEAST SQUARES

3. APPROXIMATION PACKAGE
   a. SPLINE APPROXIMATION--SINGLE VARIABLE
   b. SPLINE APPROXIMATION--TWO VARIABLES

4. TRANSFORM PACKAGE
   a. FAST FOURIER TRANSFORM
   b. HADAMARD TRANSFORM
   c. WALSH TRANSFORM
C. GENERAL STATISTICAL LIBRARY

1. STATISTICAL SUMMARY PACKAGE
   a. MEAN VECTOR COMPUTATION
   b. VARIANCE-COVARIANCE MATRIX COMPUTATION
   c. MODE, MEDIANs, RANGE, ETC.

2. DENSITIES & DISTRIBUTIONS PACKAGE
   a. MULTIVARIATE NORMAL
   b. UNIVARIATE NORMAL
   c. ERROR FUNCTION AND INVERSE ERROR FUNCTION
   d. UNIVARIATE DENSITIES--MISCELLANEOUS

3. REGRESSION PACKAGE
   a. MULTIPLE LINEAR REGRESSION
   b. NONLINEAR REGRESSION

4. STATISTICAL TESTS PACKAGE
   a. HYPOTHESIS TESTS
   b. GOODNESS OF FIT
   c. ANALYSIS OF VARIANCE
D. PATTERN RECOGNITION LIBRARY
   1. CLUSTERS PACKAGE
      a. ISOCLS
      b. SEMI–SUPERVISED CLUSTERING (G.E.)
   2. CLASSIFICATION PACKAGE
      a. BAYES OPTIMAL--m GAUSSIAN CLASSES
      b. BAYES OPTIMAL--CONVEX COMBINATIONS OF GAUSSIAN
      c. TABLE LOOKUP
      d. MAXIMUM LIKELIHOOD RESOLUTION (G.E.)
   3. FEATURE SELECTION PACKAGE
      a. DIVERGENCE CRITERION
      b. BHATTACHARYYA DISTANCE
      c. PROBABILITY OF MISCLASSIFICATION
      d. LINEAR DISCRIMINANT FUNCTIONS
      e. TRANSFORMED DIVERGENCE
   4. ESTIMATION OF PROPORTION PACKAGE
      a. MAXIMUM LIKELIHOOD
      b. METHOD OF MOMENTS
      c. ESTIMATED CONFUSION MATRIX
      d. CLASSIFICATION
      e. BAYES WEIGHTS—CONFUSION MATRIX
   5. SPATIAL PATTERN RECOGNITION PACKAGE
      a. FIELD BOUNDARY DETECTION
      b. SPATIAL FEATURE DEFINITION
      c. CLASSIFICATION USING SPATIAL FEATURES
   6. SIGNATURE EXTENSION PACKAGE
      a. MAXIMUM LIKELIHOOD FOR MEAN, COVARIANCE, PROPORTIONS
         USING UNLABELED SAMPLES AND CONTRACTABILITY
      b. Ax + b, A DIAGONAL, CORRECTION TRANSFORMATION
         (UNLABELED SAMPLES)

IAL-4
COMPUTER PROGRAM IDENTIFICATION FORMS

The computer subroutines and programs which were identified appear in the following pages. They have been arranged into the packages defined in the outline of Image Analysis Library. In some cases no computer programs were identified which provide a required functional capability. We have tried to indicate through notes on the header page for each package where such programs exist for purposes of future identification and acquisition.
A. PRE-ANALYSIS DATA PROCESSING LIBRARY

1. PREPROCESSING PACKAGE

Computer programs are available to meet some of the functional requirements of this package and can be supplied by either LEC or ERIM.
I. NAME: GENERAL RADIOMETRIC CORRECTION

II. SOURCE (include coder/person with knowledge of program usage): General Electric/Jim Brienly

III. PROGRAMMING LANGUAGE: FORTRAN

IV. PURPOSE: See next page

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

   Reference: See next page

   Description: See next page

VI. SPECIAL FEATURES: None

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available _ Not Available _ Will be Available

IX. X Software available off-the-shelf. Approximate Cost: $7,712

   Is X Is not compatible with Image 100 configuration in present form

   _ Non-PDP 11/45 FORTRAN

   _ Some machine language conversion necessary

   _ In language other than FORTRAN. Specify ________________

   _ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

   _ General purpose X Special purpose X Program package

   _ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE _ Non-LACIE

   _ Training _ Classification _ Estimation of Proportion

   _ Feature Selection _ Signature Extension

   _ Temporal Sampling _ Systems Development _ Technique Development

   _ Crop Assessment _ Yield Estimation

   _ Other (specify) _____________________________________________

A.1-2
1.1.2 GENERAL RADIOMETRIC CORRECTION

Adjustment of the radiometric amplitudes of raw ERTS-1 MSS data may be effected using this program. Three modes of operation are available for handling a variety of data adjustment techniques:

a. General Mode

This mode assumes that the data requires correction as a function of x-y position and channel. The form of the correction applied to each pixel is:

\[ S'(x,y) = S(x,y) \cdot f(ch) \cdot s(ch) + t(x,y) \cdot g(ch) \]

where

- \( S \) is the radiometric amplitude of each pixel;
- \( x, y \) are ERTS MSS frame coordinates;
- \( ch \) is the ERTS MSS channel;
- \( f, g, s, t \) are user-supplied functions.

b. Channel Correction Mode

This mode permits the user to apply a stored lookup table correction to each of the four channels. This is to correct (or linearize) non-linear scanner sensor outputs. The lookup tables are generated under user control for each channel from the following functions:

1. \( S' = aS^2 + bS + c \) (square law function)
2. \( S' = a \ln (S+1) + b \) (log function)
3. \( S' = ae^S + b \) (exponential function)
4. Three-segment piecewise linear curve with break-points at \( a \) and \( b \) corresponding to the 10 percent and 90 percent amplitude points.

c. Sensor Correction Mode

This mode is applied to correct for calibration differences between ERTS-1 MSS sensors. Each image line is referenced back to its sensor and a stored lookup table correction is applied. The lookup tables may be loaded at the user's request; this is accomplished by scanning the image and loading each table with the corrections that provide uniform values for the mean of each sensor within a band. In this fashion, so-called "banding" corrections may be made.
A. PRE-ANALYSIS DATA PROCESSING LIBRARY

2. REGISTRATION PACKAGE
I. NAME: CORLAT

II. SOURCE (include coder/person with knowledge of program usage):
S. YAO/LEC

III. PROGRAMMING LANGUAGE: FORTRAN
COMPUTER: UNIVAC 1108

IV. PURPOSE: Does two-dimension image correlation using the fast Fourier transform technique

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference:

Description: By inputting a reference and an overlay image and the correlation patch-size, the output correlation function and correlations coefficients are obtained.

VI. SPECIAL FEATURES: One can either correlate on designated Line-pixel points or specify a set of correlation grid points.

VII. SUBROUTINES REQUIRED: HARM (2D-FFT from IBM Scientific Subroutine package)

VIII. DOCUMENTATION: Available x Not Available __ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ___________
Is x Is not __ compatible with Image 100 configuration in present form
__ Non-PDP 11/45 FORTRAN
__ Some machine language conversion necessary
__ In language other than FORTRAN. Specify __________
__ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
x General purpose ___ Special purpose ___ Program package
x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
__ Training __ Classification __ Estimation of Proportion
__ Feature Selection __ Signature Extension
__ Temporal Sampling __ Systems Development __ Technique Development
__ Crop Assessment __ Yield Estimation
x Other (specify) __ Pre-processing -- Registration

A.2-2
I. NAME: REGSTR

II. SOURCE (include coder/person with knowledge of program usage):
   S. YAO

III. PROGRAMMING LANGUAGE: FORTRAN
     COMPUTER: UNIVAC 1108

IV. PURPOSE: Does linear (1st order) geometrical corrections on 2-D images
     based on six input parameters--two scaling, two translation and two
     rotation.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference:

Description: REGSTR maps the overlay image onto the reference image,
with output image similar to the reference image in
geometrical properties. A buffer is created to store the
overlay image for output one line at a time.

VI. SPECIAL FEATURES: REGSTR does "REGISTRATION" based on results obtained
     from CORLAT. It contains the tape-merge provision,
     that is, one output image can be obtained from merging
     two adjacent ERTS strips.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: _Available__x_Not Available__Will be Available

IX. _x_Software available off-the-shelf. Approximate Cost: ___________
    Is _x_Is not__ compatible with Image 100 configuration in present form
    _Non-PDP 11/45 FORTRAN
    _Some machine language conversion necessary
    _In language other than FORTRAN. Specify _______________________
    _Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _x_General purpose__ Special purpose__ Program package
   _x_PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE__x_Non-LACIE
    _Training__ Classification__ Estimation of Proportion
    _Feature Selection__ Signature Extension
    _Temporal Sampling__ Systems Development__ Technique Development
    _Crop Assessment__ Yield Estimation
    _x_Other (specify) __pre-processing__REGISTRATION

A.2-3
A. PREF-ANALYSIS DATA PROCESSING LIBRARY

3. TRAINING FIELD SELECTION PACKAGE

A program which provides the capability of selecting irregularly shaped training fields has been developed on the Image 100 System by Ted Kell, LEC.

A display package which makes use of linear combinations of channels is being developed by Dr. Jack Bryant, Texas A&M University.
I. NAME: IRREGULARLY SHAPED TRAINING FIELDS

II. SOURCE (include coder/person with knowledge of program usage):
Ted Kell

III. PROGRAMMING LANGUAGE: FORTRAN
COMPUTER: IMAGE 100

IV. PURPOSE: Select training fields with odd shapes and/or sizes.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: Program under development by Ted Kell.

Description: This program will permit the selection of odd shaped training fields (the current system permits only rectangular fields).

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: __Available X Not Available __Will be Available

IX. Software available off-the-shelf. Approximate Cost: __________
Is X Is not __compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify __________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose _X Special purpose __Program package
__PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _X LACIE _X Non-LACIE
__Training __Classification __Estimation of Proportion
__Feature Selection __Signature Extension
__Temporal Sampling __Systems Development _X Technique Development
__Crop Assessment __Yield Estimation
__Other (specify) __________

A.3-2
I. NAME: Line find

II. SOURCE (include coder/person with knowledge of program usage):
   Ted Kell

III. PROGRAMMING LANGUAGE: FORTRAN
     COMPUTER: PDP11/45

IV. PURPOSE: To detect lines in a scene and display them on the CRT.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference:
   Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: ___ Available ___ Not Available ___ Will be Available

IX. ___ Software available off-the-shelf. Approximate Cost: ________
    Is ___ Is not ___ compatible with Image 100 configuration in present form
    ___ Non-PDP 11/45 FORTRAN
    ___ Some machine language conversion necessary
    ___ In language other than FORTRAN. Specify __________________________
    ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___ General purpose ___ Special purpose ___ Program package
   ___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___ LACIE ___ Non-LACIE
    ___ Training ___ Classification ___ Estimation of Proportion
    ___ Feature Selection ___ Signature Extension
    ___ Temporal Sampling ___ Systems Development ___ Technique Development
    ___ Crop Assessment ___ Yield Estimation
    ___ Other (specify) ___________________________________

A.3-3
I. NAME: Grey Scale Map Package For High Speed Printer

II. SOURCE (include coder/person with knowledge of program usage):
Jack Bryant, Dept. Math. TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV, PLI  COMPUTER: IBM 360/65

IV. PURPOSE: To produce single channel grey scale maps on a high speed printer.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: Jack Bryant, Program documentation OCM, HISTOG, PRINTUM, Report #35, Contract NAS-9-12777, Department of Mathematics, University of Houston, August, 1974.
Description: Computes histograms from single channel of ERTS data (single pass or registered) and produces a grey scale map on the high speed printer (8 levels of grey).

VI. SPECIAL FEATURES: Three separate main programs - not a subroutine package.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available  _Not Available_ Will be Available

IX. _x_ Software available off-the-shelf. Approximate Cost: __0__
Is__Is not_x_ compatible with Image 100 configuration in present form
_ _Non-PDP 11/45 FORTRAN
_ _Some machine language conversion necessary
_ _In language other than FORTRAN. Specify IBM 360 Assembly Language
_ _Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
_ _General purpose x Special purpose x Program package
_ _PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
_ _Training__Classification__Estimation of Proportion
_ _Feature Selection__Signature Extension
_ _Temporal Sampling__Systems Development x Technique Development
_ _Crop Assessment__Yield Estimation
_ _Other (specify) _______________________

A.3-4
I. NAME: PROGRAM PRINTUM

II. SOURCE (include coder/person with knowledge of program usage):
Jack Bryant, Dept. Math. TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: 360/65

IV. PURPOSE: Calculate cumulative distributions of the histograms.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Description: Calculate cumulative distributions (estimate maximum & minimum significant data values to be input to OCM)

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available _Not Available_ Will be Available

IX. _Software available off-the-shelf. Approximate Cost: _0_
Is _x Is not_ compatible with Image 100 configuration in present form
___Non-PDP 11/45 FORTRAN
___Some machine language conversion necessary
___In language other than FORTRAN. Specify ________________
___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___General purpose _x_ Special purpose _Program package
___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _x_ LACIE _x_ Non-LACIE
___Training ___Classification ___Estimation of Proportion
___Feature Selection ___Signature Extension
___Temporal Sampling ___Systems Development _x_ Technique Development
___Crop Assessment ___Yield Estimation
___Other (specify) ________________________________

A.3-5
I. NAME: PROGRAM HISTOG

II. SOURCE (include coder/person with knowledge of program usage):
Jack Bryant, Dept. Math. TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: 36/65

IV. PURPOSE: Outputs complete histograms of all channels.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)


Description: Accumulates, prints, punches, complete histograms of all channels used as input to OCM.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: [ ] Available [ ] Not Available [ ] Will be Available

IX. [ ] Software available off-the-shelf. Approximate Cost: ____________
Is [ ] Is not __ compatible with Image 100 configuration in present form
[ ] Non-PDP 11/45 FORTRAN
[ ] Some machine language conversion necessary
[ ] In language other than FORTRAN. Specify ____________
[ ] Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
[ ] General - Purpose [ ] Special purpose [ ] Program package
[ ] PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: [ ] LACIE [ ] Non-LACIE
[ ] Training [ ] Classification [ ] Estimation of Proportion
[ ] Feature Selection [ ] Signature Extension
[ ] Temporal Sampling [ ] Systems Development [ ] Technique Development
[ ] Crop Assessment [ ] Yield Estimation
[ ] Other (specify) ____________

A.3-6
I. NAME: PROGRAM OCM

II. SOURCE (include coder/person with knowledge of program usage):
     Jack Bryant, Dept of Math., TX A&M Univ 77843

III. PROGRAMMING LANGUAGE: FORTRAN IV
     COMPUTER: 360/65

IV. PURPOSE: One channel map.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

     Reference: Jack Bryant, "Program Documentation OCM, HISTOG, PRINTUM",

     Description: Reproduces digital picture on high speed printer by printing an appropriate selection of characters.

VI. SPECIAL FEATURES: 8 shades of grey can be reproduced.
     Requires high speed printer

VII. SUBROUTINES REQUIRED: HPO5, COLS, TODEC

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. _x_ Software available off-the-shelf. Approximate Cost: __________

   Is _ Is not _x_ compatible with Image 100 configuration in present form
   ___ Non-PDP 11/45 FORTRAN
   _x_ Some machine language conversion necessary
   _x_ In language other than FORTRAN. Specify IBM 360 Assembly Language
   ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

   ___ General purpose _x_ Special purpose _x_ Program package
   ___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _x_ LACIE _x_ Non-LACIE

   _x_ Training _x_ Classification _x_ Estimation of Proportion
   ___ Feature Selection ___ Signature Extension
   ___ Temporal Sampling ___ Systems Development _x_ Technique Development
   ___ Crop Assessment ___ Yield Estimation
   ___ Other (specify) ____________________________________________
I. NAME: KONTUR Program Package

II. SOURCE (include coder/person with knowledge of program usage):
   Charles Eleuterius, Dept. of Oceanography, TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV
     COMPUTER: IBM 360/65

IV. PURPOSE: To plot, on either a CALCOMP or Gerber plotter, a
   contour map built from a two-dimensional array of data
   values. The array size may be quite large.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: KONTUR, a modification to program CONMAP by
   David C. Haley of Lockheed Electronics Company written
   under NASA contract #NSA 0-5384. For reference to modification—"source" above.
   Description: The surface is approximated by elementary rectangles with
   grid points at the corners. All isolines that traverse the rectangle
   will be drawn while those four points are being considered.

VI. SPECIAL FEATURES: A code deck is read as the first part of the input
    data; it contains a decision table to determine cases. The code
    deck must be obtained with the program.

VII. SUBROUTINES REQUIRED: CONMAP, READIN, TAMU

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: _?--
    Is _ Is not x compatible with Image 100 configuration in present form
    _ Non-PDP 11/45 FORTRAN
    _ Some machine language conversion necessary
    _ In language other than FORTRAN. Specify ____________________________
    _ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _ x General purpose _ Special purpose _ x Program package
   _ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _ x LACIE _ x Non-LACIE
   _ x Training _ Classification _ Estimation of Proportion
   _ Feature Selection _ Signature Extension
   _ Temporal Sampling _ Systems Development _ x Technique Development
   _ Crop Assessment _ Yield Estimation
   _ Other (specify)  ____________________________________________

A.3-8
I. NAME: MAIN

II. SOURCE (include coder/person with knowledge of program usage):
Charles Eleuterius

III. PROGRAMMING LANGUAGE: FORTRAN IV       COMPUTER: IBM 360/65

IV. PURPOSE: Inputs code deck and control parameters, calls CONMAP.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See KUNTUR reference.

Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: CONMAP, LINE4

VIII. DOCUMENTATION: x Available    __ Not Available    __ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ___________
   Is x Is not x compatible with Image 100 configuration in present form
   __Non-PDP 11/45 FORTRAN
   __Some machine language conversion necessary
   __In language other than FORTRAN. Specify ________________
   __Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   __General purpose x Special purpose __Program package
   x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE X Non-LACIE
   x Training __ Classification __ Estimation of Proportion
   __ Feature Selection __ Signature Extension
   __ Temporal Sampling __ Systems Development x Technique Development
   __ Crop Assessment __ Yield Estimation
   __ Other (specify) ________________

A.3-9
I. NAME: SUBROUTINE CONMAP

II. SOURCE (include coder/person with knowledge of program usage):
   Charles Eleuterius

III. PROGRAMMING LANGUAGE: FORTRAN IV
      COMPUTER: IBM 360/65

IV. PURPOSE: To permit contouring using very large data arrays. The output
      contour maps will be drawn on the CALCOMP or Gerber plotter.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: See KONTUR reference
   Description: Four data points are considered at a time, connected to
   form two triangles. The intersection line of these triangular planes
   with each of the contour planes is plotted.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: READIN, PLOT, FACTOR, SYMBOL, TAMU

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. _ x Software available off-the-shelf. Approximate Cost: _ ?-_
      Is _ x_ Is not _ x_ compatible with Image 100 configuration in present form
      _ Non-PDP 11/45 FORTRAN
      _ Some machine language conversion necessary
      _ In language other than FORTRAN. Specify ___________________________
      _ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _ General purpose x Special purpose _ Program package
   _ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _ LACIE _ x Non-LACIE
   _ x Training _ Classification _ Estimation of Proportion
   _ Feature Selection _ Signature Extension
   _ Temporal Sampling _ Systems Development _ x Technique Development
   _ Crop Assessment _ Yield Estimation
   _ Other (specify) ________________________________________________

   A.3-10
I. NAME: SUBROUTINE READIN

II. SOURCE (include coder/person with knowledge of program usage):
Charles Eleuterius

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: To input grid array data

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See KONTUR reference

Description:

VI. SPECIAL FEATURES: User written so that data may be entered in form to conform to and take advantage of plotter characteristics of travel direction and resolution.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. _x Software available off-the-shelf. Approximate Cost: __________
Is _Is not _x compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify ________________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose x Special purpose Program package
x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE _x Non-LACIE
_x Training _x Classification _x Estimation of Proportion
__Feature Selection _x Signature Extension
__Temporal Sampling _x Systems Development _x Technique Development
__Crop Assessment _x Yield Estimation
__Other (specify) ____________________________________________

A.3-11
I. NAME: SUBROUTINE TAMU

II. SOURCE (include coder/person with knowledge of program usage):
Charles Eleuterius

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: To consider each successive rectangle and determine the type of isoline case.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See KONTUR reference.

Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: DRAW

VIII. DOCUMENTATION: x Available__Not Available___Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
Is__Is not x compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify ______________________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
General purpose x Special purpose__Program package
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
x Training__Classification__Estimation of Proportion
Feature Selection__Signature Extension
Temporal Sampling__Systems Development x Technique Development
Crop Assessment__Yield Estimation
Other (specify) ____________________________________________

A.3-12
I. NAME: SUBROUTINE DRAW

II. SOURCE (include coder/person with knowledge of program usage):
Charles Eleuterius

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: To draw actual contours, labeling the isolines, for each rectangle.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See KONTUR reference.

Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: PLOT

VIII. DOCUMENTATION: x Available__Not Available__Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ____________
Is__Is not x compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify ____________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose x Special purpose __Program package
x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: xLACIE x Non-LACIE
x Training__Classification__Estimation of Proportion
__Feature Selection__Signature Extension
__Temporal Sampling__Systems Development x Technique Development
__Crop Assessment__Yield Estimation
__Other (specify) ________________________________________

A.3-13
A. PRE-ANALYSIS DATA PROCESSING LIBRARY

4. SIMULATED DATA GENERATOR PACKAGE
B. GENERAL MATHEMATICAL LIBRARY

1. LINEAR ALGEBRA PACKAGE
I. NAME: SUBROUTINE MINVSP (A, N, E, K) (single precision)
SUBROUTINE MINVDP (A, N, E, K) (double precision)

II. SOURCE (include coder/person with knowledge of program usage):
L. F. Guseman, Jr., Math. Dept. TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV COMPUTER: 360/65

IV. PURPOSE: To invert a nonsingular N×N matrix A

V. ALGORITHM/TECHNIQUE (short description; include reference if available)


Description:

Uses Gaussian elimination with pivoting.

VI. SPECIAL FEATURES:

The inverse is built into the array originally occupied by A. The original matrix A is lost.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. _x__Software available off-the-shelf. Approximate Cost: __-?-____
Is x Is not _ compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify _______________________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
x General purpose _ Special purpose _ Program package
x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE _ Non-LACIE
Training _x_ Classification _x_ Estimation of Proportion
Feature Selection _x_ Signature Extension
Temporal Sampling _ Systems Development _ Technique Development
Crop Assessment _ Yield Estimation
Other (specify) ________________________________

B.1-2
I. NAME: LU-Decomposition Package

II. SOURCE (include coder/person with knowledge of program usage):
   N.W. Naugle, Math. Dept. TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV      COMPUTER: 360/65

IV. PURPOSE: Package for solving linear systems AX = B where A is a square nonsingular matrix. Also provides capability to compute A⁻¹

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Description: Computes LU-decomposition of A

VI. SPECIAL FEATURES:
   Original A is saved. Iterative improvement of solution or inverse is built in.

VII. SUBROUTINES REQUIRED:
   DECOMP, SOLVE, IMPRUV, SING

VIII. DOCUMENTATION: x Available __ Not Available __ Will be Available

IX. x Software, available off-the-shelf. Approximate Cost: ___ -?-
   Is x Is not __ compatible with Image 100 configuration in present form
   ___Non-PDP 11/45 FORTRAN
   ___Some machine language conversion necessary
   ___In language other than FORTRAN. Specify _______________________
   ___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   x General purpose x Special purpose _ Program package
   ___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
   ___Training _x Classification x Estimation of Proportion
   _x Feature Selection _x Signature Extension
   ___Temporal Sampling _x Systems Development _x Technique Development
   ___Crop Assessment _x Yield Estimation
   ___Other (specify) ___________________________________________
I. NAME: SUBROUTINE DECOMP (NN,A,UL)

II. SOURCE (include coder/person with knowledge of program usage):
   N.W. Naugle, Math. Dept. TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV

IV. PURPOSE: To compute the LU-decomposition of a square nonsingular matrix A. Part of package to solve systems of equations and compute inverses.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

   Reference: See LU-Decomposition Package, p. 1 of 5
   Description: Decomposes A into LU, where L is lower triangular with ones along the diagonal, and U is upper triangular. Uses scaling and Gaussian elimination with partial pivoting.

VI. SPECIAL FEATURES:
   Original matrix A is saved.

VII. SUBROUTINES REQUIRED:
   SING

VIII. DOCUMENTATION: x Available  Not Available  Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
    Is x Is not compatible with Image 100 configuration in present form
    ___ Non-PDP 11/45 FORTRAN
    ___ Some machine language conversion necessary
    ___ In language other than FORTRAN. Specify ___________________
    ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___ General purpose  x Special purpose  Program package
   ___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE  x Non-LACIE
   ___ Training  x Classification  x Estimation of Proportion
   x Feature Selection  x Signature Extension
   ___ Temporal Sampling  __ Systems Development  x Technique Development
   ___ Crop Assessment  __ Yield Estimation
   ___ Other (specify) ____________________________________________
I. NAME: SUBROUTINE SOLVE (NN,UL,B,X)

II. SOURCE (include coder/person with knowledge of program usage):
N.W. Naugle, Math. Dept. TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: 360/65

IV. PURPOSE: Given the LU-decomposition of A, and a constant vector B, the program solves LUX=B for X

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See p.1

Description: Given a square matrix A with decomposition A=LU, and a constant vector B, the solution X of the equation LUX=B is obtained.

VI. SPECIAL FEATURES: Can obtain A\(^{-1}\) by solving LUX\(_i\)=E\(_i\), where E\(_i\) is a unit vector with 1 in ith slot, i=1,2,...,NN

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available__Not Available__Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
Is x Is not compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify __________________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose__x Special purpose__Program package
x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
__Training__x Classification__Estimation of Proportion
x Feature Selection__x Signature Extension
__Temporal Sampling__Systems Development__x Technique Development
__Crop Assessment__Yield Estimation
__Other (specify) ________________________________
I. NAME: SUBROUTINE IMPRUV (NN, A, UL, B, X, DIGITS)

II. SOURCE (include coder/person with knowledge of program usage):
N.W. Naugle, Math, Dept. TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: 360/65

IV. PURPOSE: To improve the solution X of AX=B

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See p. 1

Description: Uses iterative procedure to improve solution X (of inverse) of AX=B. The procedure is machine dependent in that the tolerance and number of iterations specified depend on the word length of the machine.

VI. SPECIAL FEATURES:
Double precision accumulation of intermediate sums is required.

VII. SUBROUTINES REQUIRED:
SING

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available.

IX. x So _ Available off-the-shelf. Approximate Cost: __________
Is x In _ Not compatible with Image 100 configuration in present form
___ Non-PDP 11/45 FORTRAN
___ Some machine language conversion necessary
___ In language other than FORTRAN. Specify __________
___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___ General purpose x Special purpose ___ Program package
___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
___ Training x Classification x Estimation of Proportion
___ Feature Selection x Signature Extension
___ Temporal Sampling ___ Systems Development x Technique Development
___ Crop Assessment ___ Yield Estimation
___ Other (specify) ____________________________________________

B.1-6
I. NAME: SUBROUTINE SING (INHY)

II. SOURCE (include coder/person with knowledge of program usage):
N.W. Naugle, Math. Dept. TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: 360/65

IV. PURPOSE: To print error messages for DECOMP and IMPRUV

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See p. 1

Description: Error messages are printed if original matrix in DECOMP is singular or else no convergence is obtained in IMPRUV.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available__Not Available__Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ____________
Is x Is not__compatible with Image 100 configuration in present form
___Non-PDP 11/45 FORTRAN
___Some machine language conversion necessary
___In language other than FORTRAN. Specify ________________
___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___General purpose__x__Special purpose__ Program package
___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x__LACIE__x__Non-LACIE
___Training__x__Classification__x_Estimation of Proportion
___Feature Selection__x__Signature Extension
___Temporal Sampling__x__Systems Development__x__Technique Development
___Crop Assessement__x__Yield Estimation
___Other (specify) ____________________________

B.1-7
I. NAME: SUBROUTINE GINV2M

II. SOURCE (include coder/person with knowledge of program usage):
   F.M. Speed, Dept. Math. Mississippi State Univ.

III. PROGRAMMING LANGUAGE: FORTRAN IV, G
     COMPUTER: 360

IV. PURPOSE: To compute the generalized inverse of a matrix.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: Adi Ben-Israel and Thomas N. E. Greville, Generalized Inverse—
   Description: Uses Gram-Schmidt Orthogonalization

VI. SPECIAL FEATURES: Generalized inverse is computed in location
     occupied by original matrix.

VII. SUBROUTINES REQUIRED: FUNCTION DOT

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __?__
    Is x Is not__ compatible with Image 100 configuration in present form
    _ Non-FDP 11/45 FORTRAN
    _ Some machine language conversion necessary
    _ In language other than FORTRAN. Specify _______________________
    _ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   x General purpose __ Special purpose __ Program package
   x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE _ Non-LACIE
    __ Training __ Classification __ Estimation of Proportion
    __ Feature Selection __ Signature Extension
    __ Temporal Sampling __ Systems Development __ Technique Development
    __ Crop Assessment __ Yield Estimation
    __ Other (specify) _____________________________________________

B.1-8
I. NAME: FUNCTION DOT (double precision)

II. SOURCE (include coder/person with knowledge of program usage):
F.M. Speed, Dept. Math. Mississippi State Univ.

III. PROGRAMMING LANGUAGE: FORTRAN IV, G
COMPUTER: 360

IV. PURPOSE: Inner product of two columns of a matrix.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference:

Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: _x_Available_ _Not Available_ _Will be Available

IX. _x_Software available off-the-shelf. Approximate Cost: __________
Is _x_Is not _compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify __________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
_General purpose_ _Special purpose_ _Program package
_PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE_ _Non-LACIE
_Training_ _Classification_ _Estimation of Proportion
_Feature Selection_ _Signature Extension
_Temporal Sampling_ _Systems Development_ _Technique Development
_Crop Assessment_ _Yield Estimation
_Other (specify) ____________________________

B.1-9
I. NAME: SUBROUTINE CHLSKY (double precision)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN IV COMPUTER: IBM 360/65

IV. PURPOSE: To obtain the modified (sometimes called "alternate form") Cholesky decomposition of a real symmetric positive definite matrix A, and then its inverse.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Description: The routine is a translation and slight modification of the Algol routine "syminversion" of above reference. The matrix A is decomposed into LDLT, with L unit lower tridiagonal and D positive diagonal.

VI. SPECIAL FEATURES:
The parameter DET input into Chlsky calls for the inverse and/or determinant to be computed if DET is non-negative or positive, respectively. DET returned as non-positive indicates A is not positive definite, either originally or through accumulation of roundoff error.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ____________
Is x Is not __ compatible with Image 100 configuration in present form
__ Non-PDP 11/45 FORTRAN
__ Some machine language conversion necessary
__ In language other than FORTRAN. Specify ________________
__ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
x General purpose _ Special purpose _ Program package
x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
___ Training ___ Classification ___ Estimation of Proportion
__ x Feature Selection ___ Signature Extension
___ Temporal Sampling ___ Systems Development ___ Technique Development
___ Crop Assessment ___ Yield Estimation
___ Other (specify) ________________

B.1-10
I. NAME: TSTMIS  (Single precision)  
   TSTMID (Double precision) 

II. SOURCE (include coder/person with knowledge of program usage): 
   L.F. Guseman, Jr. 

III. PROGRAMMING LANGUAGE: FORTRAN IV  
     COMPUTER: IBM 360/65 

IV. PURPOSE: Program for testing matrix inversion routines for accuracy. 

V. ALGORITHM/TECHNIQUE (short description; include reference if available) 

   Reference: Randall E. Cline, A class of matrices to test inversion procedures, Comm. ACM 7(1964), 724-725. 

   Description: Given an \( m \times n \) matrix \( T = (t_{ij}) \), where \( t_{ij} = 0 \) if \( i \neq j \) 
   \( t_{ii} = d, \) where \( d \neq 1, d < (n-1), \) the inverse is given by \( T^{-1} = (t^{-1}_{ij}) \), where 
   \[ t^{-1}_{ii} = \frac{1}{d-1} \left( \frac{n+d-2}{n+d-1} \right), \] 
   \[ t^{-1}_{ij} = \frac{1}{d-1} \left( \frac{-1}{n+d-1} \right), \] 
   \( i \neq j. \) 

VI. SPECIAL FEATURES: 

   Eigenvalues are given by \( \lambda_1 = (n+d-1) \) and \( \lambda_i = d-1, 2 \leq i \leq n, \) and can be used to construct matrices with desired condition number. CALL Statement must be modified to call routine being tested. 

VII. SUBROUTINES REQUIRED: Inversion routine being tested. 

VIII. DOCUMENTATION: x Available  _Not Available_  Will be Available 

IX. x Software available off-the-shelf. Approximate Cost: ____ ?-____ 

   Is x Is not compatible with Image 100 configuration in present form 
   ____ Non-PDP 11/45 FORTRAN 
   ____ Some machine language conversion necessary 
   ____ In language other than FORTRAN. Specify ________________ 
   ____ Software must be designed and developed for Image 100 

X. IMPLEMENTATION LEVEL 

   ____ General purpose x Special purpose Program package 
   ____ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE 

XI. APPLICATION: x LACIE Non-LACIE 

   ____ Training __ Classification __ Estimation of Proportion 
   ____ Feature Selection __ Signature Extension 
   ____ Temporal Sampling __ Systems Development x Technique Development 
   ____ Crop Assessment __ Yield Estimation 
   ____ Other (specify) ________________ 

B.1-11
COMPUTER PROGRAM IDENTIFICATION FORM


II. SOURCE (Include coder/person with knowledge of program usage):
   W. L. Morris, Math Dept., University of Houston, Houston, Texas 77004

III. PROGRAMMING LANGUAGE: FORTRAN V  COMPUTER: 1108/EXEC 8

IV. PURPOSE:
   Compute eigenvectors and eigenvalues for a real symmetric matrix

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

   Reference: W. L. Morris, Inclusion theorems for a section of a matrix,

   Description:
   Reduces calculations to that for eigenvalues of sequence of matrices
   of order 2

VI. SPECIAL FEATURES:
   Requires approximate no. of equivalent decimal
   numbers in floating point representation for the given machine.

VII. SUBROUTINES REQUIRED:
   SUPSUM  RHA
   ORDER   RINPRD
   MINDEX

VIII. DOCUMENTATION: X Available  _ Not Available  _ Will be Available

   X Software available off-the-shelf. Approximate Cost: -------
   Is X Is not  _ compatible with Image 100 configuration in present form
   _ Non-PDP 11/45 FORTRAN
   _ Some machine language conversion necessary
   _ In language other than FORTRAN. Specify ____________________________
   _ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   X General purpose  _ Special purpose  _ Program package
   X PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE  X Non-LACIE
    _ Training  _ Classification  _ Estimation of Proportion
    _ Feature Selection  _ Signature Extension
    _ Temporal Sampling  _ Systems Development  _ Technique Development
    _ Crop Assessment  _ Yield Estimation
    _ Other (specify) _______________________________________________________

B.1-12
I. NAME: SUBROUTINE MINDEX(R, JM, IM, N)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN IV  
      COMPUTER: 1108

IV. PURPOSE: Indices of ascending elements of a vector are placed in another vector.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference:

Description: JM vector will contain the indices of ascending elements of R.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available  X Not Available  X Will be Available

IX. X Software available off-the-shelf. Approximate Cost: ____________________

Is XI is not compatible with Image 100 configuration in present form

Non-PDP 11/45 FORTRAN

Some machine language conversion necessary

In language other than FORTRAN. Specify ____________________

Software must be designed and developed for Image 100.

X. IMPLEMENTATION LEVEL

General purpose X Special purpose  X Program package

PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE  X Non-LACIE

Training X Classification X Estimation of Proportion

Feature Selection X Signature Extension

Temporal Sampling X Systems Development X Technique Development

Crop Assessment X Yield Estimation

Other (specify) ____________________
I. NAME: FUNCTION RHA(A,B,C,U,N)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN IV COMPUTER: 1108

IV. PURPOSE: For a fixed column of A and B matrices, calculate inner product A = C * B

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference:

Description: Uses RINPRD for inner product

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

RINPRD

VIII. DOCUMENTATION: ___Available ___Not Available ___Will be Available

IX. ___Software available off-the-shelf. Approximate Cost: __________
Is ___Is not ___compatible with Image 100 configuration in present form
___Non-PDP 11/45 FORTRAN
___Some machine language conversion necessary
___In language other than FORTRAN. Specify _______________________
___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___General purpose ___Special purpose ___Program package
___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___LACIE ___Non-LACIE
___Training ___Classification ___Estimation of Proportion
___Feature Selection ___Signature Extension
___Temporal Sampling ___Systems Development ___Technique Development
___Crop Assessment ___Yield Estimation
___Other (specify) ____________________________________________

B.1-14
I. NAME: FUNCTION RINPRD(A,B,N)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN IV

IV. PURPOSE: Real inner product of vector with another vector

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference:

Description:

A * B = RINPRD

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

SUPSUM

VIII. DOCUMENTATION: __Available__ x Not Available__ Will be Available

IX. Software available off-the-shelf. Approximate Cost: ____________

Is __ Is not __ compatible with Image 100 configuration in present form

Non-PDP 11/45 FORTRAN

_{Some machine language conversion necessary}

In language other than FORTRAN. Specify ____________

Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

General purpose x Special purpose Program package

PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE

Training x Classification x Estimation of Proportion

Feature Selection x Signature Extension

Temporal Sampling Systems Development x Technique Development

Crop Assessment x Yield Estimation

Other (specify) ________________
I. NAME: DOUBLE PRECISION FUNCTION SUPSUM(A, I, N)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN IV, G  COMPUTER: 360/44
IV. PURPOSE: Vector elements summed

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference:
   Description:

VI. SPECIAL FEATURES: Reduced round-off error

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: __Available X Not Available __Will be Available
IX. X Software available off-the-shelf. Approximate Cost: ____________
    Is x Is not compatible with Image 100 configuration in present form
    ___Non-PDP 11/45 FORTRAN
    ___Some machine language conversion necessary
    ___In language other than FORTRAN. Specify _________________
    ___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
    ___General purpose X Special purpose __Program package
    X PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE X Non-LACIE
    ___Training X Classification X Estimation of Proportion
    ___Feature Selection X Signature Extension
    ___Temporal Sampling ___ Systems Development ___ Technique Development
    ___Crop Assessment ___ Yield Estimation
    ___Other (specify) ________________________________

B.1-16
I. NAME: SUBROUTINE ORDER (A, I1, I2, N)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN IV, G  COMPUTER: 360/64

IV. PURPOSE: Orders elements of a vector in increasing absolute value

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference:

Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available  X Not Available  X Will be Available

IX. X Software available off-the-shelf. Approximate Cost:

Is X Is not compatible with Image 100 configuration in present form

Non-PDP 11/45 FORTRAN

Some machine language conversion necessary

In language other than FORTRAN. Specify

Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

X Non-PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE  X Non-LACIE

X Training  X Classification  X Estimation of Proportion

Feature Selection  X Signature Extension

Temporal Sampling  X Systems Development  X Technique Development

Crop Assessment  X Yield Estimation

Other (specify)
I. NAME: SUBROUTINE DSVD(A,MMAX,NMAX,M,N,P,WITHU,WITHV,S,U,V)

II. SOURCE (include coder/person with knowledge of program usage):
    G. H. Golub, Computer Science Dept., Stanford Univ., Stanford, Ca. 94305

III. PROGRAMMING LANGUAGE: FORTRAN IV  COMPUTER: 1108, 360/67, CDC6600
        ALGOL 60

IV. PURPOSE: 
    Singular value decomposition of rectangular matrix

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

    Reference: G. H. Golub and C. Reinsch, "Singular value decomposition and

    Description:
    Decompose a given matrix A into matrices U,S,V such that
    A = U * S * V

VI. SPECIAL FEATURES: A may be partitioned such that the submatrix B area
    will have the submatrix UT * B. U and/or V may be
    used in the calculations depending on the flag

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available  Not Available  Will be Available

IX.  X Software available off-the-shelf. Approximate Cost: -?

     Is X Is not compatible with Image 100 configuration in present form
     ___Non-PDP 11/45 FORTRAN
     ___Some machine language conversion necessary
     ___In language other than FORTRAN. Specify
     ___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
    X General purpose  Special purpose  Program package
    X PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE  X Non-LACIE
    ___Training  X Classification  X Estimation of Proportion
    X Feature Selection  X Signature Extension
    ___Temporal Sampling  ___Systems Development  X Technique Development
    ___Crop Assessment  ___Yield Estimation
    ___Other (specify)

II. SOURCE (include coder/person with knowledge of program usage):
    David Lowell

III. PROGRAMMING LANGUAGE: FORTRAN IV, G
     COMPUTER: 360/44

IV. PURPOSE:
    Matrix multiplication

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference:

Description:

\[ A \times X = B \]

VI. SPECIAL FEATURES:
    Reduces round-off error
    Variable dimensioning

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: __Available __Not Available __Will be Available

IX. __Software available off-the-shelf. Approximate Cost: _____?

    __Is __Is not compatible with Image 100 configuration in present form
    __Non-PDP 11/45 FORTRAN
    __Some machine language conversion necessary
    __In language other than FORTRAN. Specify __Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

    __General purpose __Special purpose __Program package
    __PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __LACIE __Non-LACIE

    __Training __Classification __Estimation of Proportion
    __Feature Selection __Signature Extension
    __Temporal Sampling __Systems Development __Technique Development
    __Crop Assessment __Yield Estimation
    __Other (specify) ____________________________________________________

B.1-19
I. NAME: SUBROUTINE EIGEN

II. SOURCE (include coder/person with knowledge of program usage):
    Paul R. Hendrick/L. F. Guseman, Jr. Department of Math. TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV     COMPUTER: IBM 360/65

IV. PURPOSE: To find all eigenvalues and eigenvectors of a real general matrix.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Description: This is merely a driver routine and calls in order the routines which balance the matrix, transform it to upper Hessenberg form and accumulate the elementary similarity transformations, compute the eigenvalues and eigenvectors of the balanced matrix, and then backtransform these to the eigenvectors of the original matrix.

VI. SPECIAL FEATURES: If the parameter IER`1 is returned as nonzero, the eigenvalue with its value as index was not computed in 30 iterations. Eigenvalues indexed from IERR + 1 to N should be correct. Eigenvectors have not been computed in this case.

VII. SUBROUTINES REQUIRED:
    BALANC, BALBAK, ELMHES, ELTRAN, HQR2, UNPK

VIII. DOCUMENTATION: x Available  Not Available  Will be Available

IX.  x Software available off-the-shelf. Approximate Cost: __________
     Is x Is not compatible with Image 100 configuration in present form
     __ Non-PDP 11/45 FORTRAN
     __ Some machine language conversion necessary
     __ In language other than FORTRAN. Specify ________________________

X. IMPLEMENTATION LEVEL
   __ General purpose __ Special purpose __ Program package
   __ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___ LACIE ___ Non-LACIE
     ___ Training ___ Classification ___ Estimation of Proportion
     ___ Feature Selection ___ Signature Extension
     ___ Temporal Sampling ___ Systems Development ___ Technique Development
     ___ Crop Assessment ___ Yield Estimation
     __ Other (specify) ____________________________________________

B.1-20
I. NAME: SUBROUTINE BALANC

II. SOURCE (include coder/person with knowledge of program usage): Burton S. Garbow, Argonne National Laboratory, Applied Mathematics Division, 9700 S Cass Ave., Argonne, Illinois 60439.

III. PROGRAMMING LANGUAGE: FORTRAN IV

IV. PURPOSE: This subroutine balances a real matrix and isolates eigenvalues whenever possible.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)


Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available _Not Available __Will be Available

IX. X Software available off-the-shelf. Approximate Cost: ____________

 Is X Is not compatible with Image 100 configuration in present form

  Non-PDP 11/45 FORTRAN

  Some machine language conversion necessary

  In language other than FORTRAN. Specify __________________________

  Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

  X General purpose _Special purpose __Program package

  PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: LACIE _Non-LACIE

  Training Classification Estimation of Proportion

  Feature Selection Signature Extension

  Temporal Sampling Systems Development Technique Development

  Crop Assessment Yield Estimation

  Other (specify) ________________________________

B.1-21
I. NAME: SUBROUTINE BALBAK

II. SOURCE (include coder/person with knowledge of program usage): Burton S. Garbow, Argonne National Laboratory, Applied Mathematics Division, 9700 S. Cass Ave., Argonne, Illinois 60439

III. PROGRAMMING LANGUAGE: FORTRAN IV COMPUTER: IBM 360/65

IV. PURPOSE: This subroutine forms the eigenvectors of a real general matrix by back transforming those of the corresponding balanced matrix determined by BALANC.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)


VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available_ Not Available_ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________

Is x Is not compatible with Image 100 configuration in present form

__ Non-PDP 11/45 FORTRAN

__ Some machine language conversion necessary

__ In language other than FORTRAN. Specify ________________

Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

x General purpose__ Special purpose__ Program package

x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: LACIE Non-LACIE

__ Training__ Classification__ Estimation of Proportion

__ Feature Selection__ Signature Extension

__ Temporal Sampling__ Systems Development__ Technique Development

__ Crop Assessment__ Yield Estimation

__ Other (specify) ____________________________________________

B.1-22
I. NAME: SUBROUTINE ELMHES

II. SOURCE (include coder/person with knowledge of program usage): Burton S. Garbow, Argonne National Laboratory, Applied Mathematics Division, 9700 S. Cass Ave, Argonne, Illinois 60439

III. PROGRAMMING LANGUAGE: FORTRAN IV  
COMPUTER: IBM 360/65

IV. PURPOSE: Given a real general matrix, this subroutine reduces a submatrix to upper Hessenberg form by stabilized elementary similarity transformations.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)


Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available  Not Available  Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ____________

Is x Is not compatible with Image 100 configuration in present form

__Non-PDP 11/45 FORTRAN

__Some machine language conversion necessary

__In language other than FORTRAN. Specify _________________

Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

x General purpose  Special purpose  Program package

x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: LACIE  Non-LACIE

__Training  Classification  Estimation of Proportion

__Feature Selection  Signature Extension

__Temporal Sampling  Systems Development  Technique Development

__Crop Assessment  Yield Estimation

__Other (specify) __________________________________________

B.1-23
I. NAME: SUBROUTINE ELTRAN

II. SOURCE (include coder/person with knowledge of program usage): Burton S. Garbow, Argonne National Laboratory, Applied Mathematics Division, 9700 S. Cass Ave., Argonne, Illinois 60439

III. PROGRAMMING LANGUAGE: FORTRAN IV COMPUTER: IBM 360/65

IV. PURPOSE: This subroutine accumulates the stabilized elementary similarity transformations used in the reduction of a real general matrix to upper Hessenberg form by ELMHES.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)


Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available___ Not Available___ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________

Is x Is not compatible with Image 100 configuration in present form

____ Non-PDP 11/45 FORTRAN

____ Some machine language conversion necessary

____ In language other than FORTRAN. Specify __________________________

____ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

x General purpose___ Special purpose___ Program package

x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___ LACIE ___ Non-LACIE

___ Training ___ Classification ___ Estimation of Proportion

___ Feature Selection ___ Signature Extension

___ Temporal Sampling ___ Systems Development ___ Technique Development

___ Crop Assessment ___ Yield Estimation

___ Other (specify) ____________________________________________________

B.1-24
**I. NAME:** SUBROUTINE HQR2

**II. SOURCE (include coder/person with knowledge of program usage):** Burton S. Garbow  
Argonne National Laboratory, Applied Mathematics Division, 9700 S. Cass Ave.,  
Argonne, Illinois 60439

**III. PROGRAMMING LANGUAGE:** FORTRAN IV  
**COMPUTER:** IBM 360/65

**IV. PURPOSE:** This subroutine finds the eigenvalues and eigenvectors of a real  
upper Hessenberg matrix by the QR method.

**V. ALGORITHM/TECHNIQUE (short description; include reference if available)**  

**VI. SPECIAL FEATURES:**

**VII. SUBROUTINES REQUIRED:**

**VIII. DOCUMENTATION:** x Available _ Not Available _ Will be Available

**IX. x Software available off-the-shelf. Approximate Cost:** ____________  
Is x Is not _ compatible with Image 100 configuration in present form  
___ Non-PDP 11/45 FORTRAN  
___ Some machine language conversion necessary  
___ In language other than FORTRAN. Specify _________________________  
___ Software must be designed and developed for Image 100

**X. IMPLEMENTATION LEVEL**  
x _ General purpose _ Special purpose _ Program package  
___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

**XI. APPLICATION:** _ LACIE _ Non-LACIE  
___ Training _ Classification _ Estimation of Proportion  
___ Feature Selection _ Signature Extension  
___ Temporal Sampling _ Systems Development _ Technique Development  
___ Crop Assessment _ Yield Estimation  
___ Other (specify) ________________________________

B.1-25
I. NAME: SUBROUTINE UNPK

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN IV COMPUTER: IBM 360/65

IV. PURPOSE: To break up the complex eigenvector matrix returned by eigenvector routines into its real and imaginary parts.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Description: The eigenvectors are originally packed in one matrix, one real eigenvector per column corresponding to a real eigenvalue, or the real part and imaginary part in two adjacent columns corresponding to a conjugate pair of eigenvalues.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
   Is x Is not _ compatible with Image 100 configuration in present form
   _ Non-PDP 11/45 FORTRAN
   _ Some machine language conversion necessary
   _ In language other than FORTRAN. Specify ________________
   _ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _x General purpose _ Special purpose _ Program package
   _x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE _ Non-LACIE
   _ Training _ Classification _ Estimation of Proportion
   _ Feature Selection _ Signature Extension
   _ Temporal Sampling _ Systems Development _ Technique Development
   _ Crop Assessment _ Yield Estimation
   _ Other (specify) ________________________________

B.1-26
B. GENERAL MATHEMATICAL LIBRARY

2. OPTIMIZATION PACKAGE
I. NAME: SUBROUTINE DFMFP

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN IV
      COMPUTER: 360/65

IV. PURPOSE: To find a local minimum of a function of several variables
by the method of Fletcher and Powell.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: R. Fletcher and M.J.D. Powell, A rapidly convergent descent
   Description:
   Uses deflected-gradient method. Converges in a finite number
   of steps if the objective function is a quadratic form.

VI. SPECIAL FEATURES:
   Requires a user-supplied subroutine which provides the values
   of the objective function and the gradient for each argument vector.

VII. SUBROUTINES REQUIRED:
   FUNCT - User supplied subroutine as described above.

VIII. DOCUMENTATION: __Available__ Not Available__ Will be Available

IX. __Software available off-the-shelf. Approximate Cost: ___-?___
   Is __ Is not __ compatible with Image 100 configuration in present form
   __Non-PDP 11/45 FORTRAN
   __Some machine language conversion necessary
   __In language other than FORTRAN. Specify ________________
   __Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   __General purpose__ Special purpose__ Program package
   __PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __LACIE__ Non-LACIE
   __Training__ Classification __Estimation of Proportion
   __Feature Selection __Signature Extension
   __Temporal Sampling__ Systems Development __Technique Development
   __Crop Assessment __Yield Estimation
   __Other (specify) ____________________________
NAME: SUBROUTINE FRKWLF

SOURCE (include coder/person with knowledge of program usage):
B. C. Peters, Jr. / L. F. Guseman, Jr. / Bruce Marion

PROGRAMMING LANGUAGE: FORTRAN IV COMPUTER: IBM 360/65

PURPOSE: To solve the quadratic programming problem: minimize \( ||Ax-y|| \)
subject to \( \sum_{i=1}^{n} x_i = 1 \), \( x_i > 0 \), \( 1 \leq i \leq n \)

ALGORITHM/TECHNIQUE (short description; include reference if available)

Description: A modification of the Frank-Wolfe algorithm

SPECIAL FEATURES:

SUBROUTINES REQUIRED:

DOCUMENTATION: __Available x Not Available __Will be Available

Software available off-the-shelf. Approximate Cost: -?-

Is x Is not compatible with Image 100 configuration in present form

__Non-PDP 11/45 FORTRAN

__Some machine language conversion necessary

__In language other than FORTRAN. Specify ____________

Software must be designed and developed for Image 100

IMPLEMENTATION LEVEL

x General purpose ___ Special purpose ___ Program package

x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

APPLICATION: x LACIE x Non-LACIE

__Training __Classification x Estimation of Proportion

__Feature Selection __Signature Extension

__Temporal Sampling __Systems Development x Technique Development

__Crop Assessment __Yield Estimation

__Other (specify) ____________________________

B.2-3
I. NAME: SUBROUTINE QM431

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV  
COMPUTER: IBM 360/65

IV. PURPOSE: Minimization of a quadratic form subject to linear inequality and nonnegativity constraints on the variables (Quadratic programming problem)

V. ALGORITHM/TECHNIQUE (short description; include reference if available)


Description: Solves the quadratic program: minimize \( z = c^T x + x^T Q x \) subject to \( A x \geq b, x \geq 0 \) using Lemke's complimentary pivot algorithm. Can also be used to solve linear programming problems.

VI. SPECIAL FEATURES: Original matrix \( Q \) is lost.

VII. SUBROUTINES REQUIRED: INITIA, NEWBAS, SORT, PIVOT

VIII. DOCUMENTATION: x Available  Not Available  Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ___________

Is x Is not compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify __________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
x General purpose  Special purpose  Program package
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE  x Non-LACIE
Training  Classification  x Estimation of Proportion
Feature Selection  Signature Extension
Temporal Sampling  Systems Development  x Technique Development
Crop Assessment  Yield Estimation
Other (specify)
I. NAME: SUBROUTINE INITIA

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: To find the initial almost complementary solution by adding an artificial variable

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See QM431

Description:

VI. SPECIAL FEATURES: Part of QM431 package

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
Is __ is not __ compatible with Image 100 configuration in present form
   ___ Non-PDP 11/45 FORTRAN
   ___ Some machine language conversion necessary
   ___ In language other than FORTRAN. Specify ________________
   ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___ General purpose _ x Special purpose ___ Program package
   _ x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE _ Non-LACIE
   ___ Training ___ Classification ___ Estimation of Proportion
   ___ Feature Selection ___ Signature Extension
   ___ Temporal Sampling ___ Systems Development _ x Technique Development
   ___ Crop Assessment ___ Yield Estimation
   ___ Other (specify) ________________
I. NAME: SUBROUTINE NLWBAS

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: To find the new basis column to enter in terms of the
current basis in performing a simplex-type algorithm

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See QM431
Description:

VI. SPECIAL FEATURES: Part of QM431 package

VII. SUBROUTINES REQUIRED: PPRINT

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
Is x Is not _ compatible with Image 100 configuration in present form
__ Non-PDP 11/45 FORTRAN
__ Some machine language conversion necessary
__ In language other than FORTRAN. Specify __________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__ General purpose x Special purpose __ Program package
x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
__ Training __ Classification __ Estimation of Proportion
__ Feature Selection __ Signature Extension
__ Temporal Sampling __ Systems Development __ Technique Development
__ Crop Assessment __ Yield Estimation
__ Other (specify) __________

B.2-6
I. NAME: SUBROUTINE PPRINT

II. SOURCE (include coder/person with knowledge of program usage):
   L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV
     COMPUTER: IBM 360/65

IV. PURPOSE: To place the current solution to complementary problem into the array ALPHA

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: See QM431
   Description: 

VI. SPECIAL FEATURES: Part of QM431 package

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available__Not Available__Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ____________
    Is_x_is not__compatible with Image 100 configuration in present form
    Non-PDP 11/45 FORTRAN
    ____ Some machine language conversion necessary
    ____ In language other than FORTRAN. Specify ________________
    ____ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ____ General purpose x Special purpose __ Program package
   x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
    ____ Training __ Classification x Estimation of Proportion
    x Feature Selection __ Signature Extension
    ____ Temporal Sampling __ Systems Development x Technique Development
    ____ Crop Assessment __ Yield Estimation
    ____ Other (specify) ___________________________________________________________________

B.2-7
I. NAME: SUBROUTINE SORT

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: To find the pivot row for next iteration by the use of (simplex-type) minimum ratio rule.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See QM431

VI. SPECIAL FEATURES: Part of QM431 package

VII. SUBROUTINES REQUIRED: PPRINT

VIII. DOCUMENTATION: [ ] Available [ ] Not Available [ ] Will be Available

IX. [ ] Software available off-the-shelf. Approximate Cost: [ ]
[ ] Is [ ] Is not [ ] compatible with Image 100 configuration in present form
[ ] Non-PDP 11/45 FORTRAN
[ ] Some machine language conversion necessary
[ ] In language other than FORTRAN. Specify ______________
[ ] Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
[ ] General purpose [ ] Special purpose [ ] Program package
[ ] PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: [ ] LACIE [ ] Non-LACIE
[ ] Training [ ] Classification [ ] Estimation of Proportion
[ ] Feature Selection [ ] Signature Extension
[ ] Temporal Sampling [ ] Systems Development [ ] Technique Development
[ ] Crop Assessment [ ] Yield Estimation
[ ] Other (specify) ________________

B.2-8
I. NAME: SUBROUTINE PIVOT

II. SOURCE (include coder/person with knowledge of program usage):
    L.F. Cuseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV
     COMPUTER: IBM 360/65

IV. PURPOSE: To perform the pivot operation by updating the inverse of the basis and Q vector.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

   Reference: See QM431

   Description:

VI. SPECIAL FEATURES: Part of QM431 package

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. _x Software available off-the-shelf. Approximate Cost: __________
    Is x Is not compatible with Image 100 configuration in present form
    _ Non-PDP 11/45 FORTRAN
    _ Some machine language conversion necessary
    _ In language other than FORTRAN. Specify ________________
    _ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
    _ General purpose x Special purpose _ Program package
    _ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
    _ Training _ Classification _x Estimation of Proportion
    _ Feature Selection _ Signature Extension
    _ Temporal Sampling _ Systems Development _ Technique Development
    _ Crop Assessment _ Yield Estimation
    _ Other (specify) __________________________

B.2-9
I. NAME: Ndimen

II. SOURCE (include coder/person with knowledge of program usage):
Henry Decell, University of Houston, Math Dept.

III. PROGRAMMING LANGUAGE: FORTRAN
COMPUTER: UNIVAC 1108

IV. PURPOSE: To determine the simultaneous solution of an overdetermined system of nonlinear equations.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Description: Problem is set up in least squares fashion and solution is computed by use of the Newton-Raphson iterative technique.

VI. SPECIAL FEATURES: There must be at least as many equations as unknowns.

VII. SUBROUTINES REQUIRED: Subroutine MOPS must be supplied by user to evaluate partial derivatives in addition to an initial guess at solution.

VIII. DOCUMENTATION: X Available__Not Available__Will be Available

IX. Software available off-the-shelf. Approximate Cost: __0__
Is X__Is not__compatible with Image 100 configuration in present form
X Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify ____________
Software must be designed and developed for Image 100.

X. IMPLEMENTATION LEVEL
__General purpose__XSpecial purpose__Program package
X PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: LACIE__Non-LACIE
__Training__Classification X Estimation of Proportion
X Feature Selection X Signature Extension
__Temporal Sampling__Systems Development__X Technique Development
__Crop Assessment__Yield Estimation
__Other (specify) ____________________________

B.2-10
B. GENERAL MATHEMATICAL LIBRARY

3. APPROXIMATION PACKAGE
I. NAME: Basic Spline Package - Single Variable

II. SOURCE (include coder/person with knowledge of program usage):
Philip W. Smith, Dept. of Math. TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV  COMPUTER: IBM 360/65

IV. PURPOSE: To handle all computations involved in evaluating B-spline functions and their derivatives, including conversion to piecewise polynomial representation.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: BSPLDR, BSPLEV, BSPLPP, BSPLWN, BSPLVD, BVALUE, INTERV, PPVALU

VIII. DOCUMENTATION: x Available  Not Available  Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ...

Is x Is not compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify ____________________________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
x General purpose  Special purpose  x Program package
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE  x Non-LACIE
Training  Classification  Estimation of Proportion
Feature Selection  Signature Extension
Temporal Sampling  Systems Development  x  Technique Development
Crop Assessment  Yield Estimation
Other (specify) ________________________________________________________

B.3-2
I. NAME: SUBROUTINE BSPLDR

II. SOURCE (include coder/person with knowledge of program usage):
Philip W. Smith

III. PROGRAMMING LANGUAGE: FORTRAN IV COMPUTER: IBM 360/65

IV. PURPOSE: Constructs divided difference table for B-spline coefficients

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See reference for Basic Spline Package—Single Variable
Description: Equation 2.2, above reference, is employed.

VI. SPECIAL FEATURES: Cases which would require division by zero because of coincidence of knots are not evaluated: their values are bypassed in the calling routines.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available__Not Available__Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ____________
Is x Is not compatible with Image 100 configuration in present form
   ___Non-PDP 11/45 FORTRAN
   ___Some machine language conversion necessary
   ___In language other than FORTRAN. Specify _______________________
   ___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___General purpose_x Special purpose_Program package
   x_PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE_x Non-LACIE
   ___Training__Classification__Estimation of Proportion
   ___Feature Selection__Signature Extension
   ___Temporal Sampling__Systems Development_x Technique Development
   ___Crop Assessment__Yield Estimation
   ___Other (specify) ________________________________________________
I. NAME: SUBROUTINE BSPLTV

II. SOURCE (include coder/person with knowledge of program usage):
   Philip W. Smith

III. PROGRAMMING LANGUAGE: FORTRAN IV
     COMPUTER: IBM 360/65

IV. PURPOSE: Calculates value of the B-spline and its derivatives
     (up to a specified order) at a particular x value.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: See references for Basic Spline Package-Single Variable
   Description: Equation 2.1, above reference, is used.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: INTERV, BSPLVN

VIII. DOCUMENTATION: x Available ___ Not Available ___ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
    Is x Is not compatible with Image 100 configuration in present form
    ___ Non-PDP 11/45 FORTRAN
    ___ Some machine language conversion necessary
    ___ In language other than FORTRAN. Specify ________________
    ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
    ___ General purpose x Special purpose ___ Program package
    ___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
    ___ Training ___ Classification ___ Estimation of Proportion
    ___ Feature Selection ___ Signature Extension
    ___ Temporal Sampling ___ Systems Development x Technique Development
    ___ Crop Assessment ___ Yield Estimation
    ___ Other (specify) ____________________________________

B.3-4
I. NAME: SUBROUTINE BSPLPP

II. SOURCE (include coder/person with knowledge of program usage):
   Philip W. Smith

III. PROGRAMMING LANGUAGE: FORTRAN IV

IV. PURPOSE: Converts B-spline representation to piecewise polynomial representation.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: See reference for Basic Spline Package—Single Variable
   Description: The necessary parameters are calculated by BSPLDR and BSPLEV.

VI. SPECIAL FEATURES: Requires temporary storage "scratch" array allocated in calling program.

VII. SUBROUTINES REQUIRED: BSPLDR, BSPLEV

VIII. DOCUMENTATION: _Available__Not Available__Will be Available

IX. _Software available off-the-shelf. Approximate Cost: ______
    Is _x Not _compatible with Image 100 configuration in present form
    _Non-PDP 11/45 FORTRAN
    _Some machine language conversion necessary
    _In language other than FORTRAN. Specify __________
    _Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _General purpose__Special purpose__Program package
   _PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE__Non-LACIE
    _Training__Classification__Estimation of Proportion
    _Feature Selection__Signature Extension
    _Temporal Sampling__Systems Development__Technique Development
    _Crop Assessment__Yield Estimation
    _Other (specify)__________________________

B.3-5
I. NAME: SUBROUTINE BSPLVD

II. SOURCE (include coder/person with knowledge of program usage):
Philip W. Smith

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: Calculates value and derivatives (up to specified order) of all B-splines which do not vanish at the x value.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: See reference for Basic Spline Package-Single Variable

Description: Repeated calls are made to routine BSPLVN and an array is built with the different order derivatives at the different pieces of the domain.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: BSPLVN

VIII. DOCUMENTATION: x Available Not Available Will be Available

IX. x Software available off-the-shelf. Approximate Cost: _________
Is x Is not Non-PDP 11/45 FORTRAN
compatible with Image 100 configuration in present form
___ Some machine language conversion necessary
___ In language other than FORTRAN. Specify _________________
___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___ General purpose x Special purpose ___ Program package
___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
___ Training ___ Classification ___ Estimation of Proportion
___ Feature Selection ___ Signature Extension
___ Temporal Sampling ___ Systems Development x Technique Development
___ Crop Assessment ___ Yield Estimation
___ Other (specify) ____________________________

B.3-6
I. NAME: SUBROUTINE BSPLVN

II. SOURCE (include coder/person with knowledge of program usage):
   Philip W. Smith

III. PROGRAMMING LANGUAGE: FORTRAN IV    COMPUTER: IBM 360/65

IV. PURPOSE: Calculates the value of all possibly non-zero B-splines of the particular order (either input or previously determined) at the x value.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

   Reference: See reference for Basic Spline Package--Single Variable

   Description: See p.20 above reference to algorithm which this routine incorporates.

VI. SPECIAL FEATURES: An argument parameter switch can be set to use previously computed values where this can save time.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available__Not Available__Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
   Is x Is not__compatible with Image 100 configuration in present form
   _Non-PDP 11/45 FORTRAN
   _Some machine language conversion necessary
   _In language other than FORTRAN. Specify ________________
   _Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _General purpose x Special purpose__Program package
   _PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
   _Training__Classification__Estimation of Proportion
   _Feature Selection__Signature Extension
   _Temporal Sampling__Systems Development x Technique Development
   _Crop Assessment__Yield Estimation
   _Other (specify) ________________

B.3-7
I. NAME: FUNCTION BVALUE

II. SOURCE (include coder/person with knowledge of program usage):
Philip W. Smith

III. PROGRAMMING LANGUAGE: FORTRAN IV COMPUTER: IBM 360/65

IV. PURPOSE: Calculates value at x of the specified-order derivative from the B-representation.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See reference for Basic Spline Package—Single Variable
Description: See section 2, above reference.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: INTERV

VIII. DOCUMENTATION: x Available __ Not Available __ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ____________
Is x Is not __ compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify ________________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
General purpose x Special purpose __ Program package
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE __ Non-LACIE
Training __ Classification __ Estimation of Proportion
Feature Selection __ Signature Extension
Temporal Sampling __ Systems Development __ Technique Development
Crop Assessment __ Yield Estimation
Other (specify) ________________

B.3-8
I. NAME: SUBROUTINE INTERV

II. SOURCE (include coder/person with knowledge of program useage):
Philip W. Smith

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: Determines largest subscript for a sequence such that
the indexed term is less than a specified value x.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See reference for Basic Spline Package-Single Variable
Description: See p.24, above reference.

VI. SPECIAL FEATURES: An attempt is made to use the previous call's
results to minimize search time.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ___________
Is x Is not compatible with Image 100 configuration in present form
___Non-PDF 11/45 FORTRAN
___Some machine language conversion necessary
___In language other than FORTRAN. Specify ________________
___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___General purpose x Special purpose ___Program package
x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
___Training ___Classification ___Estimation of Proportion
___Feature Selection ___Signature Extension
___Temporal Sampling ___Systems Development x Technique Development
___Crop Assessment ___Yield Estimation
___Other (specify) ______________________________________

B.3-9
I. NAME: FUNCTION PPVALU

II. SOURCE (include coder/person with knowledge of program usage):
Philip W. Smith

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: Calculates value at x of a specified order derivative
from the piecewise polynomial representation.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See reference for Basic Spline Package—Single Variable
Description: Equations 1.1, above reference, are used.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: INTERV

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ____________
Is x Is not __ compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify __________________________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
General purpose x Special purpose
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
Training __ Classification __ Estimation of Proportion
Feature Selection __ Signature Extension
Temporal Sampling __ Systems Development __ Technique Development
Crop Assessment __ Yield Estimation
Other (specify) ____________________________________________________________________
B. GENERAL MATHEMATICAL LIBRARY

4. TRANSFORM PACKAGE

A fairly general program which provides the required transform capabilities is available from PAR, Inc.
I. NAME: (MSFAR) Multispectral Fourier Analysis Routines

II. SOURCE (include coder/person with knowledge of program usage):
Jack D. Bryant

III. PROGRAMMING LANGUAGE: FORTRAN		COMPUTER: CDC 6400

IV. PURPOSE: To extract spatial features from multispectral scanner data sets.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Description: See reference above, volumes I and II, also.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available__ Not Available__ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: _____?
Is__Is not __compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
x Some machine language conversion necessary
In language other than FORTRAN. Specify ______________________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
x General purpose___ Special purpose__x Program package
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE__x Non-LACIE
__Training__ Classification__ Estimation of Proportion
__Feature Selection__ Signature Extension
__Temporal Sampling__ Systems Development__ Technique Development
__Crop Assessment__ Yield Estimation
x Other (specify) Spatial Recognition Pattern

B.4-2
I. NAME: MERGE

II. SOURCE (include coder/person with knowledge of program usage):
Jack D. Bryant

III. PROGRAMMING LANGUAGE: FORTRAN
COMPUTER: CDC 6400

IV. PURPOSE: To read up to 12 data files and merge selected spectral channels from each file onto one file.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See MSFAR reference, above.

Description: Data handling

VI. SPECIAL FEATURES: Examples: the data set may consist of a large number of channels (e.g. 24 channels) or may be a large file (e.g. an ERTS image).

VII. SUBROUTINES REQUIRED: MOVE*, GETD, PUTD*, SKIPF*
*Written in COMPASS
Segue*: SETC*, (CDC 6400 Assembly Language) CHAR*, GNUM*, ZFET*

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
Is Is not x compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify ________________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose x Special purpose Program package
__PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __LACIE x Non-LACIE
__Training __Classification __Estimation of Proportion
__Feature Selection __Signature Extension
__Temporal Sampling __Systems Development __Technique Development
__Crop Assessment __Yield Estimation
x Other (specify) Spatial Pattern Recognition
I. NAME: CHNL

II. SOURCE (include coder/person with knowledge of program usage):
Jack D. Bryant

III. PROGRAMMING LANGUAGE: FORTRAN
        COMPUTER: CDC 6400

IV. PURPOSE: To build a RECOG formatted data file from values read from
        punched cards for use by the Fourier transform program.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
        Reference: See MSFAR reference, above
        Description: Data handling

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: PUTD*, SETC*
        *Written in COMPASS
        (CDC 6400 Assembly Language)

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
        Is __ Is not x compatible with Image 100 configuration in present form
        _ Non-PDP 11/45 FORTRAN
        _ x Some machine language conversion necessary
        _ In language other than FORTRAN. Specify ________________
        _ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
        _ General purpose x Special purpose _ Program package
        _ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _ LACIE x Non-LACIE
        _ Training _ Classification _ Estimation of Proportion
        _ Feature Selection _ Signature Extension
        _ Temporal Sampling _ Systems Development _ Technique Development
        _ Crop Assessment _ Yield Estimation
        _ x Other (specify) _ Spatial Pattern Recognition
I. NAME: FFT2D

II. SOURCE (include coder/person with knowledge of program usage):
Jack D. Bryant

III. PROGRAMMING LANGUAGE: FORTRAN       COMPUTER: CDC 6400

IV. PURPOSE: FFT2D obtains fast Fourier transforms of the input data streams employing dynamic dimensioning for major arrays.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See MSFAR reference, above

Description: Driver program for FOURT. (Fast Fourier Transform Subroutine)

VI. SPECIAL FEATURES: Two modes of operation are provided: only one aperture within the flight line can be used or the window can be forced to move through the flight line.

VII. SUBROUTINES REQUIRED: DOIT, CORE*, SETC*, CALCP, FOURT, SKIPF*
RELOC, GETO, PUTD*

*Written in COMPASS (CDC 6400 Assembly Language)

VIII. DOCUMENTATION: _Available____Not Available____Will be Available

IX. _Software available off-the-shelf. Approximate Cost: ____________
Is_ Is not_x compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
_x Some machine language conversion necessary
__In language other than FORTRAN. Specify ______________________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose_x Special purpose__Program package
__PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE_x Non-LACIE
__Training__Classification__Estimation of Proportion
__Feature Selection__Signature Extension
__Temporal Sampling__Systems Development__Technique Development
__Crop Assessment__Yield Estimation
_x Other (specify) Spatial Pattern Recognition

B.4-5
I. NAME: SUBROUTINE FOUR2

II. SOURCE (include coder/person with knowledge of program usage):
   Jack D. Bryant

III. PROGRAMMING LANGUAGE: FORTRAN    COMPUTER: IBM 360

IV. PURPOSE: To obtain the Cooley-Tukey Fast Fourier Transform

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: IEEE Audio Transactions, June 1967, special issue on FFT.
   Description: Obtains two-dimensional FFT when the number of data points is $2^N \times 2^M$.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available  Not Available  Will be Available

IX. X Software available off-the-shelf. Approximate Cost: __________
   Is X Is not compatible with Image 100 configuration in present form
   _ Non-PDP 11/45 FORTRAN
   _ Some machine language conversion necessary
   _ In language other than FORTRAN. Specify __________
   _ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _ General purpose  Special purpose  Program package
   _ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE_ X Non-LACIE
   _ Training  Classification  Estimation of Proportion
   _ Feature Selection  Signature Extension
   _ Temporal Sampling  Systems Development  Technique Development
   _ Crop Assessment  Yield Estimation
   X Other (specify) Spatial Pattern Recognition
I. NAME: SUBROUTINE FOURI

II. SOURCE (include coder/person with knowledge of program usage):
Jack D. Bryant

III. PROGRAMMING LANGUAGE: FORTRAN    COMPUTER: IBM 360

IV. PURPOSE: To obtain the Cooley-Tukey Fast Fourier Transform

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: IEEE Audio Transactions, June 1967, special issue on FFT

Description: Obtains one-dimensional FFT when the number of data points is a power of two.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available  Not Available  Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ____________
   Is x Is not compatible with Image 100 configuration in present form
   ___ Non-PDP 11/45 FORTRAN
   ___ Some machine language conversion necessary
   ___ In language other than FORTRAN. Specify ________________
   ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___ General purpose  Special purpose  Program package
   ___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __ LACIE  x Non-LACIE
    ___ Training  ___ Classification  ___ Estimation of Proportion
    ___ Feature Selection  ___ Signature Extension
    ___ Temporal Sampling  ___ Systems Development  ___ Technique Development
    ___ Crop Assessment  ___ Yield Estimation
    x Other (specify)  ___ Spatial Pattern Recognition
I. NAME: SUBROUTINE FOURT

II. SOURCE (include coder/person with knowledge of program usage):
Jack D. Bryant

III. PROGRAMMING LANGUAGE: FORTRAN  
COMPUTER: CDC 6400

IV. PURPOSE: To obtain the Cooley-Tukey Fast Fourier Transform.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: IEEE Audio Transactions, June 1967, special issue on FFT.

Description: This is the fastest and most versatile version of the FFT known.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available  _ Not Available _ Will be Available

IX. X Software available off-the-shelf. Approximate Cost: ____________
Is X Is not compatible with Image 100 configuration in present form
___ Non-PDP 11/45 FORTRAN
___ Some machine language conversion necessary
___ In language other than FORTRAN. Specify ______________
___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
X General purpose _ Special purpose _ Program package
X PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _ LACIE X Non-LACIE
___ Training _ Classification _ Estimation of Proportion
___ Feature Selection _ Signature Extension
___ Temporal Sampling _ Systems Development _ Technique Development
___ Crop Assessment _ Yield Estimation
X Other (specify) _ Spatial Pattern Recognition

B.4-8
I. NAME: TRANSF

II. SOURCE (include coder/person with knowledge of program usage):
   Jack D. Bryant

III. PROGRAMMING LANGUAGE: FORTRAN
     COMPUTER: CDC 6400

IV. PURPOSE: Driver program for user-supplied program TRANS which samples data generated by FFT2D and writes a RECOG formatted tape or file. This may then be analyzed using RECOG or CLUSTD.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: See MSFAR reference
   Description: Data handling

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: GED, PUTD*, TRANS (user supplied), CORE*, SETC*, PTAPE

*Written in COMPASS (CDC 6400 Assembly Language)

VIII. DOCUMENTATION: x Available __ Not Available __ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
   Is ___ Is not x compatible with Image 100 configuration in present form
   ___ Non-PDP 11/45 FORTRAN
   x Some machine language conversion necessary
   ___ In language other than FORTRAN. Specify ________________
   ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___ General purpose x Special purpose __ Program package
   ___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __ LACIE x Non-LACIE
   ___ Training ___ Classification ___ Estimation of Proportion
   ___ Feature Selection ___ Signature Extension
   ___ Temporal Sampling ___ Systems Development ___ Technique Development
   ___ Crop Assessment ___ Yield Estimation
   x Other (specify) Spatial Pattern Recognition

B.4-9
I. NAME: NORMLX

II. SOURCE (include coder/person with knowledge of program usage):
   Jack D. Bryant

III. PROGRAMMING LANGUAGE: FORTRAN  
     COMPUTER: CDC 6400

IV. PURPOSE: Normalizes and rewrites in RECOG format output of the circular TRANS subroutine.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: See MSFAR reference

Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: READTP, GETD, PUTD*
   *WRITTEN IN COMPASS (CDC 6400 Assembly Language)

VIII. DOCUMENTATION: x Available__Not Available__Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
   Is___Is not x compatible with Image 100 configuration in present form
   ___Non-PDP 11/45 FORTRAN
   ___Some machine language conversion necessary
   ___In language other than FORTRAN. Specify __________
   ___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ____General purpose x Special purpose__Program package
   ____PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __LACIE x Non-LACIE
   ____Training__Classification__Estimation of Proportion
   ____Feature Selection__Signature Extension
   ____Temporal Sampling__Systems Development__Technique Development
   ____Crop Assessment__Yield Estimation
   x Other (specify) Spatial Pattern Recognition
I. NAME: WSORT

II. SOURCE (include coder/person with knowledge of program usage):
   Jack D. Bryant

III. PROGRAMMING LANGUAGE: FORTRAN
     COMPUTER: CDC 6400

IV. PURPOSE: Reads and performs straight or normalized sort of spatial features obtained by wedge sampling, and produces a new data file, in RECOG format, of sorted spatial features.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: See MSFAR reference.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: SORT, NSORT, RDTAPE, WRTAPE, GETO, PUD*
     *WRITTEN IN COMPASS (CDC 6400 Assembly Language)

VIII. DOCUMENTATION: x Available__Not Available__Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ____________
    Is__Is not__compatible with Image 100 configuration in present form
    __Non-PDP 11/45 FORTRAN
    __Some machine language conversion necessary
    __In language other than FORTRAN. Specify ____________
    __Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
    __General purpose__Special purpose__Program package
    __PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __LACIE__Non-LACIE
    __Training__Classification__Estimation of Proportion
    __Feature Selection__Signature Extension
    __Temporal Sampling__Systems Development__Technique Development
    __Crop Assessment__Yield Estimation
    __Other (specify) Spatial Pattern Recognition
C. GENERAL STATISTICAL LIBRARY

1. STATISTICAL SUMMARY
I. NAME: SUBROUTINE GROPl(X,N,NG,XMIN,XMAX,F)

II. SOURCE (include coder/person with knowledge of program usage):
Theory & Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN

IV. PURPOSE:
Group data into specified number of equally spaced groups

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: JSC STAT CAT

Description: Calculate frequencies of each point in each group

VI. SPECIAL FEATURES:
XMIN = lower end of the first group
XMAX = upper end of the last group
NG = number of groups

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available _ Not Available _ Will be Available

IX. _ X Software available off-the-shelf. Approximate Cost: __________
Is__ Is not__ compatible with Image 100 configuration in present form
__ Non-PDP 11/45 FORTRAN
__ Some machine language conversion necessary
__ In language other than FORTRAN. Specify ________________
__ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__ General purpose _ Special purpose _ Program package
__ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTIN

XI. APPLICATION: _ LACIE _ Non-LACIE
__ Training _ Classification _ Estimation of Proportion
__ Feature Selection _ Signature Extension
__ Temporal Sampling _ Systems Development _ Technique Development
__ Crop Assessment _ Yield Estimation
__ Other (specify) ____________________________

C.1-2
I. NAME: SUBROUTINE MEDIAN(X,N,XMED)

II. SOURCE (include coder/person with knowledge of program usage):
   UNIVAC STAT PACK

III. PROGRAMMING LANGUAGE: FORTRAN V
      COMPUTER: 1108

IV. PURPOSE: Calculate median of a sequence of data points

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: JSC STAT CAT
               UNIVAC STAT PACK
   Description: Computes rank of median and observations

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available _ Not Available _ Will be Available

IX. X Software available off-the-shelf. Approximate Cost: ____________
   Is __ not __ compatible with Image 100 configuration in present form
   ____ Non-PDP 11/45 FORTRAN
   ____ Some machine language conversion necessary
   ____ In language other than FORTRAN. Specify ________________________
   ____ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ____ General purpose _ Special purpose _ Program package
   ____ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _ LACIE _ Non-LACIE
    ____ Training _ Classification _ Estimation of Proportion
    ____ Feature Selection _ Signature Extension
    ____ Temporal Sampling _ Systems Development _ Technique Development
    ____ Crop Assessment _ Yield Estimation
    ____ Other (specify) ________________________________________________

C.1-3
I. NAME: SUBROUTINE MODE (X,N,XMOD,XB,XM2,XM3,XM4,G1,G2,SKEW,K)

II. SOURCE (include coder/person with knowledge of program usage):
   JSC Theory of Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V       COMPUTER: 1108

IV. PURPOSE: Calculate estimate of mode of a distribution from sample of data

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: JSC STAT CAT
   Description:

VI. SPECIAL FEATURES: Finds central moments, correct 3rd and 4th central moments, calculate coefficient of skewness and excess. Distributions must be unimodal and belong to class of Pearson system distributions (gamma, normal)

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available  __ Not Available  __ Will be Available

IX. ___ Software available off-the-shelf. Approximate Cost: ____________
   ___ Is  ___ Is not  ___ compatible with Image 100 configuration in present form
   ___ Non-PDP 11/45 FORTRAN
   ___ Some machine language conversion necessary
   ___ In language other than FORTRAN. Specify __________________
   ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___ General purpose  ___ Special purpose  ___ Program package
   ___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___ LACIE  ___ Non-LACIE
   ___ Training  ___ Classification  ___ Estimation of Proportion
   ___ Feature Selection  ___ Signature Extension
   ___ Temporal Sampling  ___ Systems Development  ___ Technique Development
   ___ Crop Assessment  ___ Yield Estimation
   ___ Other (specify) _________________________________________

C.1-4
I. NAME: SUBROUTINE RANGE(X,N,R)

II. SOURCE (include coder/person with knowledge of program usage):
UNIVAC STAT PACK

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE: Calculate range of sequence of numbers

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: JSC STAT CAT

Description: \[ \text{Range} = X_{\text{max}} - X_{\text{min}} \]

VI. SPECIAL FEATURES:

VII. SUBS. YES REQUIRED:

VIII. DOCUMENTATION: _Available_ _Not Available_ _Will be Available_

IX. _Software available off-the-shelf. Approximate Cost: ___________
__Is not compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify ________________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose _Special purpose_ _Program package
__PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE_ _Non-LACIE_ _Training_ _Classification_ _Estimation of Proportion_ _Feature Selection_ _Signature Extension_ _Temporal Sampling_ _Systems Development_ _Technique Development_ _Crop Assessment_ _Yield Estimation_ _Other (specify) ____________________________________________

C.1-5
I. NAME: SUBROUTINE MNDEV(X,N,IND,D)

II. SOURCE (include coder/person with knowledge of program usage): corrected from JSC Theory and Analysis Office, Houston
   STAT PACK

III. PROGRAMMING LANGUAGE: FORTRAN V
     COMPUTER: 1108

IV. PURPOSE: Calculate mean deviation of an array of data

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: JSC STAT CAT
               UNIVAC STAT PACK
   Description:
   \[
   \text{deviation} = \frac{1}{N} \sum_{i=1}^{N} |X_i - u|, \quad u = \text{median or mean} \\
   X_i = i^{th} \text{ observation} \\
   N = \text{no. of observations}
   \]

VI. SPECIAL FEATURES:
   Option to find deviation from median or arithmetic mean

VII. SUBROUTINES REQUIRED: MEDIAN (if deviation to be found from median)

VIII. DOCUMENTATION: X_Available__Not Available__Will be Available

IX. X_Software available off-the-shelf. Approximate Cost: ____________
    Is__Is not__compatible with Image 100 configuration in present form
    __Non-PDP 11/45 FORTRAN
    __Some machine language conversion necessary
    __In language other than FORTRAN. Specify _________________
    __Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___General purpose__Special purpose__Program package
   ___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __LACIE__Non-LACIE
    ___Training___Classification___Estimation of Proportion
    ___Feature Selection___Signature Extension
    ___Temporal Sampling___Systems Development___Technique Development
    ___Crop Assessment___Yield Estimation
    ___Other (specify) ________________________________
I. NAME: SUBROUTINE SDEV(X,N,IND,XB,S)

II. SOURCE (include coder/person with knowledge of program usage):
JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V   COMPUTER: 1108

IV. PURPOSE: Calculate standard deviation of sequence of data points

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: JSC STAT CAT

Description:
\[ S = \frac{\sqrt{\sum (x_i - \bar{x})^2}}{N-1} \quad \text{or} \quad S = \frac{\sqrt{\sum (x_i - \bar{x})^2}}{N} \]

VI. SPECIAL FEATURES: Option if estimate to be used in unbiased or maximum likelihood

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: XAvailable Not Available Will be Available

IX. X Software available off-the-shelf. Approximate Cost: __________
Is Is not compatible with Image 100 configuration in present form
___Non-PDP 11/45 FORTRAN
___Some machine language conversion necessary
___In language other than FORTRAN. Specify ________________
___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___General purpose ___Special purpose ___Program package
___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___LACIE ___Non-LACIE
___Training ___Classification ___Estimation of Proportion
___Feature Selection ___Signature Extension
___Temporal Sampling ___Systems Development ___Technique Development
___Crop Assessment ___Yield Estimation
___Other (specify) ____________________________

C.1-7
I. NAME: SUBROUTINE ORDER(X,N)

II. SOURCE (include coder/person with knowledge of program usage):
    JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V
     COMPUTER: 1108

IV. PURPOSE: Arrange an array in ascending order

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: JSC STAT CAT
   Description:

VI. SPECIAL FEATURES: Ordered data returned in X array locations

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available  Not Available  Will be Available

IX. Software available off-the-shelf. Approximate Cost:
    X Non-PDP 11/45 FORTRAN
    ___ Some machine language conversion necessary
    ___ In language other than FORTRAN. Specify
    ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
    ___ General purpose  ___ Special purpose  ___ Program package
    ___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___ LACIE  ___ Non-LACIE
    ___ Training  ___ Classification  ___ Estimation of Proportion
    ___ Feature Selection  ___ Signature Extension
    ___ Temporal Sampling  ___ Systems Development  ___ Technique Development
    ___ Crop Assessment  ___ Yield Estimation
    ___ Other (specify)
I. NAME: PLOT PAC

II. SOURCE (include coder/person with knowledge of program usage):
Ted Kell

III. PROGRAMMING LANGUAGE: FORTRAN/MACRO
COMPUTER: 11/45

IV. PURPOSE: To provide the user with a variety of data plotting options
(histogram /scattergram/graphs/etc.)

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference:

Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: __Available__ Not Available__ Will be Available

IX. __Software available off-the-shelf. Approximate Cost: ____________
Is __Is not __compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify ________________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose__ Special purpose__ Program package
__PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __LACIE__ __Non-LACIE
__Training__ Classification__ Estimation of Proportion
__Feature Selection__ Signature Extension
__Temporal Sampling__ Systems Development__ Technique Development
__Crop Assessment__ Yield Estimation
__Other (specify) ________________

C.1-9
I. NAME: Binary Search/N-Dimensional Histogram Acquisition

II. SOURCE (include coder/person with knowledge of program usage):
General Electric/Jim Brierly

III. PROGRAMMING LANGUAGE: FORTRAN

IV. PURPOSE: To reduce the time necessary to acquire N-Dimensional histograms.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: See next page
   Description: See next page

VI. SPECIAL FEATURES: See next page

VII. SUBROUTINES REQUIRED: None

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: $6,300
   x Is _ x Is not _ compatible with Image 100 configuration in present form
   _ Non-PDP 11/45 FORTRAN
   _ Some machine language conversion necessary
   _ In language other than FORTRAN. Specify ___________________________
   _ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _ General purpose x Special purpose x Program package
   _ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _ LACIE _ Non-LACIE
    _ x Training _ x Classification _ Estimation of Proportion
    _ x Feature Selection _ x Signature Extension
    _ Temporal Sampling _ x Systems Development _ x Technique Development
    _ Crop Assessment _ Yield Estimation
    _ Other (specify) ____________________________________________

C.1-10
1.2.2 BINARY SEARCH/N-DIMENSIONAL HISTOGRAM ACQUISITION

The time necessary to acquire N-dimensional histograms is normally significantly reduced using this program. A binary search technique is employed to (potentially) reduce the number of cell interrogations required for signature generation by testing large volumes of feature space rather than each individual cell. This is accomplished by successively bisecting each feature space axis, each time testing each produced volume for non-zero pixel counts. Any volume with a zero pixel count is subsequently ignored, and in most cases will enable a substantial reduction in the number of single cells otherwise requiring consideration. Any volume with a non-zero count will be further subdivided until the required resolution is reached. The pixel counts for the smallest cells are recorded as is done in the N-D Histogram.

Use of this program generally results in orders-of-magnitude reductions in histogram acquisition time, resulting in N-dimensional training being more attractive as an analysis tool. In addition, the operation of post-training functions such as semi-supervised cluster analysis (described in paragraph 1.4.2) becomes more efficient.
C. GENERAL STATISTICAL LIBRARY

2. DENSITIES & DISTRIBUTIONS PACKAGE
I. NAME: FUNCTION PHINV (P)

II. SOURCE (include coder/person with knowledge of program usage):
    JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V    COMPUTER: 1108

IV. PURPOSE: Inverse of normal distribution function

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

   Reference: JSC STAT CAT

   Description: Given mean 0 and variance 1, using Newton Raphson iterations

VI. SPECIAL FEATURES: Checks probability P for validity and prints error message if P is invalid.

VII. SUBROUTINES REQUIRED:
    PHI

VIII. DOCUMENTATION: X Available  Not Available  Will be Available

IX. X Software available off-the-shelf. Approximate Cost: ____________
    Is__Is not__compatible with Image 100 configuration in present form
    ___Non-PDP 11/45 FORTRAN
    ___Some machine language conversion necessary
    ___In language other than FORTRAN. Specify ____________
    __Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
    ___General purpose__Special purpose__Program package
    ___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: LACIE  Non-LACIE
    ___Training__Classification__Estimation of Proportion
    ___Feature Selection__Signature Extension
    ___Temporal Sampling__Systems Development__Technique Development
    ___Crop Assessment__Yield Estimation
    ___Other (specify) ____________________________________________________

C.2-2
I. NAME: DOUBLE PRECISION FUNCTION DPHI(X)

FUNCTION PHI(X)

II. SOURCE (include coder/person with knowledge of program usage):
S.W. Kahng, JSC/LEC, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE: Normal probability integral for real X

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: JSC STAT CAT

Description: \[
\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \exp\left(-\frac{t^2}{2}\right) dt
\]

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: \_\_Available\_\_ Not Available\_\_ Will be Available

IX. \_\_Software available off-the-shelf. Approximate Cost: \_\_\_\_

Is\_\_ Is not\_\_ compatible with Image 100 configuration in present form

\_\_Non-PDP 11/45 FORTRAN

\_\_Some machine language conversion necessary

\_\_In language other than FORTRAN. Specify \_\_\_\_

\_\_Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

\_\_General purpose\_\_ Special purpose\_\_ Program package

\_\_PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: \_\_LACIE\_\_ Non-LACIE

\_\_Training\_\_ Classification\_\_ Estimation of Proportion

\_\_Feature Selection\_\_ Signature Extension

\_\_Temporal Sampling\_\_ Systems Development\_\_ Technique Development

\_\_Crop Assessment\_\_ Yield Estimation

\_\_Other (specify) \_\_\_

C.2-3
I. NAME: REAL FUNCTION FISH(F,N1, N2)

II. SOURCE (include coder/person with knowledge of program usage):
corrected from UNIVAC STAT-PACK; JSC Theory and Analysis Office, Houston.

III. PROGRAMMING LANGUAGE: FORTRAN V  COMPUTER: 1108

IV. PURPOSE: Approximate Fisher's f-distribution

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
JSC STAT CAT
Reference: George Neel, Larry Whitehead, Robert Bottenburg, "Calculation
of the percentage points of the F-distribution," Technical Documentary Report
PFL-TDR-64-16, 6570th Personal Research Lab., Aerospace Medical Div.,
Description: Air Force Systems Command, Lackland
AFB, Texas

VI. SPECIAL FEATURES: N1 and N2 ≥ 1

VII. SUBROUTINES REQUIRED: PHI

VIII. DOCUMENTATION: □ Available __ Not Available __ Will be Available

IX. □ Software available off-the-shelf. Approximate Cost: ___________
   □ Is__Is not__compatible with Image 100 configuration in present form
   □ Non-PDP 11/45 FORTRAN
   □ Some machine language conversion necessary
   □ In language other than FORTRAN. Specify __________
   □ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   □ General purpose __ Special purpose __ Program package
   □ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: □ LACIE __ Non-LACIE
   □ Training __ Classification __ Estimation of Proportion
   □ Feature Selection __ Signature Extension
   □ Temporal Sampling __ Systems Development __ Technique Development
   □ Crop Assessment __ Yield Estimation
   □ Other (specify) __________

C.2-4
I. NAME: DOUBLE PRECISION FUNCTION DERF(X)
FUNCTION ERF(X)

II. SOURCE (include coder/person with knowledge of program usage):
S.W. Kahng, JSC/LEC, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V   COMPUTER: 1108

IV. PURPOSE: Error function

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: JSC STAT CAT

Description:
\[
\frac{2}{\sqrt{\pi}} \int_0^x \exp \left(-t^2\right) \, dt
\]

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: xAvailable__Not Available__Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
Is___Is not___compatible with Image 100 configuration in present form
___Non-PDP 11/45 FORTRAN
___Some machine language conversion necessary
___In language other than FORTRAN. Specify ______________
___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___General purpose___Special purpose___Program package
___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___LACIE___Non-LACIE
___Training___Classification___Estimation of Proportion
___Feature Selection___Signature Extension
___Temporal Sampling___Systems Development___Technique Development
___Crop Assessment___Yield Estimation
___Other (specify) ________________

C.2-5
I. NAME: DOUBLE PRECISION FUNCTION DERFC(X)

II. SOURCE (include coder/person with knowledge of program usage):
S.W. KAHNG, JSC/LEC, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE: Complimentary Error function

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: JSC STAT CAT
Description: 1-ERF(K)

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available__Not Available__Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
Is__Is not__compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify __________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose__Special purpose__Program package
__PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE__Non-LACIE
__Training__Classification__Estimation of Proportion
__Feature Selection__Signature Extension
__Temporal Sampling__Systems Development__Technique Development
__Crop Assessment__Yield Estimation
__Other (specify) ____________________________

C.2-6
I. NAME: REAL FUNCTION CHI2 (X, V)

II. SOURCE (include coder/person with knowledge of program usage):
JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE: Approximate $\chi^2$ distribution

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: JSC STAT CAT

Description: Given a point and degrees of freedom, approximate value of the $\chi^2$ distribution at the point.
Method used depends on values of the point and the degree of freedom.

VI. SPECIAL FEATURES: Provision for overflow
$X \geq 0.0$
uses CBRT function

VII. SUBROUTINES REQUIRED: ZIP (calls FACTOR)
OVERFL
PHI

VIII. DOCUMENTATION: X Available__Not Available__Will be Available

IX. X Software available off-the-shelf. Approximate Cost: __________
Is___Is not___compatible with Image 100 configuration in present form
___Non-PDP 11/45 FORTRAN
___Some machine language conversion necessary
___In language other than FORTRAN. Specify ___________________________
___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___General purpose___Special purpose___Program package
___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: LACIE Non-LACIE
___Training___Classification___Estimation of Proportion
___Feature Selection___Signature Extension
___Temporal Sampling___Systems Development___Technique Development
___Crop Assessment___Yield Estimation
___Other (specify) _________________________________________
I. NAME: FUNCTION EXPAN(N,T)

II. SOURCE (include coder/person with knowledge of program usage):
   JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V  COMPUTER: 1108

IV. PURPOSE: Approximate student's t-distribution

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: JSC STAT CAT
   Description: Using series expansion method, given degrees of freedom

VI. SPECIAL FEATURES: Values of N decide which equations to use.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available  Not Available  Will be Available

IX. X Software available off-the-shelf. Approximate Cost: ____________
   Is _ Is not compatible with Image 100 configuration in present form
   _ Non-PDP 11/45 FORTRAN
   _ Some machine language conversion necessary
   _ In language other than FORTRAN. Specify _______________________
   _ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _ General purpose  _ Special purpose  _ Program package
   _ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: LACIE  Non-LACIE
   _ Training  _ Classification  _ Estimation of Proportion
   _ Feature Selection  _ Signature Extension
   _ Temporal Sampling  _ Systems Development  _ Technique Development
   _ Crop Assessment  _ Yield Estimation
   _ Other (specify) ____________________________________________
I. NAME: REAL FUNCTION POIS(N,XMU)

II. SOURCE (include coder/person with knowledge of program usage):
   JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V
     COMPUTER: 1108

IV. PURPOSE: Value of Poisson distribution function

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: JSC STAT CAT

   Description: POIS(N,XMU) = e^{-XMU} \sum_{i=0}^{N} \frac{XMU^i}{i!}; XMU = mean of distribution

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available _ Not Available _ Will be Available

IX. X Software available off-the-shelf. Approximate Cost: __________
   Is__Is not__compatible with Image 100 configuration in present form
   __Non-PDP 11/45 FORTRAN
   __Some machine language conversion necessary
   __In language other than FORTRAN. Specify ________________
   __Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   __General purpose__ Special purpose__ Program package
   __PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __ LACIE __ Non-LACIE
   __ Training__ Classification__ Estimation of Proportion
   __ Feature Selection__ Signature Extension
   __ Temporal Sampling__ Systems Development__ Technique Development
   __ Crop Assessment __ Yield Estimation
   __ Other (specify) ________________

C.2-9
I. NAME: FUNCTION FISHIN (ALPHA,N1,N2)

II. SOURCE (include coder/person with knowledge of program usage):
Corrected from UNIVAC STAT PACK

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE: Inverse Fisher's distribution

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: JSC STAT CAT


VI. SPECIAL FEATURES: 0 < ALPHA < 1, ALPHA is the confidence coefficient.

VII. SUBROUTINES REQUIRED: FISH PHINV

VIII. DOCUMENTATION: X Available __ Not Available __ Will be Available

IX. X Software available off-the-shelf. Approximate Cost: ___________
   __ Is not __ compatible with Image 100 configuration in present form
   __ Non-PDP 11/45 FORTRAN
   __ Some machine language conversion necessary
   __ In language other than FORTRAN. Specify _______________________
   __ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   __ General purpose __ Special purpose __ Program package
   __ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __ LACIE __ Non-LACIE
   __ Training __ Classification __ Estimation of Proportion
   __ Feature Selection __ Signature Extension
   __ Temporal Sampling __ Systems Development __ Technique Development
   __ Crop Assessment __ Yield Estimation
   __ Other (specify) __________

C.2-10
I. NAME: REAL FUNCTION BIN(N,P,M)

II. SOURCE (include coder/person with knowledge of program usage):
    JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V       COMPUTER: 1108

IV. PURPOSE: Value of binomial distribution function

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: JSC STAT CAT

Description:

VI. SPECIAL FEATURES: For values of M > 1000, PHI is called in the calculations

VII. SUBROUTINES REQUIRED:
    PHI
    ZOT

VIII. DOCUMENTATION: _X_Available  _Not Available  _Will be Available

IX. _X_Software available off-the-shelf. Approximate Cost: __________
    Is__Is not__compatible with Image 100 configuration in present form
    _Non-PDP 11/45 FORTRAN
    __Some machine language conversion necessary
    __In language other than FORTRAN. Specify ____________
    _Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
    _General purpose__Special purpose__Program package
    _PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE__Non-LACIE
    _Training__Classification__Estimation of Proportion
    _Feature Selection__Signature Extension
    _Temporal Sampling__Systems Development__Technique Development
    _Crop Assessment__Yield Estimation
    _Other (specify) ________________________________

C.2-11
I. NAME: FUNCTION HYTRIC(K,N,N1,NR)

II. SOURCE (include coder/person with knowledge of program usage):
JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE: Hypergeometric distribution

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: JSC STAT CAT

Description: Calculate probability that a random variable with a hypergeometric distribution is less than or equal to a given value

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:
FCTRLG
FACTOR

VIII. DOCUMENTATION: X Available _ Not Available __ Will be Available

IX. _ X Software available off-the-shelf. Approximate Cost: ____________
Is ___ Is not ___ compatible with Image 100 configuration in present form
__ Non-PDP 11/45 FORTRAN
__ Some machine language conversion necessary
__ In language other than FORTRAN. Specify ______________________
__ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__ General purpose ___ Special purpose ___ Program package
__ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___ LACIE ___ Non-LACIE
___ Training ___ Classification ___ Estimation of Proportion
___ Feature Selection ___ Signature Extension
___ Temporal Sampling ___ Systems Development ___ Technique Development
___ Crop Assessment ___ Yield Estimation
___ Other (specify) ____________________________

C.2-12
I. NAME: REAL FUNCTION BETINC(X,A,B)

II. SOURCE (include coder/person with knowledge of program usage): corrected from UNIVAC STAT PACK

III. PROGRAMMING LANGUAGE: FORTRAN V COMPUTER: 1108

IV. PURPOSE: INCOMPLETE BETA DISTRIBUTION

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: JSC STAT CAT
UNIVAC STAT PACK

Description: Compute probability that a random variable, distributed as the incomplete Beta function with given values of parameters, is less than or equal to a given value.

VI. SPECIAL FEATURES: The Modified Jacobi Quadrature formula is used in computing integrals. Uses CBRT function

VII. SUBROUTINES REQUIRED:

PHI
CHI2

VIII. DOCUMENTATION: X Available__Not Available__Will be Available

IX. X Software available off-the-shelf. Approximate Cost: __________

Is__Is not__compatible with Image 100 configuration in present form

__Non-PDP 11/45 FORTRAN

__Some machine language conversion necessary

__In language other than FORTRAN. Specify ________________________

__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

__General purpose__ Special purpose__Program package

__PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __LACIE__Non-LACIE

__Training__Classification__Estimation of Proportion

__Feature Selection__Signature Extension

__Temporal Sampling__Systems Development__Technique Development

__Crop Assessment__Yield Estimation

__Other (specify) ________________________________

C.2-13
I. NAME: REAL FUNCTION GAMIN(X,A)

II. SOURCE (include coder/person with knowledge of program usage):
UNIVAC STAT PACK

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE: Incomplete gamma function

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: JSC STAT CAT
UNIVAC STAT PACK

Description:

\[ P(A,X) = \frac{1}{\Gamma(A)} \int_0^X e^{-t} t^{A-1} dt \text{ with } P_N(A,X) = X^A e^{-X} \sum_{n=0}^{N} \frac{X^n}{\Gamma(A+n+1)} + R_N \]

where \( N \) is such that \( \frac{P_{N-1}(A,X)}{P_N(A,X)} \leq 10^{-6} \)

VI. SPECIAL FEATURES: \( A \) and \( X > 0 \)

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available  Not Available  Will be Available

IX. _XSoftware available off-the-shelf. Approximate Cost: ____________

Is__Is not__compatible with Image 100 configuration in present form

__Non-PDP 11/45 FORTRAN

__Some machine language conversion necessary

__In language other than FORTRAN. Specify ____________

__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

__General purpose__ Special purpose__ Program package

__PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE_ Non-LACIE

__Training__ Classification__ Estimation of Proportion

__Feature Selection__ Signature Extension

__Temporal Sampling__ Systems Development__ Technique Development

__Crop Assessment__ Yield Estimation

__Other (specify) ____________
I. NAME: REAL FUNCTION STUDIN(N,P)

II. SOURCE (include coder/person with knowledge of program usage):
   JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V
     COMPUTER: 1108

IV. PURPOSE: Inverse student's t-value

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: JSC STAT CAT
   Description: Given degrees of freedom and significance level, using Newton Raphson iterations

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:
   FACTOR PHINV
   EXPAN

VIII. DOCUMENTATION: X Available _ Not Available _ Will be Available

IX. X Software available off-the-shelf. Approximate Cost: _____________
   Is _ Is not _ compatible with Image 100 configuration in present form
   _ Non-PDP 11/45 FORTRAN
   _ Some machine language conversion necessary
   _ In language other than FORTRAN. Specify _________________
   _ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _ General purpose _ Special purpose _ Program package
   _ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _ LACIE _ Non-LACIE
    _ Training _ Classification _ Estimation of Proportion
    _ Feature Selection _ Signature Extension
    _ Temporal Sampling _ Systems Development _ Technique Development
    _ Crop Assessment _ Yield Estimation
    _ Other (specify) ____________________________________________

C.2-15
I. NAME: REAL FUNCTION ZOT(N)

II. SOURCE (include coder/person with knowledge of program usage):
   JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V
     COMPUTER: 1108

IV. PURPOSE: ZOT = ALOG(N!)

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: JSC STAT CAT
   Description: Calls FACTOR with \( \alpha = N + 1 \)

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:
   FACTOR

VIII. DOCUMENTATION: _Available_ _Not Available_ _Will be Available_

IX. _Software available off-the-shelf. Approximate Cost: _
    Is _Is not _compatible with Image 100 configuration in present form
       _Non-PDP 11/45 FORTRAN
       _Some machine language conversion necessary
       _In language other than FORTRAN. Specify _______________________
       _Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _General purpose_ _Special purpose_ _Program package
   _PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE_ _Non-LACIE_
    _Training_ _Classification_ _Estimation of Proportion_
    _Feature Selection_ _Signature Extension_
    _Temporal Sampling_ _Systems Development_ _Technique Development_
    _Crop Assessment_ _Yield Estimation_
    _Other (specify)__________________________________________

C.2-16
I. NAME:  FUNCTION RANDOM

II. SOURCE (include coder/person with knowledge of program usage):
Richard Rosencranz, JSC Engineering Applications, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V  COMPUTER: 1108

IV. PURPOSE:  Generate random numbers from uniformly distributed set

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: JSC STAT CAT

Description:

VI. SPECIAL FEATURES:  Option to return number from uniformly distributed set or number that is a function of input
Used mainly as a random starting point for cyclical set of numbers in ZOR function.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION:  X Available__ Not Available__ Will be Available

IX.  X Software available off-the-shelf. Approximate Cost: __________
Is__ Is not__ compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify ________________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose__ Special purpose__ Program package
__PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION:  __LACIE__ Non-LACIE
__Training__ Classification__ Estimation of Proportion
__Feature Selection__ Signature Extension
__Temporal Sampling__ Systems Development__ Technique Development
__Crop Assessment__ Yield Estimation
__Other (specify) ________________________________

C.2-17
I. NAME: REAL FUNCTION ZIP(A)

II. SOURCE (Include coder/person with knowledge of program usage):
    JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V     COMPUTER: 1108

IV. PURPOSE: Compute ln_e of the gamma function

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

    Reference: JSC STAT CAT

    Description: Calls FACTOR with α = A

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

        FACTOR

VIII. DOCUMENTATION: _X_Available__Not Available__Will be Available

IX. _X_Software available off-the-shelf. Approximate Cost: __________

    Is__Is not__compatible with Image 100 configuration in present form

    __Non-PDP 11/45 FORTRAN

    __Some machine language conversion necessary

    __In language other than FORTRAN. Specify _______________

    Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

    __General purpose__Special purpose__Program package

    __PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE__Non-LACIE

    __Training__Classification__Estimation of Proportion

    __Feature Selection__Signature Extension

    __Temporal Sampling__Systems Development__Technique Development

    __Crop Assessment__Yield Estimation

    __Other (specify) _______________

C.2-18
I. NAME: REAL FUNCTION ZARF(Z)

II. SOURCE (include coder/person with knowledge of program usage):
    JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V  COMPUTER: 1108

IV. PURPOSE: Compute complete gamma function \( \Gamma(Z) \)

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: JSC STAT CAT

Description: Calls FACTOR with \( \alpha = Z + 1.0 \)

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

FACTOR

VIII. DOCUMENTATION: X Available _ Not Available _ Will be Available

IX. X Software available off-the-shelf. Approximate Cost: __________

Is_ Is not_ compatible with Image 100 configuration in present form

Non-PDP 11/45 FORTRAN

Some machine language conversion necessary

In language other than FORTRAN. Specify __________

Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

General purpose_ Special purpose_ Program package

PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _ LACIE_ Non-LACIE

_Training_ Classification_ Estimation of Proportion

_Feature Selection_ Signature Extension

_Temporal Sampling_ Systems Development_ Technique Development

_Crop Assessment_ Yield Estimation

_Other (specify) __________

C.2-19
I. NAME: FUNCTION KPSNSM (AS)
   FUNCTION KPSNLG (AL)

II. SOURCE (include coder/person with knowledge of program usage):
   JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V
     COMPUTER: 1108

IV. PURPOSE: random numbers from a Poisson distribution.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: JSC STAT CAT
   Description:
   KPSNSM: \( \prod_{i=1}^{k+1} \mu_i < e^{-\mu} \)
   KPSNLG: \( \sum_{i=1}^{k+1} \ln \mu_i < -\mu \)

VI. SPECIAL FEATURES: Use KPSNLG if AL is greater than 88.028. If ZOR is initialized with a large odd number in the calling program, the sequence of random numbers will be repeated.

VII. SUBROUTINES REQUIRED: ZOR

VIII. DOCUMENTATION: The software is available off-the-shelf. Approximate Cost: ________
     Is it not compatible with Image 100 configuration in present form
     Non-PDP 11/45 FORTRAN
     Some machine language conversion necessary
     In language other than FORTRAN. Specify
     Software must be designed and developed for Image 100

IX. IMPLEMENTATION LEVEL
    General purpose
    Special purpose
    Program package
    PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

X. APPLICATION: LACIE Ikon—LACIE
    Training
    Classification
    Estimation of Proportion
    Feature Selection
    Signature Extension
    Temporal Sampling
    Systems Development
    Technique Development
    Crop Assessment
    Yield Estimation
    Other (specify)
I. NAME: SUBROUTINE BIN2 (N,I,BINCO3D7)

II. SOURCE (include coder/person with knowledge of program usage):
JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V
COMPUTER: 1108

IV. PURPOSE: Compute binomial coefficient.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: JSC STAT CAT

Description: Compute N things taken 1 at a time.

\[
\binom{N}{I} = \frac{N!}{I!(N-I)!}
\]

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: Values of I and N determine the calculations done.

VIII. DOCUMENTATION: x Available ___ Not Available ___ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
Is ___ Is not ___ compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify ____________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
General purpose ___ Special purpose ___ Program package
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___ LACIE ___ Non-LACIE
Training ___ Classification ___ Estimation of Proportion
Feature Selection ___ Signature Extension
Temporal Sampling ___ Systems Development ___ Technique Development
Crop Assessment ___ Yield Estimation
Other (specify) ______________________________________________________

C.2-21
COMPUTER PROGRAM IDENTIFICATION FORM

I. NAME: SUBROUTINE OVERFL(I)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN V       COMPUTER: 1108

IV. PURPOSE: Checks values for overflow condition

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference:

Description: Checks for overflow condition and return a one if overflow occurred

VI. SPECIAL FEATURES: OVERFL is part of 1108 system

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: ___Available X Not Available ___Will be Available

IX. XSoftware available off-the-shelf. Approximate Cost: __________

Is ___Is not ___compatible with Image 100 configuration in present form

Non-PDP 11/45 FORTRAN

Some machine language conversion necessary

In language other than FORTRAN. Specify ________________________

Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

___General purpose ___Special purpose ___Program package

PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___LACIE ___Non-LACIE

Training ___Classification ___Estimation of Proportion

Feature Selection ___Signature Extension

Temporal Sampling ___Systems Development ___Technique Development

Crop Assessment ___Yield Estimation

Other (specify) _______________________________________

C.2-22
C. GENERAL STATISTICAL LIBRARY

3. REGRESSION PACKAGE

II. SOURCE (include coder/person with knowledge of program usage):
JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V COMPUTER: 1108

IV. PURPOSE: Hotelling's T² test on means.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: JSC STAT CAT

Description: Test at a desired confidence level the null hypothesis that the mean vector of a set of observations equals a given vector.

VI. SPECIAL FEATURES: Variable dimensioning of arrays. Acceptance or rejection message is printed and option is available to print output.

VII. SUBROUTINES REQUIRED: COVARI GINV2M FISHIN

VIII. DOCUMENTATION: __ Available __ Not Available __ Will be Available

IX. __ Software available off-the-shelf. Approximate Cost: ____________
Is___Is not ___compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify _______________________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___General purpose ___Special purpose ___Program package
___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___LACIE___Non-LACIE
___Training___Classification___Estimation of Proportion
___Feature Selection___Signature Extension
___Temporal Sampling___Systems Development___Technique Development
___Crop Assessment___Yield Estimation
___Other (specify) ____________________________

C.4-2
I. NAME: SUBROUTINE COVARI (A,N,M,MM,NN,S,X)

II. SOURCE (include coder/person with knowledge of program usage):
JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE: Compute covariances between observed variables.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: JSC STAT CAT

Description:

\[ S(i,j) = \left( \frac{1}{N-1} \right) \sum_{k=1}^{N} \sum_{i=1}^{M} \sum_{j=1}^{M} \left[ A(k,i) - X(i) \right] \left[ A(k,j) - X(j) \right] \]

VI. SPECIAL FEATURES:
A is a matrix where column i contains the observations for variable i. N and M ≥ 2

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ____________
Is ___ Is not ___ compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify __________________________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
General purpose Special purpose Program package
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _ LACIE _ Non-LACIE
Training Classification Estimation of Proportion
Feature Selection Signature Extension
Temporal Sampling Systems Development Technique Development
Crop Assessment Yield Estimation
Other (specify) __________________________________________________________________
COMPUTER PROGRAM IDENTIFICATION FORM


II. SOURCE (include coder/person with knowledge of program usage): corrected from
JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V COMPUTER: 1108

IV. PURPOSE: One way analysis of variance

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: JSC STAT CAT

Description: One way analysis of variance with unequal number of replications in each cell; computes all sums of squares, degrees of freedom, mean squares, F-levels and probabilities that F-levels are exceeded.

VI. SPECIAL FEATURES: Control may be returned to a labelled statement in calling program in event of overflow
Option flag specifies lines to be printed.

VII. SUBROUTINES REQUIRED: FISH

VIII. DOCUMENTATION: X Available Not Available Will be Available

IX. X Software available off-the-shelf. Approximate Cost: ________
Is____Is not____compatible with Image 100 configuration in present form
___Non-PDP 11/45 FORTRAN
___Some machine language conversion necessary
___In language other than FORTRAN. Specify ________________
___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___General purpose___Special purpose___Program package
___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: LACIE Non-LACIE
___Training___Classification___Estimation of Proportion
___Feature Selection___Signature Extension
___Temporal Sampling___Systems Development___Technique Development
___Crop Assessment___Yield Estimation
___Other (specify) ____________________________________________

C.4-4

II. SOURCE (include coder/person with knowledge of program usage): corrected from
JSC Theory and Analysis Office, Houston	 UNIVAC STAT PACK

III. PROGRAMMING LANGUAGE: FORTRAN V	 COMPUTER: 1108

IV. PURPOSE: Two way analysis of variance

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: JSC STAT CAT

Description: 2 way analysis of variance with an equal number of
replications in each cell; computes all sums of squares,
degrees of freedom, mean squares, F-levels and probabilities
that F-levels are exceeded.

VI. SPECIAL FEATURES: If overflow occurs, control may be returned to some
labelled statement in the calling program
Option flag determines type of output desired.

VII. SUBROUTINES REQUIRED: FISH

VIII. DOCUMENTATION: X Available__ Not Available__ Will be Available

IX. __XSoftware available off-the-shelf. Approximate Cost: __________
Is__ Is not__ compatible with Image 100 configuration in present form
__ Non-PDP 11/45 FORTRAN
__ Some machine language conversion necessary
__ In language other than FORTRAN. Specify __________
__ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__ General purpose__ Special purpose__ Program package
__ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __ LACIE__ Non-LACIE
__ Training__ Classification__ Estimation of Proportion
__ Feature Selection__ Signature Extension
__ Temporal Sampling__ Systems Development__ Technique Development
__ Crop Assessment__ Yield Estimation
__ Other (specify) __________________________

C.4-5
I. NAME: SUBROUTINE RBANOV(Y,N,NB,NT,NR,B,R,SS,NDF,SM,F,PF, § K)

II. SOURCE (include coder/person with knowledge of program usage):
JSC Theory Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V 
COMPUTER: 1108

IV. PURPOSE: Analysis of variance on a randomized block design

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: JSC STAT CAT

Description: Analysis of variance on a randomized block design with an equal number of replications in each experimental unit; computes all sums of squares, degrees of freedom, mean squares, F-levels and probabilities that the F levels are exceeded.

VI. SPECIAL FEATURES: If overflow occurs, control will be returned to a labelled statement in the calling program

VII. SUBROUTINES REQUIRED:
BTALOG
PROBLY

VIII. DOCUMENTATION: X Available _ _ _ Not Available _ _ _ Will be Available

IX. _ _ _ Software available off-the-shelf. Approximate Cost: ______________
Is _ _ _ Is not __ compatible with Image 100 configuration in present form
____ Non-PDP 11/45 FORTRAN
____ Some machine language conversion necessary
____ In language other than FORTRAN. Specify ________________
____ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
____ General purpose __ Special purpose __ Program package
____ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __ LACIE __ Non-LACIE
____ Training __ Classification __ Estimation of Proportion
____ Feature Selection __ Signature Extension
____ Temporal Sampling __ Systems Development __ Technique Development
____ Crop Assessment __ Yield Estimation
____ Other (specify) ____________________________________________

C.4-6
I. NAME: FUNCTION ZOR(N)

II. SOURCE (include coder/person with knowledge of program usage):
Richard Rosencranz, JSC Engineering Applications, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V
COMPUTER: 11C8

IV. PURPOSE: Random number generator

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: JSC STAT CAT

Description: Uses uniform distribution set between 0 and 1 or normal distribution with mean 0 and variance 1

VI. SPECIAL FEATURES: Flag to choose distribution set
Calling program should declare ZOR to be an ABNORMAL FUNCTION

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: _X_ Available _Not Available_ _Will be Available_

IX. _X_ Software available off-the-shelf. Approximate Cost: ____________
Is_ is not __ compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify ____________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose__ Special purpose__ Program package
__PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE_ Non-LACIE
__Training__ Classification__ Estimation of Proportion
Feature Selection__ Signature Extension
Temporal Sampling__ Systems Development__ Technique Development
Crop Assessment__ Yield Estimation
__Other (specify) ________________________________

C.4-7
I. NAME: SUBROUTINE KOLSME(\(X, N, F, KW, KN, D\))

II. SOURCE (include coder/person with knowledge of program usage):
    JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V
    COMPUTER: 1108

IV. PURPOSE: Kolmogorov-Smirnov test of goodness of fit

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
    Reference: JSC STAT CAT

Description: Test goodness of fit of data to a specified theoretical
    cumulative distributive function

VI. SPECIAL FEATURES: Cumulative distributive function may be applied to
    raw or normalized data; prints output
    Print option specifies lines to be printed out.
    Function option specifies type of function F is to be used.

VII. SUBROUTINES REQUIRED:

ORDER

VIII. DOCUMENTATION: X Available _ Not Available _ Will be Available

IX. _Software available off-the-shelf. Approximate Cost: ____________
    Is _ Is not _ compatible with Image 100 configuration in present form
    _Non-PDP 11/45 FORTRAN
    _Some machine language conversion necessary
    _In language other than FORTRAN. Specify ______________
    Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
    _General purpose _ Special purpose _ Program package
    _PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE _ Non-LACIE
    _Training _ Classification _ Estimation of Proportion
    _Feature Selection _ Signature Extension
    _Temporal Sampling _ Systems Development _ Technique Development
    _Crop Assessment _ Yield Estimation
    _Other (specify) ______________

C.4-8
I. NAME: SUBROUTINE FACTOR (ALPHA, EXPLAN, YEXPLAN)

II. SOURCE (include coder/person with knowledge of program usage):
   JSC Theory and Analysis Office, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V
      COMPUTER: 1108

IV. PURPOSE: Approximate complete gamma (factorial) function

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: JSC STAT CAT
   Description: Evaluate gamma function and \ln_e of the complete gamma function

VI. SPECIAL FEATURES: Value of \alpha determines equations used.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available, Not Available, Will be Available

IX. X Software available off-the-shelf. Approximate Cost: ____________
   Is__Is not__compatibility with Image 100 configuration in present form
   ___Non-PDP 11/45 FORTRAN
   ___Some machine language conversion necessary
   ___In language other than FORTRAN. Specify __________
   ___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___General purpose__Special purpose__Program package
   ___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___LACIE__Non-LACIE
    ___Training__Classification__Estimation of Proportion
    ___Feature Selection__Signature Extension
    ___Temporal Sampling__Systems Development__Technique Development
    ___Crop Assessment__Yield Estimation
    ___Other (specify) ____________________________

C.4-9
D. PATTERN RECOGNITION LIBRARY

1. CLUSTERING PACKAGE
I. NAME: Semi-supervised Cluster Analysis

II. SOURCE (include coder/person with knowledge of program usage):
    General Electric/Jim Brierly

III. PROGRAMMING LANGUAGE: FORTRAN

IV. PURPOSE: To determine the feature space location of homogenous clusters from the results of N-dimensional histogram analysis.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
    Reference: See next page
    Description: See next page

VI. SPECIAL FEATURES: See next page

VII. SUBROUTINES REQUIRED: None

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

    x Software available off-the-shelf. Approximate Cost: $6,049
    Is x is not compatible with Image 100 configuration in present form
    ___Non-PDP 11/45 FORTRAN
    ___Some machine language conversion necessary
    ___In language other than FORTRAN. Specify ______________________
    ___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
    ___General purpose x Special purpose x Program package
    ___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
    ___Training x Classification x Estimation of Proportion
    ___Feature Selection x Signature Extension
    ___Temporal Sampling x Systems Development x Technique Development
    ___Crop Assessment x Yield Estimation
    ___Other (specify) ____________________________

D.1-2
1.4.2 SEMI-SUPERVISED CLUSTER ANALYSIS

The function of this program is to determine, if possible, the approximate feature space location of homogeneous cell groupings (clusters) from the results of N-dimensional histogram analysis, in a semi-supervised manner. Using the results of a previous N-dimensional training step, this program attempts to categorize the N-D results into a user-specified number of clusters. A migrating means technique is used for partitioning feature space with the means initially set to arbitrary starting values. The program then iterates through a succession of new partitions to determine the optimum assignment of each cell to one of the number of clusters specified by the user. The user may stop the program at any point and accept the results to-date, or may elect to let the program run to conclusion. In either case, the program displays the results on the Graphics Display Terminal. It is possible that an acceptable solution may not be reached for the given number or any other number of specified clusters. The program will terminate after fifty iterations.
I. NAME: DRIVER PROGRAM (ISOCLS)

II. SOURCE (include coder/person with knowledge of program usage):
R. MINTER/LEC also E. KAN/LEC

III. PROGRAMMING LANGUAGE: FORTRAN V
COMPUTER: UNIVAC 1108 EXEC 2
SLEUTH

IV. PURPOSE: Driver program to perform iterative clustering

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: "Computer Program Documentation, ISOCLS, Program C094"
Description: LEC-3984, Nov. 1974.
Iteratively group data into homogenous nominal-sized clusters, the nominal size is to be preset by users.

VI. SPECIAL FEATURES: See references

VII. SUBROUTINES REQUIRED: TDATE, SETUP, TAPERD, ISODAT, COVARR, PCHSTA, CHAIN, PRINT, DASTAP (See next page)

VIII. DOCUMENTATION: _x_ Available _x_ Not Available _x_ Will be Available

IX. _x_ Software available off-the-shelf. Approximate Cost: ___________
Is _x_ Is not _Non-PDP 11/45 FORTRAN_ compatible with Image 100 configuration in present form
   _x_ Some machine language conversion necessary
   _x_ In language other than FORTRAN. Specify ___________________
   _x_ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _x_ General purpose _x_ Special purpose _x_ Program package
   _x_ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _x_ LACIE _x_ Non-LACIE
   _x_ Training _x_ Classification _x_ Estimation of Proportion
   _Feature Selection _Signature Extension
   _Temporal Sampling _Systems Development _Technique Development
   _Crop Assessment _Yield Estimation
   _Other (specify) ________________________________
General flow of the program *I socls*

- **ISOCLS**
  - **TDAT**E
    - Obtains current date
  - **SETUP**
    - Reads card input and makes drum assignments
  - **TAPERD**
    - Reads tape input and stores on drum.
  - **ISODAT**
    - Performs clustering algorithm.
  - **COVARR**
    - Calculates and prints covariance matrices
  - **PCHSTA**
    - Punches and prints means and covariance matrices
  - **CHAIN**
    - Performs chaining algorithm
  - **PRINT**
    - Prints final results
  - **DASTAP**
    - Creates tape for PMIS-DAS

1. **System routine** which returns the number of words available on FH432 and FH1782 drums.
2. **System routine** which assigns specific word length to drum unit.
3. **System binary I/O routine**.
4. **System routine** which sets the margin at the top and bottom of the page.
I. NAME: SUBROUTINES TDATE, SETUP, etc. (See first page of ISOCLS)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: 

IV. PURPOSE:

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference:
   Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: _Available_ Not Available _Will be Available

IX. _Software available off-the-shelf. Approximate Cost: ____________
   Is __Is not__ compatible with Image 100 configuration in present form
   _Non-PDP 11/45 FORTRAN
   _Some machine language conversion necessary
   _In language other than FORTRAN. Specify ______________________
   _Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _General purpose_ Special purpose _Program package
   _PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE_ Non-LACIE
   _Training_ Classification _Estimation of Proportion
   _Feature Selection_ Signature Extension
   _Temporal Sampling_ Systems Development _Technique Development
   _Crop Assessment_ Yield Estimation
   _Other (specify) ____________________________________

D.1-6
D. PATTERN RECOGNITION LIBRARY

2. CLASSIFICATION PACKAGE

Maximum likelihood classification algorithms are being implemented on the Image 100 System by LEC.
I. NAME: ELLTAB

II. SOURCE (include coder/person with knowledge of program usage):
NASA/MTF Clay Jones

III. PROGRAMMING LANGUAGE: FORTRAN
COMPUTER: UNIVAC.1108

IV. PURPOSE: Classify multispectral scanner data.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See next page
Description: See next page

VI. SPECIAL FEATURES: See next page

VII. SUBROUTINES REQUIRED: None

VIII. DOCUMENTATION: x Available__ Not Available__ Will be Available

IX. _x Software available off-the-shelf. Approximate Cost: 0
Is x Is not__ compatible with Image 100 configuration in present form
_x Non-PDP 11/45 FORTRAN
_Some machine language conversion necessary
_In language other than FORTRAN. Specify __________
 Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
_x General purpose__ Special purpose__ Program package
_x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
_x Training x Classification x Estimation of Proportion
_x Feature Selection x Signature Extension
_x Temporal Sampling x Systems Development x Technique Development
_x Crop Assessment x Yield Estimation
_x Other (specify) _____________________________________________

D.2-2
AN IMPROVED VERSION OF THE TABLE LOOK-UP
ALGORITHM FOR PATTERN RECOGNITION

W. G. Eppler

Lockheed Electronics Company
Houston, Texas

ABSTRACT

The Table Look-Up Approach to pattern recognition has been used for 3 years at several research centers in a variety of applications. A new version has been developed which is faster, requires significantly less core memory, and retains full precision of the input data. The new version can be used on low-cost minicomputers having 32K words (16 bits each) of core memory and fixed-point arithmetic; no special-purpose hardware is required. An initial FORTRAN version of this system can classify an ENTS computer-compatible tape into 24 classes in less than 15 minutes.

IMPLEMENTATION OF AN ADVANCED TABLE LOOK-UP CLASSIFIER
FOR LARGE AREA LAND-USE CLASSIFICATION

Clay Jones

Johnson Space Center
Earth Resources Laboratory
National Aeronautics and Space Administration
Bay St. Louis, Mississippi 39520

ABSTRACT

Software employing Eppler's improved table look-up approach to pattern recognition has been developed, and results from this software are presented. The look-up table for each class is a computer representation of a hyperellipsoid in four dimensional space. During implementation of the software Eppler's look-up procedure was modified to include multiple ranges in order to accommodate hollow regions in the ellipsoids. In a typical ENTS classification run less than 6000 36-bit computer words were required to store tables for 24 classes. Classification results from the improved table look-up are identical with those produced by the conventional method, i.e., by calculation of the maximum likelihood decision rule at the moment of classification. With the new look-up approach an entire ENTS MSS frame can be classified into 24 classes in 1.3 hours, compared to 22.5 hours required by the conventional method. The new software is coded completely in FORTRAN to facilitate transfer to other digital computers.
I. NAME: Maximum Likelihood Resolution

II. SOURCE (include coder/person with knowledge of program usage):
   General Electric/Jim Brierly

III. PROGRAMMING LANGUAGE: FORTRAN
     COMPUTER: IMAGE-100/PDP-11

IV. PURPOSE: To resolve conflicts between overlapping spectral signatures.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: See next page
   Description: See next page

VI. SPECIAL FEATURES: See next page

VII. SUBROUTINES REQUIRED: None

VIII. DOCUMENTATION: x Available  Not Available  Will be Available

IX. x Software available off-the-shelf. Approximate Cost: $6,286
    Is x Is not compatible with Image 100 configuration in present form
    ___Non-PDP 11/45 FORTRAN
    ___Some machine language conversion necessary
    ___In language other than FORTRAN. Specify __________________
    ___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
    ___General purpose  x Special purpose  x Program package
    ___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE  x Non-LACIE
    ___Training  x Classification  ___Estimation of Proportion
    ___Feature Selection  ___Signature Extension
    ___Temporal Sampling  ___Systems Development  ___Technique Development
    ___Crop Assessment  ___Yield Estimation
    ___Other (specify) ____________________________________________

D.2-4
1.3.1 Maximum Likelihood Resolution

This program permits conflicts between overlapping spectral signatures to be resolved by assigning spectral cells to the class which has highest probability, where probability is based on the frequency of occurrence of a given multispectral pixel value normalized with respect to the training area.

The user first specifies two signature files (results of N-Dimensional Histogram Acquisition) presumably generated from the same image data. The option of simultaneous theme modification is available and if desired, the one or two corresponding themes tracks are also specified. The image data must also be stored in the Image Memory Unit.

The two signature files are compared in feature space, and any areas of overlap are examined. The overlapping cells are assigned to one or the other signature on the basis of maximum likelihood. That is, for any feature space cell, the normalized number of pixels having that cell's coordinates is computed for each signature, and the largest one is retained in its file while the other file's cell is deleted; thus, assuring that each cell is assigned to only one signature file. The themes, if desired, are also modified accordingly by deleting the pixels corresponding to the deleted cells.
D. PATTERN RECOGNITION LIBRARY

3. FEATURE SELECTION PACKAGE
I. NAME: PROGRAM UH Linear Feature Selection

II. SOURCE (include coder/person with knowledge of program usage):
    J. A. Quirein, LEC-JSC Houston; H. P. Decell/R. Teun, Math. Dept., UH

III. PROGRAMMING LANGUAGE: FORTRAN
        COMPUTER: 1108/EXEC 8
              360/67

IV. PURPOSE: Linear feature selection to minimize loss of separability
           among classes.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

    Reference: H. P. Decell & J. A. Quirein, "An Iterative Approach to the Feature
    Baker, "Users Guide to the Univ. of Houston Linear Feature Selection Program,"
                July, 1974

    Linear transformation B of measurement x such that the
    average transformed divergence is maximized for all
    interclass pairs.

VI. SPECIAL FEATURES: Reduces dimensions of data to be classified from n to k. Uses Davidson Iterator to find best B.

VII. SUBROUTINES REQUIRED: See tree on p. 1a.
    DAVIDN  SHUTLE  MPROD  EIGEN  TRANDV
    CUBIC  CHLSKY  XPROD  BHATCH
    FINT  MVPFR  HALM  DMVFR

VIII. DOCUMENTATION: X Available__Not Available__Will be Available

IX. X Software available off-the-shelf. Approximate Cost: __________

   Is__Is not X compatible with Image 100 configuration in present form
   ___Non-PDP 11/45 FORTRAN
   ___Some machine language conversion necessary
   ___In language other than FORTRAN. Specify ____________________
   ___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___General purpose__X Special purpose__X Program package
   ___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE__X Non-LACIE
      ___Training__Classification__Estimation of Proportion
      X Feature Selection__Signature Extension
      ___Temporal Sampling__Systems Development__Technique Development
      ___Crop Assessment__Yield Estimation
      ___Other (specify) ____________________________________________

D.3-2
Feature Selection Main Program

- DAVIDN
- FINT
- CUBIC

SHUTLE

- HALM
  - EIGEN
  - XPROD
  - MVPR
  - BHATCH
  - DMVPR
  - TRANDV

- MPROD
- CHLSKY
I. NAME: SUBROUTINE DAVIAN

II. SOURCE (include coder/person with knowledge of program usage):
Ivan Johnson, JSC/MPAD, Houston

III. PROGRAMMING LANGUAGE: FORTRAN

IV. PURPOSE: Davidon-Fletcher-Powell iterator

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Description: Davidon- Fletcher-Powell optimization method to find best k linear combination B matrix.

VI. SPECIAL FEATURES: Optimal B is derived iteratively from an initial guess B and gradient.

VII. SUBROUTINES REQUIRED: CUBIC, FINT, SHUTLE

VIII. DOCUMENTATION: Available x Not Available __ Will be Available

IX. _x_Software available off-the-shelf. Approximate Cost: ___________
Is___Is not __x_compatible with Image 100 configuration in present form
___Non-PDP 11/45 FORTRAN
___Some machine language conversion necessary
___In language other than FORTRAN. Specify ________________
___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
_x_General purpose__ Special purpose__ Program package
_x_PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
__Training__ Classification__ Estimation of Proportion
_x_Feature Selection__ Signature Extension
__Temporal Sampling__ Systems Development_x_Technique Development
__Crop Assessment__ Yield Estimation
__Other (specify) ____________________________

D.3-4
I. NAME: SUBROUTINE FINT (FNT, IPART)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE: Compute numerical partial derivatives.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: See DAVIDN

Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: SHUTLE

VIII. DOCUMENTATION: ___Available___ Not Available___ Will be Available

IX. ___Software available off-the-shelf. Approximate Cost: ____________

Is ___Is not ___compatible with Image 100 configuration in present form

___Non-PDP 11/45 FORTRAN

___Some machine language conversion necessary

___In language other than FORTRAN. Specify ________________

___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

___General purpose ___Special purpose ___Program package

___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___LACIE ___Non-LACIE

___Training ___Classification ___Estimation of Proportion

___Feature Selection ___Signature Extension

___Temporal Sampling ___Systems Development ___Technique Development

___Crop Assessment ___Yield Estimation

___Other (specify) ________________

D. 3-5
I. NAME: SUBROUTINE CUBIC(XX,YY,XMIN2)

II. SOURCE (include coder/person with knowledge of program usage):
Ivan Johnson, JSC/MPAD, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V
COMPUTER: 1108
360/67

IV. PURPOSE: Cubic fit technique.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See DAVIDN
Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: ______Available ______Not Available ______Will be Available

IX. ______Software available off-the-shelf. Approximate Cost: ______
Is ______Is not ______compatible with Image 100 configuration in present form
____Non-PDP 11/45 FORTRAN
____Some machine language conversion necessary
____In language other than FORTRAN. Specify ______________________
____Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
____General purpose ______Special purpose ______Program package
____PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ______LACIE ______Non-LACIE
____Training ______Classification ______Estimation of Proportion
____Feature Selection ______Signature Extension
____Temporal Sampling ______Systems Development ______Technique Development
____Crop Assessment ______Yield Estimation
____Other (specify) ________________________________

D.3-6
I. NAME: SUBROUTINE SHUTLE(FNT,IPART)

II. SOURCE (include coder/person with knowledge of program usage):
J. Quirein, LEC/JSC; H.P. Decell, R. Teun, Math. Dept. UH

III. PROGRAMMING LANGUAGE: FORTRAN V  COMPUTER: 1108

IV. PURPOSE: Calculate interclass divergences and probability of misclassification bound.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Description: See above report for equations used.

VI. SPECIAL FEATURES: Option to find Bhattacharyya bound and transformed average divergence.

VII. SUBROUTINES REQUIRED: MPROD, CHLSKY, HALM, BHATCH, TRANDV

VIII. DOCUMENTATION: _Available x Not Available_ Will be Available

IX. _Software available off-the-shelf. Approximate Cost: ___________
   Is_is not _compatible with Image 100 configuration in present form
   _Non-PDP 11/45 FORTRAN
   _Some machine language conversion necessary
   _In language other than FORTRAN. Specify ___________
   _Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _General purpose x Special purpose _Program package
   _PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
   _Training __Classification ___Estimation of Proportion
   _Feature Selection __Signature Extension
   _Temporal Sampling __Systems Development x Technique Development
   _Crop Assessment __Yield Estimation
   _Other (specify) __________

D.3-7
I. NAME: SUBROUTINE CHLSKY (XTEMP, XUP, CHI, K)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN
COMPUTER: 1108
360/67

IV. PURPOSE: Invert a positive definite symmetric matrix.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference:

Description: XTEMP is factored into 2 upper triangular matrices that are inverted.

VI. SPECIAL FEATURES: Option to check inverse by multiplying the inverse by the original matrix and printing the result.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: __Available__ x Not Available__ Will be Available

IX. _x_ Software available off-the-shelf. Approximate Cost: __________
Is _x_ Is not __compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify ______________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
_x_ General purpose __Special purpose__ Program package
_x_ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _x_ LACIE _x_ Non-LACIE
__Training__x__Classification__x__Estimation of Proportion
__Feature Selection__ Signature Extension
__Temporal Sampling__ Systems Development _x_ Technique Development
__Crop Assessment__ Yield Estimation
__Other (specify) __________

D.3-8
I. NAME: SUBROUTINE MVPR(XTEMP, VECT, XVECT, KDM, KN)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE: Post-multiply m×n matrix by n×1 vector.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference:

Description: XTEMP × VECT = XVECT

VI. SPECIAL FEATURES: Single precision. Dimensions less than or equal to 12.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: _Available _Not Available _Will be Available

IX. _Software available off-the-shelf. Approximate Cost: _

Is _Is not _compatible with Image 100 configuration in present form

_Non-PDP 11/45 FORTRAN

_Some machine language conversion necessary

_In language other than FORTRAN. Specify ______________

_Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

_General purpose _Special purpose _Program package

_PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE _Non-LACIE

_Training _Classification _Estimation of Proportion

_Feature Selection _Signature Extension

_Temporal Sampling _Systems Development _Technique Development

_Crop Assessment _Yield Estimation

_Other (specify) ____________________________

D.3-9
I. NAME: SUBROUTINE MPROD(XX,YY,ZZ,K1,K2,K3)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE: Matrix multiplication.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference:

Description: XX \times YY = ZZ

VI. SPECIAL FEATURES: Double Precision: Dimensions must be less than or equal to 12.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: Available

IX. Software available off-the-shelf. Approximate Cost: __________

Is __ Is not __ compatible with Image 100 configuration in present form

__ Non-PDP 11/45 FORTRAN

__ Some machine language conversion necessary

__ In language other than FORTRAN. Specify __________

__ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

__ General purpose __ Special purpose __ Program package

__ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __ LACIE __ Non-LACIE

__ Training __ Classification __ Estimation of Proportion

__ Feature Selection __ Signature Extension

__ Temporal Sampling __ Systems Development __ Technique Development

__ Crop Assessment __ Yield Estimation

__ Other (specify) __________

D.3-10
I. NAME: SUBROUTINE XPROD(XX,YY,ZZ,K1,K2,K3)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE: Single precision matrix multiplication,

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference:

Description: XX×YY=ZZ

VI. SPECIAL FEATURES: Dimensions must be less than or equal to 12.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: [ ] Available [ ] Not Available [ ] Will be Available

IX. [ ] Software available off-the-shelf. Approximate Cost: _________

[ ] Is [ ] Is not compatible with Image 100 configuration in present form

[ ] Non-PDP 11/45 FORTRAN

[ ] Some machine language conversion necessary

[ ] In language other than FORTRAN. Specify ________________________

[ ] Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

[ ] General purpose [ ] Special purpose [ ] Program package

[ ] PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: [ ] LACIE [ ] Non-LACIE

[ ] Training [ ] Classification [ ] Estimation of Proportion

[ ] Feature Selection [ ] Signature Extension

[ ] Temporal Sampling [ ] Systems Development [ ] Technique Development

[ ] Crop Assessment [ ] Yield Estimation

[ ] Other (specify) ________________________________

D.3-11
I. NAME: SUBROUTINE HALM(N, IFLAG, ERFT)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE: Pairwise bounds on probability of misclassification.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: See references for UH feature selection.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: EIGEN, XPROD, MVPR

VIII. DOCUMENTATION: __Available x Not Available__ Will be Available

IX. __Software available off-the-shelf. Approximate Cost: __________

   Is__Is not__compatible with Image 100 configuration in present form

   ____Non-PDP 11/45 FORTRAN

   ____Some machine language conversion necessary

   ____In language other than FORTRAN. Specify ________________

   ____Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

   ____General purpose x Special purpose__ Program package

   x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __LACIE x Non-LACIE

   ____Training x Classification __Estimation of Proportion

   x Feature Selection __Signature Extension

   ____Temporal Sampling __Systems Development x Technique Development

   ____Crop Assessment __Yield Estimation

   ____Other (specify) _________________________________________

D.3-12
I. NAME: SUBROUTINE EIGEN(AA,N, MV, A, E, R)

II. SOURCE (include coder/person with knowledge of program usage):
Jane Montgomery, TRW Systems

III. PROGRAMMING LANGUAGE: FORTRAN V
COMPUTER: 1108

IV. PURPOSE:
eigenvalues and eigenvectors of a real symmetric matrix

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Description: Jacobi method of diagonalization

VI. SPECIAL FEATURES:
option to compute eigenvalues only

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION:_Available X Not Available__Will be Available

IX. _X Software available off-the-shelf. Approximate Cost: ____________
Is_X is not__compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify __________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
_X General purpose__Special purpose___Program package
_X PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION:_X LACIE__X Non-LACIE
__Training__Classification__Estimation of Proportion
__Feature Selection__Signature Extension
__Temporal Sampling__Systems Development__X Technique Development
__Crop Assessment__Yield Estimation
__Other (specify) ____________________________________________

D.3-13
I. NAME: SUBROUTINE BHATCH(FNT,IPART)

II. SOURCE (include coder/person with knowledge of program usage):
J. A. Quirein, LEC/JSC, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE:
compute minimum average Bhattacharyya bound on the probability of misclassification

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: UH feature selection

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:
MPROD
CHLSKY
DMVR

VIII. DOCUMENTATION: _Available_ X_Not Available_ Will be Available

IX. _Software available off-the-shelf. Approximate Cost: ___________
Is___ Is not Xcompatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify _________________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose X Special purpose Program package
X PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _X_LACIE_ X Non-LACIE
__Training__ Classification__ Estimation of Proportion
X Feature Selection__ Signature Extension
__Temporal Sampling__ Systems Development__ Technique Development
__Crop Assessment__ Yield Estimation
__Other (specify) ________________________________

D.3-14
I. NAME: SUBROUTINE DMVPR(XTEMP, VECT, XVECT, KUM, KN)

II. SOURCE (include coder/person with knowledge of program usage):

III. PROGRAMMING LANGUAGE: FORTRAN V

IV. PURPOSE:

   multiply matrix by vector

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

   Reference: UH feature selection

   Description:
   XTEMP * VECT = XVECT

VI. SPECIAL FEATURES:

   double precision

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: Available X Not Available Will be Available

IX. X Software available off-the-shelf. Approximate Cost: __________
   Is X Is not compatible with Image 100 configuration in present form
   ___Non-PDP 11/45 FORTRAN
   ___Some machine language conversion necessary
   ___In language other than FORTRAN. Specify ________________
   ___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___General purpose___Special purpose___Program package
   ___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE X Non-LACIE
   ___Training___Classification___Estimation of Proportion
   ___Feature Selection___Signature Extension
   ___Temporal Sampling___Systems Development___Technique Development
   ___Crop Assessment___Yield Estimation
   ___Other (specify) ___________________________

D.3-15
I. NAME: SUBROUTINE TRANDV

II. SOURCE (include coder/person with knowledge of program usage):
   J. A. Quirein, LEC/JSC, Houston

III. PROGRAMMING LANGUAGE: FORTRAN V COMPUTER: 1108
     360/67

IV. PURPOSE:
   minimum average transformed divergence

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: UH feature selection

   Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:
   MPROD
   CHLSKY
   DMVPR

VIII. DOCUMENTATION: _Available_ _Not Available_ _Will be Available

IX. _Software available off-the-shelf. Approximate Cost: ___________
   _Is_ _Is not_ _Xcompatible with Image 100 configuration in present form
   _Non-PDP 11/45 FORTRAN
   _Some machine language conversion necessary
   _In language other than FORTRAN. Specify ________________
   _Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _General purpose_ _Special purpose_ _Program package
   _PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _X LACIE_ _X Non-LACIE
   _Training_ _Classification_ _Estimation of Proportion
   _X Feature Selection__Signature Extension
   _Temporal Sampling__Systems Development__Technique Development
   _Crop Assessment__Yield Estimation
   _Other (specify) ____________

D.3-16
I. NAME: LFSPMC : Linear Feature Selection Probability of Misclassification

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce D. Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV

IV. PURPOSE: To compute a single linear combination of features which minimizes the probability of misclassification

V. ALGORITHM/TECHNIQUE (short description; include reference if available)


VI. SPECIAL FEATURES:
COMPLETE PROGRAM PACKAGE: INDIVIDUAL SUBROUTINES AND DRIVER ATTACHED.

VII. SUBROUTINES REQUIRED:
See subroutine tree on la of 18

VIII. DOCUMENTATION: x Available__ Not Available__ Will be Available

IX. _Software available off-the-shelf. Approximate Cost: __________
Is___ Is not ___ compatible with Image 100 configuration in present form
___Non-PDP 11/45 FORTRAN
___Some machine language conversion necessary
___In language other than FORTRAN. Specify __________
___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___General purpose _x_ Special purpose _x_ Program package
___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _x_ LACIE _x_ Non-LACIE
___Training ___ Classification ___ Estimation of Proportion
___Feature Selection ___ Signature Extension
___Temporal Sampling ___ Systems Development ___ Technique Development
___Crop Assessment ___ Yield Estimation
___Other (specify) ____________________________

D.3-17
I. NAME: DRIVER PROGRAM (LFSPMC)

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV  COMPUTER: 360/65

IV. PURPOSE: Driver program to set common dimensions throughout LFSPMC Package

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See previous LFSPMC

Description: Sets value MX for maximum numbers of classes and value NX for maximum number of features. Provides maximum string lengths.

VI. SPECIAL FEATURES: MX and NX must not be exceeded during any run for a given compilation.

VII. SUBROUTINES REQUIRED: PRDIM

VIII. DOCUMENTATION: _x_Available__Not Available__Will be Available

IX. _x_Software available off-the-shelf. Approximate Cost: ________________
Is___Is not _x-compatible with Image 100 configuration in present form
___Non-PDP 11/45 FORTRAN
___Some machine language conversion necessary
___In language other than FORTRAN. Specify _______________________
___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___General purpose _x_Special purpose___Program package
_x_PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _x_LACIE__Non-LACIE
___Training___Classification___Estimation of Proportion
_x_Feature Selection___Signature Extension
___Temporal Sampling___Systems Development___Technique Development
___Crop Assessment___Yield Estimation
___Other (specify) ________________________

D.3-19
I. NAME: SUBROUTINE PRDIM

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marion.

III. PROGRAMMING LANGUAGE: FORTRAN IV  COMPUTER: IBM 360/65

IV. PURPOSE: To provide dimensioning information to the subroutines of LFSPMC, effectively simulating object-time dimensioning.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: LFSPMC

Description: Starting addresses of subset arrays contained within single, large, previously-defined one-dimensional arrays are computed.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:
BMAT

VIII. DOCUMENTATION: x Available  _Not Available  _Will be Available

IX. _x Software available off-the-shelf. Approximate Cost: ____________
Is_x Is not _x compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify __________________________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
General purpose  x Special purpose  Program package
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE  _Non-LACIE
Training  Classification  Estimation of Proportion
x Feature Selection  Signature Extension
Temporal Sampling  Systems Development  Technique Development
Crop Assessment  Yield Estimation
Other (specify) ____________________________

D.3-20
I. NAME: SUBROUTINE BMAT

II. SOURCE (include coder/person with knowledge of program usage):
   L. F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV    COMPUTER: IBM 360/65

IV. PURPOSE: Main Driving Routine for LFSPMC. It performs all input and output of class statistics, executes user specified program options.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: LFSPMC

   Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:
     BVECT, CLSNEW, ERRMAT, RANCLN

VIII. DOCUMENTATION: _Available_ _Not Available_ _Will be Available

IX. _Software available off-the-shelf. Approximate Cost: _________
   _Is_ _Is not_ _compatible with Image 100 configuration in present form
   _Non-PDP 11/45 FORTRAN
   _Some machine language conversion necessary
   _In language other than FORTRAN. Specify _________
   _Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _General purpose_ _Special purpose_ _Program package
   _PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE_ _Non-LACIE
    _Training_ _Classification_ _Estimation of Proportion
    _Feature Selection_ _Signature Extension
    _Temporal Sampling_ _Systems Development_ _Technique Development
    _Crop Assessment_ _Yield Estimation
    _Other (specify)________________________________________

D.3-21
I. NAME: SUBROUTINE BVECT

II. SOURCE (include coder/person with knowledge of program usage):
L.P. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV  
COMPUTER: IBM 360/65

IV. PURPOSE: Compute the vector B which minimizes the probability of misclassification function

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: LFSPMC

Description: BVECT is a driver routine. It inputs iteration parameters, either inputs a starting value for the B vector or calls for its computation (BCOMP), calls for iteration on B for function minimization computation (DFMFP), and calls for computation and output of the final (lower case) function value. (FUNCT.)

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:
BCOMP, DFMFP, FUNCT

VIII. DOCUMENTATION: x Available  Not Available  Will be Available

IX. Software available off-the-shelf. Approximate Cost: _______________

Is___Is not x compatible with Image 100 configuration in present form

___Non-PDP 11/45 FORTRAN

___Some machine language conversion necessary

___In language other than FORTRAN. Specify ____________________________

___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

___General purpose  x Special purpose___ Program package
___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE  x Non-LACIE

___Training  ___Classification  ___Estimation of Proportion
___Feature Selection  ___Signature Extension
___Temporal Sampling  ___Systems Development  ___Technique Development
___Crop Assessment  ___Yield Estimation
___Other (specify) ________________________________________________

D.3-22
I. NAME: SUBROUTINE BCOMP

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV  COMPUTER: IBM 360/65

IV. PURPOSE: Compute the initial B vector for input to the minimization iteration routine.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: LFSPMC

Description: Determines iterative solution of a special case of the M-class problem (equal covariances) and uses this as starting vector.

VI. SPECIAL FEATURES:
No computation is performed in the special case of two classes with equal a priori probabilities; it merely calls routine BC2CP.

VII. SUBROUTINES REQUIRED:
BC2CP, EIGEN

VIII. DOCUMENTATION: x Available  _ Not Available  _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
Is_is_not_x_compatible_with_Image_100_configuration_in_present_form
__Non-PDP 11/45 FORTRAN
__Some_machine_language_conversion_necessary
__In_language_other_than_FORTRAN. Specify ________________________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose  x Special purpose  __ Program package
__PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE  x Non-LACIE
__Training  __Classification  __Estimation of Proportion
__Feature Selection  __Signature Extension
__Temporal Sampling  __Systems Development  __Technique Development
__Crop Assessment  __Yield Estimation
__Other (specify) ________________

D.3-23
I. NAME: SUBROUTINE BC2CP

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: Compute initial vector Bo for input to the minimization iteration routine - 2 class case with equal a priori probabilities

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: LFSPMC

Description:
$$Bo=(\mu_1-\mu_2)^T(\Sigma_1+\Sigma_2)^{-1}$$

VI. SPECIAL FEATURES:
Called only in the special case of two classes with equal a priori probabilities

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: _____________
Is _ Is not x compatible with Image 100 configuration in present form
___ Non-PDP 11/45 FORTRAN
___ Some machine language conversion necessary
___ In language other than FORTRAN. Specify _______________________
___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___ General purpose x Special purpose ___ Program package
___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE _ Non-LACIE
___ Training ___ Classification ___ Estimation of Proportion
___ Feature Selection ___ Signature Extension
___ Temporal Sampling ___ Systems Development ___ Technique Development
___ Crop Assessment ___ Yield Estimation
___ Other (specify) ________________________________

D.3-24
I. NAME: SUBROUTINE EIGFN

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: Compute eigenvalues and eigenvectors of a real symmetric matrix.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Description:
Implements the Jacobi diagonalization method as adapted by Von Neumann

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
Is x Is not x compatible with Image 100 configuration in present form
__ Non-PDP 11/45 FORTRAN
__ Some machine language conversion necessary
__ In language other than FORTRAN. Specify ____________
__ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
x General purpose _ Special purpose _ Program package
x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __ LACIE _ Non-LACIE
__ Training _ Classification _ Estimation of Proportion
__ Feature Selection _ Signature Extension
__ Temporal Sampling _ Systems Development _ Technique Development
__ Crop Assessment _ Yield Estimation
__ Other (specify) ________________________________

D.3-25
I. NAME: SUBROUTINE DFMFP

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV
      COMPUTER: IBM 360/65

IV. PURPOSE: To find a local minimum of a function of several variables.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: R. Fletcher and M.J.P.Powell, A rapidly convergent
   Description:
   Uses a deflected gradient procedure to determine a local
   minimum of a function of several variables. Requires analytical
   expressions for gradient.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:
   FUNCT - A user supplied routine which computes the objective
   function and gradient.

VIII. DOCUMENTATION: x Available  _ Not Available  _ Will be Available

IX. _x_ Software available off-the-shelf. Approximate Cost: ____________
      Is _x_ Is not _x_ compatible with Image 100 configuration in present form
      _x_ Non-PDP 11/45 FORTRAN
      _x_ Some machine language conversion necessary
      _x_ In language other than FORTRAN. Specify _______________
      _x_ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _x_ General purpose _ Special purpose _ Program package
   _x_ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _x_ LACIE  _ Non-LACIE
   _x_ Training _ Classification _ Estimation of Proportion
   _x_ Feature Selection _ Signature Extension
   _x_ Temporal Sampling _ Systems Development _ Technique Development
   _x_ Crop Assessment _ Yield Estimation
   _x_ Other (specify)
I. NAME: SUBROUTINE FUNCT

II. SOURCE (include coder/person with knowledge of program usage):
L.E. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE:
COMPUTER:
FORTRAN IV IBM 360/65

IV. PURPOSE: Compute the probability of misclassification and its
gradient with respect to a vector

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: LFSPMC

Description: Uses analytical variational equations and closed
form expressions for the probability of misclassification to compute
functional values and gradient vector for optimization package

VI. SPECIAL FEATURES: Has variable dimensioning

VII. SUBROUTINES REQUIRED: XNDF, DPHI, DERF

VIII. DOCUMENTATION: x Available__ Not Available__ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
Is__ Is not__ compatible with Image 100 configuration in present form
__ Non-PDP 11/45 FORTRAN
__ Some machine language conversion necessary
__ In language other than FORTRAN. Specify ____________
__ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__ General purpose x Special purpose__ Program package
x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
__ Training__ Classification__ Estimation of Proportion
x Feature Selection__ Signature Extension
__ Temporal Sampling__ Systems Development__ Technique Development
__ Crop Assessment__ Yield Estimation
__ Other (specify) ____________________________________

D.3-27
I. NAME: FUNCTION XNDF

II. SOURCE (include coder/person with knowledge of program usage):
   L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV   COMPUTER: IBM 360/65

IV. PURPOSE: Evaluate one-dimensional normal density function with
   mean XMU and variance SIG at a point A.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

   Reference: LFSPMC: Linear Feature Selection Program Using the
   Probability of Misclassification

   Description: XNDF(A,XMU,SIG) = \( \frac{2\pi}{\sqrt{\text{SIG}}} \left( \frac{1}{\text{SIG}} \right) \exp \left( -\frac{1}{2} \frac{(A-XMU)^2}{\text{SIG}} \right) \)

VI. SPECIAL FEATURES: Sets XNDF(A,XMU,SIG) = 0 if argument in EXP is
   less than -175

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available __ Not Available __ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
   Is __ Is not x compatible with Image 100 configuration in present form
   ___ Non-PDP 11/45 FORTRAN
   ___ Some machine language conversion necessary
   ___ In language other than FORTRAN. Specify _________________
   ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   x General purpose __ Special purpose __ Program package
   x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
   ___ Training ___ Classification ___ Estimation of Proportion
   x Feature Selection ___ Signature Extension
   ___ Temporal Sampling ___ Systems Development ___ Technique Development
   ___ Crop Assessment ___ Yield Estimation
   ___ Other (specify) ____________________________________________

D.3-28
I. NAME: SUBROUTINE DERF

II. SOURCE (include coder/person with knowledge of program usage):
   L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV
     COMPUTER: IBM 360/65

IV. PURPOSE: To evaluate the error function of a variable X.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference:
   Description: \( \text{DERF}(X) = (2\pi)^{-1/2} \int_{-a}^{X} \exp\left( -\frac{t^2}{2} \right) \, dt \)

VI. SPECIAL FEATURES: Has additional entry point DPHI to compute
    \( \text{DPHI}(X) = 0.5 + 0.5 \left( \text{DERF}(X/\sqrt{2}) \right) \)

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: __Available__ Not Available __Will be Available

IX. __Software available off-the-shelf. Approximate Cost: _________
    Is__Is not__compatible with Image 100 configuration in present form
    ___Non-PDP 11/45 FORTRAN
    ___Some machine language conversion necessary
    ___In language other than FORTRAN. Specify _________
    ___Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___General purpose__ Special purpose__ Program package
   ___PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: __LACIE__ Non-LACIE
    ___Training__ Classification__ Estimation of Proportion
    ___Feature Selection__ Signature Extension
    ___Temporal Sampling__ Systems Development__ Technique Development
    ___Crop Assessment__ Yield Estimation
    ___Other (specify) ______________________________

D.3-29
I. NAME: SUBROUTINE CLSNEW

II. SOURCE (include coder/person with knowledge of program usage):
   L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV

IV. PURPOSE: Classify labeled measurement vectors using the B vector and associated decision regions previously determined by the minimization procedure.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: LFSPMC
   Description: Each measurement vector is classified by first forming its inner product with the optimal B vector and then choosing the decision region of the result. An error matrix is built to record correct/incorrect classifications.

VI. SPECIAL FEATURES: Each vector, its label, and assigned class may be output by setting appropriate option flags.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: ___ Available ___ Not Available ___ Will be Available

IX. ___ Software available off-the-shelf. Approximate Cost: ____________
   Is ___ Is not ___ compatible with Image 100 configuration in present form
   ___ Non-PDP 11/45 FORTRAN
   ___ Some machine language conversion necessary
   ___ In language other than FORTRAN. Specify ____________
   ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___ General purpose ___ Special purpose ___ Program package
   ___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: ___ LACIE ___ Non-LACIE
   ___ Training ___ Classification ___ Estimation of Proportion
   ___ Feature Selection ___ Signature Extension
   ___ Temporal Sampling ___ Systems Development ___ Technique Development
   ___ Crop Assessment ___ Yield Estimation
   ___ Other (specify) ______________

D.3-30
I. NAME: SUBROUTINE ERRMAT

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: Computes and outputs estimated confusion matrix based on the error matrix generated by the classification routine.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: LFSPMC

Description: The \( p_{ij} \) entry in the confusion matrix is the estimated probability that something in class \( j \) is classified into class \( i \).

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: \( \square \) Available  \( \square \) Not Available  \( \square \) Will be Available

IX. \( \square \) Software available off-the-shelf. Approximate Cost: 
Is\( \square \) Is not \( \square \) compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
General purpose  \( \square \) Special purpose  \( \square \) Program package
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: \( \square \) LACIE  \( \square \) Non-LACIE
Training  \( \square \) Classification  \( \square \) Estimation of Proportion
Feature Selection  \( \square \) Signature Extension
Temporal Sampling  \( \square \) Systems Development  \( \square \) Technique Development
Crop Assessment  \( \square \) Yield Estimation
Other (specify) 

D.3-31
I. NAME: SUBROUTINE RANCLN

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marlon

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: Generate and classify random vectors according to original class statistics to estimate probability of misclassification in the original feature space

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: LFSPMC

Description: Mean vector and covariance matrix for each class are used to produce random n-dimensional vectors. Each such vector is classified (Bayesian classifier) and a confusion matrix is estimated.

VI. SPECIAL FEATURES: Variable dimensioned

VII. SUBROUTINES REQUIRED: MCHLSK, GAUSS

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ___________
Is _ Is not x compatible with Image 100 configuration in present form
___ Non-PDP 11/45 FORTRAN
___ Some machine language conversion necessary
___ In language other than FORTRAN. Specify _________________________
___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
_x General purpose _ Special purpose _ Program package
_x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
___ Training x Classification x Estimation of Proportion
_x Feature Selection _ Signature Extension
___ Temporal Sampling __ Systems Development __ Technique Development
___ Crop Assessment _ Yield Estimation
___ Other (specify) ____________________________________________

D.3-32
I. NAME: SUBROUTINE MCHLSK

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: Compute the modified Cholesky decomposition of the covariance matrix.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Description: Uses a modified method of Cholesky to decompose a positive definite symmetric matrix into upper and lower triangular matrices.

VI. SPECIAL FEATURES: The decompositions overlay the elements of the original matrix.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available __Not Available __Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________________
Is x Is not compatible with Image 100 configuration in present form
____ Non-PDP 11/45 FORTRAN
____ Some machine language conversion necessary
____ In language other than FORTRAN. Specify __________________
____ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
x General purpose __Special purpose __Program package
x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
____ Training x Classification x Estimation of Proportion
____ Feature Selection __Signature Extension
____ Temporal Sampling __Systems Development __Technique Development
____ Crop Assessment __Yield Estimation
____ Other (specify) _______________________________________

D.3-33
I. NAME: SUBROUTINE GAUSS

II. SOURCE (include coder/person with knowledge of program usage):
L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/65

IV. PURPOSE: Compute a normally distributed random number of mean zero and covariance one.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Description: Twelve uniformly distributed random numbers on the interval 0 to 1 are added, giving a random number approximately normally distributed about 0; then 0 is subtracted, giving the desired result.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: RANDU

VIII. DOCUMENTATION: x Available __Not Available __ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: ___________
Is__ Is not x compatible with Image 100 configuration in present form
___ Non-PDP 11/45 FORTRAN
___ Some machine language conversion necessary
___ In language other than FORTRAN. Specify __________
___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
x General purpose __ Special purpose __ Program package
x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
___ Training x Classification __ Estimation of Proportion
___ Feature Selection __ Signature Extension
___ Temporal Sampling __ Systems Development __ Technique Development
___ Crop Assessment __ Yield Estimation
___ Other (specify) ________________________________

D.3-34
I. NAME: SUBROUTINE RANDU

II. SOURCE (include coder/person with knowledge of program usage):
    L.F. Guseman, Jr. / Bruce Marion

III. PROGRAMMING LANGUAGE: FORTRAN IV    COMPUTER: IBM 360/65

IV. PURPOSE: Compute a uniformly distributed random number between zero
    and one.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: System/360 Scientific Subroutine Package, Version III,
5th Edition, Form GH20-0205-4, International Business Machines,
August, 1970.
Description:

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: _x_ Available _ Not Available _ Will be Available

IX. _x_ Software available off-the-shelf. Approximate Cost: __________

   Is___ Is not _x_ compatible with Image 100 configuration in present form

   ___ Non-PDP 11/45 FORTRAN

   ___ Some machine language conversion necessary

   ___ In language other than FORTRAN. Specify ______________________

   ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

   _x_ General purpose _ Special purpose _ Program package

   __ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _x_ LACIE _x_ Non-LACIE

   ___ Training ___ Classification ___ Estimation of Proportion

   ___ Feature Selection ___ Signature Extension

   ___ Temporal Sampling ___ Systems Development ___ Technique Development

   ___ Crop Assessment ___ Yield Estimation

   ___ Other (specify) ________________________________

D.3-35
I. NAME: CANONICAL

II. SOURCE (include coder/person with knowledge of program usage):
Walter Eppler

III. PROGRAMMING LANGUAGE: FORTRAN
COMPUTER: IBM 360/75

IV. PURPOSE: To classify multispectral data.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See next page

Description: See next page

VI. SPECIAL FEATURES: See next page

VII. SUBROUTINES REQUIRED: None

VIII. DOCUMENTATION: _Available_ _Not Available_ _Will be Available_

IX. _xSoftware available off-the-shelf. Approximate Cost: _0_________
Is _xIs not__ compatible with Image 100 configuration in present form
_xNon-PDP 11/45 FORTRAN
_Some machine language conversion necessary
_In language other than FORTRAN. Specify ________________________
_Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
_xGeneral purpose_ _Special purpose_ _Program package
_xPDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE_ _Non-LACIE_ _Training_ _Classification_ _Estimation of Proportion
_xFeature Selection_ _Signature Extension
_xTemporal Sampling_ _Systems Development_ _Technique Development
_xCrop Assessment_ _Yield Estimation
_xOther (specify) __________________________

D.3.36
1. Introduction

The well-known classification rule based on the maximum-likelihood criterion and assumed normal probability density functions involves evaluating quadratic forms in the case of $M$ classes. Sometimes a linear transformation is performed on the original $N$ measurements to form $N \times N$ measurements for use in evaluating the quadratic forms resulting in a reduction in computation time. The disadvantages of this approach are:

1. Additional computer time is required to perform the linear transformations.
2. It is inevitable that some (usually small but unknown) class separability is lost in the dimensionality-reduction.

The algorithm described in this paper has the advantage that it uses only as many channels as necessary to make the desired discriminations; if necessary, all channels are used and no information is sacrificed. Classification speed is achieved by using first those channels which are most important for discrimination. The paper describes how the proper order is determined; the derivation has obvious application in the general area of channel-selection. Empirical results are presented to show the optimum channel-order and resulting increase in classification speed in typical applications.
D. PATTERN RECOGNITION LIBRARY

4. ESTIMATION OF PROPORTION PACKAGE

A package which estimates proportions by using maximum likelihood, method of moments, estimated confusion matrix, and classification is being documented by Dr. Bill Coberly (currently at the University of Houston).
I. NAME: SUBROUTINE APREST -- ESTIMATION OF PROPORTION PACKAGE

II. SOURCE (include coder/person with knowledge of program usage):
L. F. Guseman, Jr./Bruce Marion, Department of Mathematics, TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: 360/65

IV. PURPOSE: To estimate the proportion of each of \( m \) classes from a set of random observation vectors.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Description: Given a classification procedure, its associated confusion matrix, and a set of random observation vectors selected from among \( m \) classes, the vector of proportions for the classes is estimated.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: LSI, AWNW

VIII. DOCUMENTATION: \( x \) Available  \( x \) Not Available  \( x \) Will be Available

IX. \( x \) Software available off-the-shelf. Approximate Cost: __________
Is \( x \) is not compatible with Image 100 configuration in present form
___ Non-PDP 11/45 FORTRAN
___ Some machine language conversion necessary
___ In language other than FORTRAN. Specify __________________________
___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___ General purpose \( x \) Special purpose \( x \) Program package
___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: \( x \) LACIE \( x \) Non-LACIE
___ Training  Classification \( x \) Estimation of Proportion
___ Feature Selection  Signature Extension
___ Temporal Sampling  Systems Development \( x \) Technique Development
___ Crop Assessment  Yield Estimation
___ Other (specify) ______________________________________________________

D.4-2
I. **NAME:** SUBROUTINE LSI

II. **SOURCE** (include coder/person with knowledge of program usage):
L. F. Guseman, Jr./Bruce P. Marion, Dept. Math., TAMU

III. **PROGRAMMING LANGUAGE:** FORTRAN IV
**COMPUTER:** 360/65

IV. **PURPOSE:** To solve the least squares problem with inequality constraints (LSI):
\[ \text{minimize } \|Ex - u\| \text{ subject to } x \geq 0, \sum x_i = 1 \]

V. **ALGORITHM/TECHNIQUE** (short description; include reference if available)

Description: Converts LSI into least distance problem (LDP).

VI. **SPECIAL FEATURES:** Checks for singular E (assumed square).

VII. **SUBROUTINES REQUIRED:** SVDM, LDP

VIII. **DOCUMENTATION:**
- Available
- Not Available
- Will be Available

IX. Software available off-the-shelf. Approximate Cost: -?
- Is not compatible with Image 100 configuration in present form
- Non-PDP 11/45 FORTRAN
- Some machine language conversion necessary
- In language other than FORTRAN. Specify
- Software must be designed and developed for Image 100

X. **IMPLEMENTATION LEVEL**
- General purpose
- Special purpose Program package
- PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. **APPLICATION:**
- LACIE
- Non-LACIE
- Training
- Classification
- Estimation of Proportion
- Feature Selection
- Signature Extension
- Temporal Sampling
- Systems Development
- Technique Development
- Crop Assessment
- Yield Estimation
- Other (specify)

D.4-3
I. NAME: SUBROUTINE SVDM

II. SOURCE (include coder/person with knowledge of program usage):
G. H. Golub, Computer Science Dept., Stanford Univ., Stanford, Ca. 94305

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: 1108, 360/65, CDC6600
ALGOL 60

IV. PURPOSE: Singular value decomposition of rectangular matrix

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Description:
Decompose a given matrix A into matrices U, S, V such that
A = U * S * V^T

VI. SPECIAL FEATURES:
Modification of SUBROUTINE DSVD.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available  Not Available  Will be Available

IX. x Software available off-the-shelf. Approximate Cost: -?

Is x Is not _compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify _____________________________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
x General purpose  Special purpose  Program package
x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE  x Non-LACIE
Training  x Classification  x Estimation of Proportion
x Feature Selection  x Signature Extension
Temporal Sampling  Systems Development  x Technique Development
Crop Assessment  x Yield Estimation
Other (specify) ________________________________

D.4.4
I. NAME: SUBROUTINE LDP

II. SOURCE (include coder/person with knowledge of program usage):
L. F. Guseman, Jr./Bruce D. Marion, Dept. of Math., TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: 360/65

IV. PURPOSE: To solve the least distance problem (LDP): minimize $||g||$
subject to $Ag > w$

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See LSI

Description: Converts LDP into nonnegative least squares problem (NNLS).

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: NNLS

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. Software available off-the-shelf. Approximate Cost: --?
Is x Is not compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify ____________________________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
General purpose _ Special purpose _ Program package
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE x Non-LACIE
Training _ Classification _ Estimation of Proportion
Feature Selection _ Signature Extension
Temporal Sampling _ Systems Development _ Technique Development
Crop Assessment _ Yield Estimation
Other (specify) ____________________________________________

D.4-5
I. NAME: SUBROUTINE NNLS

II. SOURCE (include coder/person with knowledge of program usage):
L. F. Guseman, Jr./Bruce F. Marion, Dept. Math., TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV  COMPUTER: 360/65

IV. PURPOSE: To solve the nonnegative least squares problem (NNLS):
minimize $||Cz-v||$ subject to $z \geq 0$.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See LSI

Description: Given an $m \times n$ matrix $C$, and an $m$-vector $v$, compute an
$n$-vector $z$ with nonnegative entries which minimizes
$||Cz-v||$.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: H12, G1, G2, DIFF

VIII. DOCUMENTATION: _ Available__ Not Available__ Will be Available

IX. _ Software available off-the-shelf. Approximate Cost: $-?-?
Is not compatible with Image 100 configuration in present form
___ Non-PDP 11/45 FORTRAN
___ Some machine language conversion necessary
___ In language other than FORTRAN. Specify ________________
___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
___ General purpose___ Special purpose___ Program package
___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _ LACIE_ _ Non-LACIE
___ Training___ Classification___ Estimation of Proportion
___ Feature Selection___ Signature Extension
___ Temporal Sampling___ Systems Development___ Technique Development
___ Crop Assessment___ Yield Estimation
___ Other (specify) ____________________________________________

D.4-6
I. NAME: SUBROUTINE H12

II. SOURCE (include coder/person with knowledge of program usage):
L. F. Guseman, Jr./Bruce P. Marion, Dept. Math., TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: 360/65

IV. PURPOSE: Construct and apply a Householder Transformation:
\[ Q = I + U(U^T)/B \]

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference: See LSI

Description: Given \( m \)-vector \( v \) and integers \( l_p \) and \( l_1 \), computes \( m \)-vector \( u \) and \( S \) such that symmetric orthogonal matrix \( A = I + (uu^T)/(SU_1) \) satisfies \( Qv = w \).

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available _ Not Available _ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: _-$-

Is x Is not _compatible with Image 100 configuration in present form
__ Non-PDP 11/45 FORTRAN
__ Some machine language conversion necessary
__ In language other than FORTRAN. Specify ________________
__ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__ General purpose x Special purpose _ Program package
__ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE _ Non-LACIE
__ Training _ Classification _ Estimation of Proportion
__ Feature Selection _ Signature Extension
__ Temporal Sampling _ Systems Development _ Technique Development
__ Crop Assessment _ Yield Estimation
__ Other (specify) ____________________________

D.4-7
I. NAME: SUBROUTINE G1

II. SOURCE (include coder/person with knowledge of program usage):
L. F. Guseman, Jr./Bruce P. Marion, Dept. of Math., TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: 360/65

IV. PURPOSE: Construction and application of rotation matrices

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: See LSI

Description: Given $c$, $s$, $z_1$, $z_2$, computes

$$
G \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \equiv \begin{bmatrix} c & s \\ -s & c \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}
$$

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: _Available__ Not Available__ Will be Available

IX. _Software available off-the-shelf. Approximate Cost: _?-__
Is _compatible with Image 100 configuration in present form
__Non-PDP 11/45 FORTRAN
__Some machine language conversion necessary
__In language other than FORTRAN. Specify _______________________
__Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__General purpose _Special purpose__ Program package
_x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: _LACIE _Non-LACIE
__Training__ Classification _Estimation of Proportion
__Feature Selection__ Signature Extension
__Temporal Sampling__ Systems Development _Technique Development
__Crop Assessment__ Yield Estimation
__Other (specify) _______________________

D. 4-8
I. NAME: SUBROUTINE G?

II. SOURCE (include coder/person with knowledge of program usage):
   L. F. Guseman, Jr./Bruce P. Marion, Dept. Math., TAMU

III. PROGRAMMING LANGUAGE: FORTRAN IV
     COMPUTER: 360/65

IV. PURPOSE: Construction and application of rotation matrices.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: See LSI
   Description: Applies the rotation computed by G1 to \( x_1, x_2 : \)
               \[
               \begin{pmatrix}
               z_1 \\
               z_2 
               \end{pmatrix} = G
               \begin{pmatrix}
               x_1 \\
               x_2 
               \end{pmatrix}
               \]

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: x Available _Not Available_ Will be Available

IX. x Software available off-the-shelf. Approximate Cost: __________
    Is_x Is not _compatible with Image 100 configuration in present form
    _Non-PDP 11/45 FORTRAN
    _Some machine language conversion necessary
    _In language other than FORTRAN. Specify _________________
    _Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   _General purpose_ x Special purpose_ Program package
   x PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE _Non-LACIE
    _Training_ Classification _X Estimation of Proportion
    _Feature Selection_ Signature Extension
    _Temporal Sampling_ Systems Development _X Technique Development
    _Crop Assessment_ Yield Estimation
    _Other (specify) ____________________________

D.4-9
I. NAME: SUBROUTINE DIFF

II. SOURCE (include coder/person with knowledge of program usage):
   L. F. Guseman, Jr./Bruce P. Marion, Dept. Math., TAMU

III. PROGRAMMING LANGUAGE: FORTRAN
     COMPUTER: 360/65

IV. PURPOSE: To test \[ \text{IF}((x+h)-x) \neq 0 \]

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: See LSI

   Description: The intermediate sum \( z = x+h \) is computed in the calling
   program using \( n \) precision arithmetic. The difference \( z-x \)
   is computed by this function using \( n \) precision arithmetic.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: 
   x Available  Not Available  Will be Available

IX. Software available off-the-shelf. Approximate Cost: ____________
    Is x Is not compatible with Image 100 configuration in present form
     ___ Non-PDP 11/45 FORTRAN
     ___ Some machine language conversion necessary
     ___ In language other than FORTRAN. Specify ____________
     ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ___ General purpose  x Special purpose  Program package
   ___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: x LACIE  x Non-LACIE
    ___ Training  ___ Classification  x Estimation of Proportion
    ___ Feature Selection  ___ Signature Extension
    ___ Temporal Sampling  ___ Systems Development  x Technique Development
    ___ Crop Assessment  ___ Yield Estimation
    ___ Other (specify) ________________________________

D.4-10
I. NAME:  PROPORTION ESTIMATION PACKAGE

II. SOURCE (include coder/person with knowledge of program usage):
   W. A. Coberly, Dept. of Math. Sci., U. of Tulsa

III. PROGRAMMING LANGUAGE: FORTRAN IV   COMPUTER: 360/75

IV. PURPOSE:  Compute proportion estimates for use in acreage estimation.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
   Reference: "An empirical comparison of five proportion estimates,"
   Description:

VI. SPECIAL FEATURES:  Five separate driver programs

VII. TIMES REQUIRED:
   *CLASS   *MIXTUR   MINV
   Main   *MXLIKE   *MOMENT   Subroutines   PREP
   *CONF   QUADPR

VIII. DOCUMENTATION:  X Available  Not Available  Will be Available

IX. Software available off-the-shelf. Approximate Cost: ____________
   Is  Is not  compatible with Image 100 configuration in present form
   ____Non-PDP 11/45 FORTRAN
   ____Some machine language conversion necessary
   ____In language other than FORTRAN. Specify ____________
   ____Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
   ____General purpose  X Special purpose  X Program package
   ____PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION:  ____LACIE  ____Non-LACIE
   ____Training  ____Classification  ____Estimation of Proportion
   ____Feature Selection  ____Signature Extension
   ____Temporal Sampling  ____Systems Development  ____Technique Development
   ____Crop Assessment  ____Yield Estimation
   ____Other (specify) _______________________________
DATA PRODUCTS REQUIRED

1. Unlabeled (recognition) data set in intermediate format (vector by vector).
2. Test data set in above format.
3. Labeled (training) statistics.
4. Histograms of labeled data.
5. Unlabeled statistics.
6. Histograms of unlabeled data.
1. Classification estimator ($\alpha_{CL}$).

```
UNLABELED DATA
LABELED STATS

\arrow{\rightarrow}{CLASS}

\alpha_{CL}
```

2. Maximum likelihood estimate ($\alpha_{ML}$).

```
UNLABELED DATA
LABELED STATS

\arrow{\rightarrow}{CLASS}

\arrow{\downarrow}{LIKELIHOODS}

\alpha_{ML}
```

3. Odell-Chhikara confusion matrix estimate ($\alpha_{OC}$)

```
TEST DATA
LABELED STATS

\arrow{\rightarrow}{CLASS}

\arrow{\downarrow}{CONFUSION MATRIX}

\alpha_{CL}

\arrow{\rightarrow}{CONF}

\alpha_{OC}
```

D.4-13
4. Minimum Chi-square estimate ($\alpha_{\text{MX}}$)

```
\begin{center}
\begin{tikzpicture}
  \node (unlabeled_histog) at (0,0) {UNLABELED HISTOG};
  \node (labeled_histog) at (2,0) {LABELED HISTOG};
  \node (mixture) at (4,0) {MIXTUR};
  \node (alpha_mx) at (6,0) {$\alpha_{\text{MX}}$};
  \draw[->] (unlabeled_histog) -- (labeled_histog);
  \draw[->] (labeled_histog) -- (mixture);
  \draw[->] (mixture) -- (alpha_mx);
\end{tikzpicture}
\end{center}
```

5. Moment estimate ($\alpha_{\text{MO}}$)

```
\begin{center}
\begin{tikzpicture}
  \node (unlabeled_stats) at (0,0) {UNLABELED STATS};
  \node (labeled_stats) at (2,0) {LABELED STATS};
  \node (moment) at (4,0) {MOMENT};
  \node (alpha_mo) at (6,0) {$\alpha_{\text{MO}}$};
  \draw[->] (unlabeled_stats) -- (labeled_stats);
  \draw[->] (labeled_stats) -- (moment);
  \draw[->] (moment) -- (alpha_mo);
\end{tikzpicture}
\end{center}
```
I. NAME: CLASS

II. SOURCE (include coder/person with knowledge of program usage):
   W. A. Coberly, Dept. of Math., U. of Tulsa

III. PROGRAMMING LANGUAGE: FORTRAN IV  
      COMPUTER: 360/75

IV. PURPOSE: Classify observation vectors (pixels)

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

   Reference: "An empirical comparison of five proportion estimates,"
   Description: Maximum likelihood classification rule

VI. SPECIAL FEATURES: Inputs are training signatures and unlabeled data. The likelihoods may be saved on temporary disk storage.

VII. SUBROUTINES REQUIRED: MINV

VIII. DOCUMENTATION: X Available  Not Available  Will be Available

IX. X Software available off-the-shelf. Approximate Cost: ____________

   Is__ Is not__ compatible with Image 100 configuration in present form

   Non-PDP 11/45 FORTRAN

   ___ Some machine language conversion necessary
   ___ In language other than FORTRAN. Specify ____________________
   ___ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

   ___ General purpose  X Special purpose  Program package

   ___ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE  X Non-LACIE

   ___ Training  ___ Classification  ___ Estimation of Proportion
   ___ Feature Selection  ___ Signature Extension
   ___ Temporal Sampling  ___ Systems Development  ___ Technique Development
   ___ Crop Assessment  ___ Yield Estimation
   ___ Other (specify) ____________________________
I. NAME: MXLIKE

II. SOURCE (include coder/person with knowledge of program usage):
W. A. Coberly, Dept. of Math., U. of Tulsa

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/75

IV. PURPOSE: Maximum likelihood solution of proportions. (Fixed
signatures)

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: "The Numerical evaluations of maximum-likelihood
estimate of mixture proportions," Peters and Coberly
NASA/JSC Tech. Report, 1975, UTD.
Description:
Iteration scheme for finding maximum likelihood
estimates of proportions.

VI. SPECIAL FEATURES: Uses output of likelihoods for each
from CLASS, stored in a temporary disk file.

VII. SUBROUTINES REQUIRED: NONE

VIII. DOCUMENTATION: X Available__ Not Available__ Will be Available

IX. X Software available off-the-shelf. Approximate Cost:
Is___ Is not __ compatible with Image 100 configuration in present form
__ Non-PDP 11/45 FORTRAN
__ Some machine language conversion necessary
__ In language other than FORTRAN. Specify __________________
__ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
__ General purpose __ Special purpose __ Program package
__ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE __ Non-LACIE
__ Training __ Classification __ Estimation of Proportion
__ Feature Selection __ Signature Extension
__ Temporal Sampling __ Systems Development X__ Technique Development
__ Crop Assessment __ Yield Estimation
__ Other (specify) ____________________________________________

D.4-16
I. NAME: CONF

II. SOURCE (include coder/person with knowledge of program usage):
W. A. Coberly, Dept. of Math., U. of Tulsa

III. PROGRAMMING LANGUAGE: FORTRAN IV COMPUTER: IBM 360/75

IV. PURPOSE: Proportion estimation by Odell-Chhikara method using the confusion matrix.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Description: Finds constrained solution of the equation 
\[ \hat{\theta} = P\hat{\theta} \] where \( \hat{\theta} \) is the classification estimate of the proportions and \( P \) is the confusion matrix.

VI. SPECIAL FEATURES: The confusion matrix \( P \) is estimated by the classification of test data.

VII. SUBROUTINES REQUIRED: QUADPR, PREP

VIII. DOCUMENTATION: \( \checkmark \) Available \( \times \) Not Available \( \times \) Will be Available

IX. \( \checkmark \) Software available off-the-shelf. Approximate Cost: _________
Is\( \times \) Is not\( \checkmark \) compatible with Image 100 configuration in present form

- Non-PDP 11/45 FORTRAN
- Some machine language conversion necessary
- In language other than FORTRAN. Specify __________________
- Software must be designed and developed for Image 100.

X. IMPLEMENTATION LEVEL
- General purpose\( \checkmark \) Special purpose\( \times \) Program package
- PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: \( \checkmark \) LACIE \( \times \) Non-LACIE
- Training\( \checkmark \) Classification\( \times \) Estimation of Proportion
- Feature Selection\( \checkmark \) Signature Extension
- Temporal Sampling\( \checkmark \) Systems Development\( \times \) Technique Development
- Crop Assessment\( \checkmark \) Yield Estimation
- Other (specify) ___________________________________________________________________

D.4-17
I. NAME: MIXTUR

II. SOURCE (include coder/person with knowledge of program usage):
W. A. Coberly, Dept. of Math., U. of Tulsa

III. PROGRAMMING LANGUAGE: FORTRAN IV COMPUTER: IBM 360/75

IV. PURPOSE: Proportion estimation by method of minimum chi-square.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)


Description: Constrained least squares solution of system found by equating the percentiles of the marginal mixture distributions.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: QUADPR, PREP

VIII. DOCUMENTATION: X Available Not Available Will be Available

IX. X Software available off-the-shelf. Approximate Cost: __________

Is Is not compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify ________________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
General purpose X Special purpose Program package
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: XLACIE Non-LA.CIE
Training Classification X Estimation of Proportion
Feature Selection Signature Extension
Temporal Sampling Systems Development X Technique Development
Crop Assessment Yield Estimation
Other (specify) ____________________________

D.4-18
I. NAME: MOMENT

II. SOURCE (include coder/person with knowledge of program usage):
W. A. Coberly, Math. Dept, U. of Tulsa

III. PROGRAMMING LANGUAGE: FORTRAN IV    COMPUTER: IBM 360/75

IV. PURPOSE: Proportion estimation by method of moments.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)


Description: Constrained weighted least square solution of mixture moment equations.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: QUADPR, PREP

VIII. DOCUMENTATION: X Available__ Not Available__ Will be Available

IX. Software available off-the-shelf. Approximate Cost: __________

Is__ Is not__ compatible with Image 100 configuration in present form

____ Non-PDP 11/45 FORTRAN

____ Some machine language conversion necessary

____ In language other than FORTRAN. Specify _____________________

____ Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL

____ General purpose__ X Special purpose__ Program package

____ PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE__ Non-LACIE

____ Training__ Classification__ X Estimation of Proportion

____ Feature Selection__ Signature Extension

____ Temporal Sampling__ Systems Development__ X Technique Development

____ Crop Assessment__ Yield Estimation

____ Other (specify) _______________________________________

D.4-19
I. NAME: QUADPR

II. SOURCE (include coder/person with knowledge of program usage):
W. A. Coberly, Dept. of Math., U. of Tulsa

III. PROGRAMMING LANGUAGE: FORTRAN IV
COMPUTER: IBM 360/75

IV. PURPOSE: Constrained quadratic programming scheme (Wolfe)

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Description: Quadratic programming routine used to solve constrained least squares problems.

VI. SPECIAL FEATURES: Does not handle singular quadratic objective functions.

VII. SUBROUTINES REQUIRED: None

VIII. DOCUMENTATION: X Available  _ Not Available_ Will be Available

IX. X Software available off-the-shelf. Approximate Cost: ________________
Is Is not compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify _____________________________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
X General purpose_ Special purpose___Program package
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE _ Non-LACIE
Training_ Classification X Estimation of Proportion
Feature Selection_ Signature Extension
Temporal Sampling_ Systems Development_ Technique Development
Crop Assessment_ Yield Estimation
Other (specify) _______________________________________________________

D.4-20
I. NAME: PREP

II. SOURCE (include coder/person with knowledge of program usage):
    W. A. Coberly, Dept. of Math., U. of Tulsa

III. PROGRAMMING LANGUAGE: FORTRAN IV    COMPUTER: IBM 360/75

IV. PURPOSE: Prepare objective function from a system of linear equations for input to QUADPR.

V. ALGORITHM/TECHNIQUE (short description; include reference if available)

Reference:

Description: Constructs quadratic objective function for constrained least square solution by Wolfe's method.

VI. SPECIAL FEATURES:

VII. SUBROUTINES REQUIRED: NONE

VIII. DOCUMENTATION: X Available  Not Available  Will be Available

IX. Software available off-the-shelf. Approximate Cost: ____________
    Is__Is not__compatible with Image 100 configuration in present form
    __Non-PDP 11/45 FORTRAN
    __Some machine language conversion necessary
    __In language other than FORTRAN. Specify ________________
    __Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
    X General purpose__Special purpose__Program package
    __PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE__Non-LACIE
    __Training__Classification X Estimation of Proportion
    __Feature Selection__Signature Extension
    __Temporal Sampling__Systems Development__Technique Development
    __Crop Assessment__Yield Estimation
    __Other (specify) ________________________________

D.4-21
I. NAME: MINV

II. SOURCE (include coder/person with knowledge of program usage):
W. A. Coberly, Dept. of Math., U. of Tulsa

III. PROGRAMMING LANGUAGE: FORTRAN
COMPUTER: 360/75

IV. PURPOSE: Invert a matrix

V. ALGORITHM/TECHNIQUE (short description; include reference if available)
Reference: IBM SSP-III Manual
Description: An elementary Gaussian elimination routine

VI. SPECIAL FEATURES: A routine inverting only a symmetric positive-definite covariance matrix is required.

VII. SUBROUTINES REQUIRED:

VIII. DOCUMENTATION: X Available Not Available Will be Available

IX. X Software available off-the-shelf. Approximate Cost: -0-
Is Is not compatible with Image 100 configuration in present form
Non-PDP 11/45 FORTRAN
Some machine language conversion necessary
In language other than FORTRAN. Specify __________________________
Software must be designed and developed for Image 100

X. IMPLEMENTATION LEVEL
X General purpose Special purpose Program package
PDP 11/45 FORTRAN LIBRARY FUNCTION OR SUBROUTINE

XI. APPLICATION: X LACIE Non-LACIE
Training Classification X Estimation of Proportion
Feature Selection Signature Extension
Temporal Sampling Systems Development Technique Development
Crop Assessment Yield Estimation
Other (specify) __________________________

D.4-22
D. PATTERN RECOGNITION LIBRARY

5. SPATIAL PATTERN RECOGNITION PACKAGE

D.5-1
D. PATTERN RECOGNITION LIBRARY

6. SIGNATURE EXTENSION PACKAGE

A program is being developed at the University of Houston to perform signature extension using the maximum likelihood function. A similar, but more specialized, algorithm for signature extension is being implemented by LEC. A specialized version of the LEC algorithm is being studied by ERIM (MASC Algorithm). An additional signature extension technique is being developed by Dr. Ungar at GFSC (no details available).
IMPLEMENTATION PRIORITY SUMMARY

The following is a summary by package of those subroutines and programs for which identification forms have been completed. Each program was assigned one of the implementation priorities defined in Section IV and repeated below for ease of reference.

Priority I - Basic utility subroutine or program required for the implementation of existing image analysis techniques

Priority II - Existing image analysis techniques (requires majority of Priority I items)

Priority III - Subroutine or program required to support development and/or refinement of image analysis techniques

Priority IV - Image analysis techniques in research and development stage.

IAL-6
A. PRE-ANALYSIS DATA PROCESSING LIBRARY

1. PREPROCESSING PACKAGE
   GENERAL RADIOMETRIC CORRECTION (G.E.) I

2. REGISTRATION PACKAGE
   SUBROUTINE CORLAT II
   SUBROUTINE REGSTR II

3. TRAINING FIELD SELECTION PACKAGE
   IRREGULARLY-SHAPED FIELDS I
   LINE FIND ROUTINE I
   GREY SCALE MAP PACKAGE IV
   KONTUR PACKAGE IV

4. SIMULATED DATA GENERATOR PACKAGE
B. GENERAL MATHEMATICAL LIBRARY

1. LINEAR ALGEBRA PACKAGE

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<thead>
<tr>
<th>Subroutine</th>
<th>Priority</th>
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<tbody>
<tr>
<td>MINVSP</td>
<td>I</td>
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<tr>
<td>MINVDP</td>
<td>I</td>
</tr>
<tr>
<td>LU-Decomposition Package</td>
<td>I</td>
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<tr>
<td>GINV2M</td>
<td>I</td>
</tr>
<tr>
<td>CHLSKY</td>
<td>I</td>
</tr>
<tr>
<td>TSTMIS (single precision)</td>
<td>I</td>
</tr>
<tr>
<td>TSTMD (double precision)</td>
<td>I</td>
</tr>
<tr>
<td>SEIGEN</td>
<td>I</td>
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<tr>
<td>DSVD</td>
<td>I</td>
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<tr>
<td>MATMUL</td>
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<td>EIGEN</td>
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2. OPTIMIZATION PACKAGE

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<td>DFMFP</td>
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<tr>
<td>QM431</td>
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<td>LSI</td>
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3. APPROXIMATION PACKAGE

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<tr>
<td>Basic Spline Routines--Single Variable</td>
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4. TRANSFORM PACKAGE

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<tr>
<td>(MSFAR) Multispectral Fourier Analysis Routines</td>
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C. GENERAL STATISTICAL LIBRARY

1. STATISTICAL SUMMARY PACKAGE

   SUBROUTINE MECOV
   SUBROUTINE GROP1
   SUBROUTINE MEDIAN
   SUBROUTINE MODE
   SUBROUTINE RANGE
   SUBROUTINE MNDEV
   SUBROUTINE SDEV
   SUBROUTINE ORDER
   PLOT PAC
   BINARY SEARCH/N-DIMENSION HISTOGRAM ACQUISITION (G.E.)

2. DENSITIES & DISTRIBUTIONS PACKAGE

   FUNCTION PHINV (P)
   DOUBLE PRECISION FUNCTION DPHI
   REAL FUNCTION FISH
   DOUBLE PRECISION FUNCTION DERF
   SINGLE PRECISION FUNCTION ERF
   DOUBLE PRECISION FUNCTION DERFC
   SINGLE PRECISION FUNCTION ERFC
   REAL FUNCTION CHI2
   FUNCTION EXPAN
   REAL FUNCTION POSI
   FUNCTION FISHIN
   REAL FUNCTION BIN
   FUNCTION HYTRIC
   REAL FUNCTION BETINC
   REAL FUNCTION GAMIN
   REAL FUNCTION STUDIN
   REAL FUNCTION ZOT
   FUNCTION RANDOM
   REAL FUNCTION ZIP
   REAL FUNCTION ZARF
   FUNCTION KPSNSM
   SUBROUTINE BIN2
   SUBROUTINE OVERFL(I)

3. REGRESSION PACKAGE

4. STATISTICAL TESTS

   SUBROUTINE TTEST
   SUBROUTINE COVARI
   SUBROUTINE ANOV1
   SUBROUTINE ANOVA2
   SUBROUTINE RBANOV
   FUNCTION ZOR
   SUBROUTINE KOLSMR
   SUBROUTINE FACTOR

IP-3
<table>
<thead>
<tr>
<th>PROGRAM</th>
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<td>D. PATTERN RECOGNITION LIBRARY</td>
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<td>1. CLUSTERING PACKAGE</td>
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<tr>
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<tr>
<td>UH Linear Feature Selection</td>
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<td>LF MC : Linear Feature Selection (PMC)</td>
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<td>4. ESTIMATION OF PROPORTION PACKAGE</td>
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<td>5. SPATIAL PATTERN RECOGNITION PACKAGE</td>
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<tr>
<td>6. SIGNATURE EXTENSION PACKAGE</td>
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