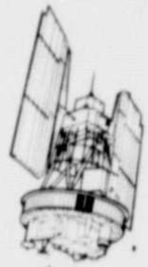
NASA CR-147873 JSC-11376

DETECTION AND MAPPING PACKAGE



77-10100

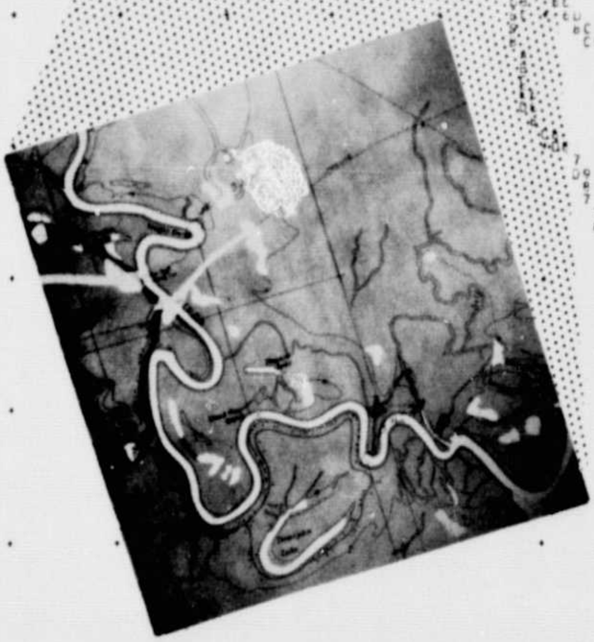
"Made available under NASA sponsorship in the interest of early and wide dissemination of Earth Resources Survey Program information and without liability for any use made thereof."

VOLUME 1: GENERAL PROCEDURE

(E77-10100) DETECTION AND MAPPING (DAM) PACKAGE. VOLUME 1: GENERAL PROCEDURE Final Report, Jan. - Jun. 1976 (Lockheed Electronics Co.) 28 p HC A03/MF A01 CSCL 08H G3/43

N77-18516

Unclas 00100



JUNE 1976

NASA

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center

Houston, Texas 77058

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle DETECTION AND MAPPING (DAM) PACKAGE Volume 1: General Procedure		5. Report Date June 1976 6. Performing Organization Code
7. Author(s) Edward H. Schlosser M. L. Brown		8. Performing Organization Report No. LEC-8663 10. Work Unit No.
9. Performing Organization Name and Address Lockheed Electronics Company, Inc. Aerospace Systems Division 16811 El Camino Real Houston, Texas 77058		11. Contract or Grant No. NAS 9-12200 13. Type of Report and Period Covered Final, Jan. – June 1976
12. Sponsoring Agency Name and Address A. W. Patteson Earth Observations Division Lyndon B. Johnson Space Center, Houston, Texas 77058		14. Sponsoring Agency Code

15. Supplementary Notes
Software available from: COSMIC
University of Georgia
112 Barrow Hall
Athens, Georgia 30602

16. Abstract
The DAM package is an integrated set of manual procedures, computer programs, and graphic devices designed for efficient production of precisely registered and formatted maps from digital Landsat multispectral scanner (MSS) data. The software can be readily implemented on any Univac 1100 series computer with standard peripheral equipment. This version of the software includes pre-defined spectral limits for use in classifying and mapping surface water.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Computer programs, Earth resources, Earth satellites, land use, Landsat satellites, mapping, remote sensors, surface water, thematic mapping	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified		

*For sale by the National Technical Information Service, Springfield, Virginia 22161

JSC Form 1424 (Rev Nov 75) NASA — JSC

PREFACE

Multispectral scanners onboard NASA unmanned Landsat satellites provide an ideal source of current data for Earth resources applications. The Detection and Mapping (DAM) package was originally developed at the Johnson Space Center for rapid conversion of the Landsat digital data into hydrographic maps matching standard topographic quadrangle series. Recent improvements in both the manual procedures and computer programs within the DAM package make it easier to use, faster, and more general purpose.

Documentation and software for the DAM package are available to all public and private agencies, in accordance with the NASA policy of encouraging maximum use of remote sensing technology.

Published documentation, of which this is volume 1, is comprised of the following volumes:

Volume 1: General Procedure

Volume 2: Software User Manual (in two parts)

Volume 3: Control Network Establishment

These volumes supersede the previous documentation published in 1973. Software releases prior to version 7602 cannot be used with the current documentation.

PREFACE

Multispectral scanners onboard NASA unmanned Landsat satellites provide an ideal source of current data for Earth resources applications. The Detection and Mapping (DAM) package was originally developed at the Johnson Space Center for rapid conversion of the Landsat digital data into hydrographic maps matching standard topographic quadrangle series. Recent improvements in both the manual procedures and computer programs within the DAM package make it easier to use, faster, and more general purpose.

Documentation and software for the DAM package are available to all public and private agencies, in accordance with the NASA policy of encouraging maximum use of remote sensing technology.

Published documentation, of which this is volume 1, is comprised of the following volumes:

Volume 1: General Procedure

Volume 2: Software User Manual (in two parts)

Volume 3: Control Network Establishment

These volumes supersede the previous documentation published in 1973. Software releases prior to version 7602 cannot be used with the current documentation.

JSC - 11376

DETECTION AND MAPPING PACKAGE

VOLUME 1: GENERAL PROCEDURE

APPROVED BY

A. W. Patteson
Chief, Exploratory Investigations Branch

R. B. MacDonald
Chief, Earth Observations Division

EARTH OBSERVATIONS DIVISION
SCIENCE AND APPLICATIONS DIRECTORATE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

June 1976

CONTENTS

FIGURES

ACRONYMS

CCT	computer-compatible tape
DAM	Detection and Mapping package
GMT	Greenwich mean time
JSC	Lyndon B. Johnson Space Center
MSS	multispectral scanner
Pixel	picture element
RMS	root mean square
USGS	United States Geological Survey
UTM	Universal Transverse Mercator

ACRONYMS

CCT	computer-compatible tape
DAM	Detection and Mapping package
GMT	Greenwich mean time
JSC	Lyndon B. Johnson Space Center
MSS	multispectral scanner
Pixel	picture element
RMS	root mean square
USGS	United States Geological Survey
UTM	Universal Transverse Mercator

1. INTRODUCTION

The Detection and Mapping (DAM) package is an integrated set of computer programs, manual procedures, and graphic devices designed for efficient production of maps from digital Land Satellite (Landsat) multispectral scanner (MSS) data.

1.1 LANDSAT MULTISPECTRAL SCANNER

The Landsat Earth resources satellites circle the Earth in near-polar, Sun-synchronous orbits. During each southbound (daylight) pass the MSS onboard produces digital images of the Earth's surface radiance in the following spectral bands:

MSS channel	Spectral band	Wavelength (micrometers)
1	4 (green)	0.5 – 0.6
2	5 (red)	0.6 – 0.7
3	6 (near IR)	0.7 – 0.8
4	7 (near IR)	0.8 – 1.1

Each image or scene covers a nearly square area approximately 185 kilometers (100 nautical miles) on a side. These scenes are available in digital form on computer-compatible tape (CCT) and in pictorial form as prints and film transparencies.

1.2 USE OF THE DAM PACKAGE

Figure 1 illustrates the five general steps required to produce maps from digital data for a Landsat scene. These steps are discussed more fully in the subsequent sections of this volume.

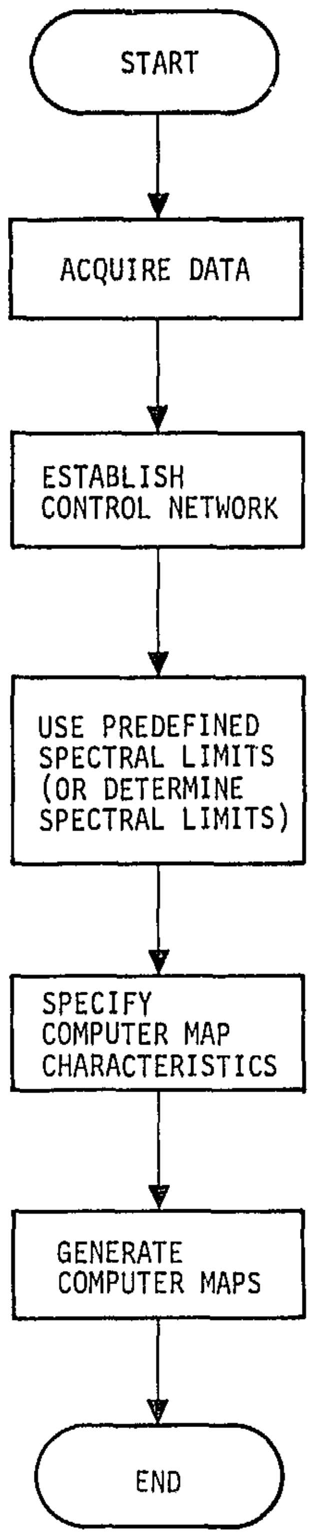


Figure 1.— General flow chart.

2. ACQUIRE DATA

Each Landsat passes over any given area of the Earth once every 18 days. Thus, surface features in a selected region could potentially be recorded 20 times in one year. This section discusses the process of selecting and acquiring the Landsat data and ancillary data most suitable for a user's application.

2.1 CRITERIA

The surface radiance of a feature on the Earth, as recorded by the four MSS channels on each Landsat pass, depends on the incident Sun illumination and on the surface materials present in the feature. Given constant illumination, the four MSS channels will record a different set of radiance values for each different surface material viewed.

To ensure maximum reliability in the classification of Landsat MSS data, the following factors should be considered in selecting scenes.

a. Cloud cover — Clouds mask the Earth's surface both from Sun illumination and from the MSS. Therefore, scenes with clouds over the area of interest should not be selected. In perennially cloudy regions, no scene may be totally cloud free, and different portions of several scenes at different dates must be selected to achieve the required coverage.

b. Data quality — Occasionally, hardware malfunctions impair the data quality. Scenes with poor image quality in any of the MSS channels should not be selected.

c. Sun elevation — Low Sun elevation angles decrease available illumination and increase the incidence and extent of terrain shadows. Scenes with Sun angles less than 30 degrees occur during the winter and should be avoided if possible.

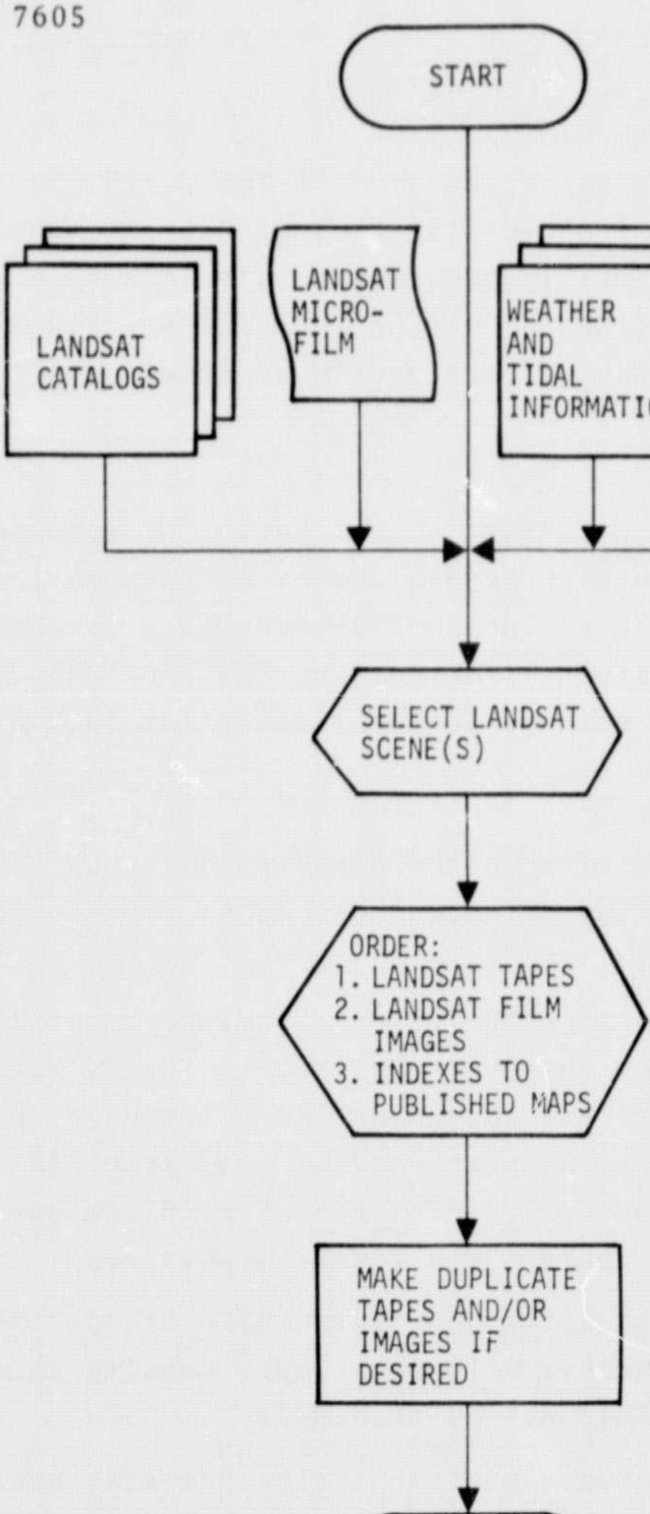


Figure 2.— Acquire data.

d. Precipitation — Unusually wet or dry weather conditions, prior to the date of a Landsat pass, will affect the extent and condition of water bodies and vegetation.

e. Seasonal changes — These affect the extent and condition of water, ice, snow, and vegetation.

f. Tides — Although the Landsats are Sun-synchronous, the Moon is not. Therefore, when selecting data for coastal areas, tidal stages and their effects on the land/water interface should be considered.

Materials required for evaluating the above factors include Landsat catalogs; Landsat microfilm; and climatic, weather, and tidal information.

2.2 LANDSAT DATA

Once the appropriate scenes have been selected, Landsat data in the following forms should be ordered:

a. System-corrected MSS digital data on CCT (density dependent on user tape drives).

b. Positive film transparencies at a nominal scale of 1:1,000,000 for all four MSS channels.

Both computer tapes and film images are subject to deterioration. If data from the same scene are to be used several times, duplicate copies should be made.

2.3 CONVENTIONAL MAPS

Computer-generated maps produced by the DAM package will normally be used in conjunction with conventional maps to provide comparative or complementary information. In addition, conventional maps are required to measure the Earth coordinates of control points used in registering the computer-generated maps (see section 3). Maps for measuring control point coordinates, if not already available, should be ordered as soon as potential control points have been selected.

3. ESTABLISH CONTROL NETWORK

Landsat MSS data are recorded in a dynamic, scanner-oriented coordinate system. To produce useful maps, the data must be corrected for orbital characteristics and scanner geometry and then transformed into a conventional Earth-based coordinate system. This process is termed registration. The necessary registration parameters are derived from a network of control points for which both scanner-oriented and Earth-oriented coordinates have been measured precisely.

The DAM package requires one network of 6 to 18 control points to register each Landsat scene. The process of selecting and validating the points in this network is organized as follows:

a. Select potential control points from 1:1,000,000-scale Landsat film imagery.

b. Measure the approximate scanner coordinates of each point from film images with special MSS scales.

c. Generate computer displays of MSS data in the vicinity of the estimated scanner coordinates for each point.

d. Correlate, visually, each control point as shown on the computer-generated display with its representation on a map.

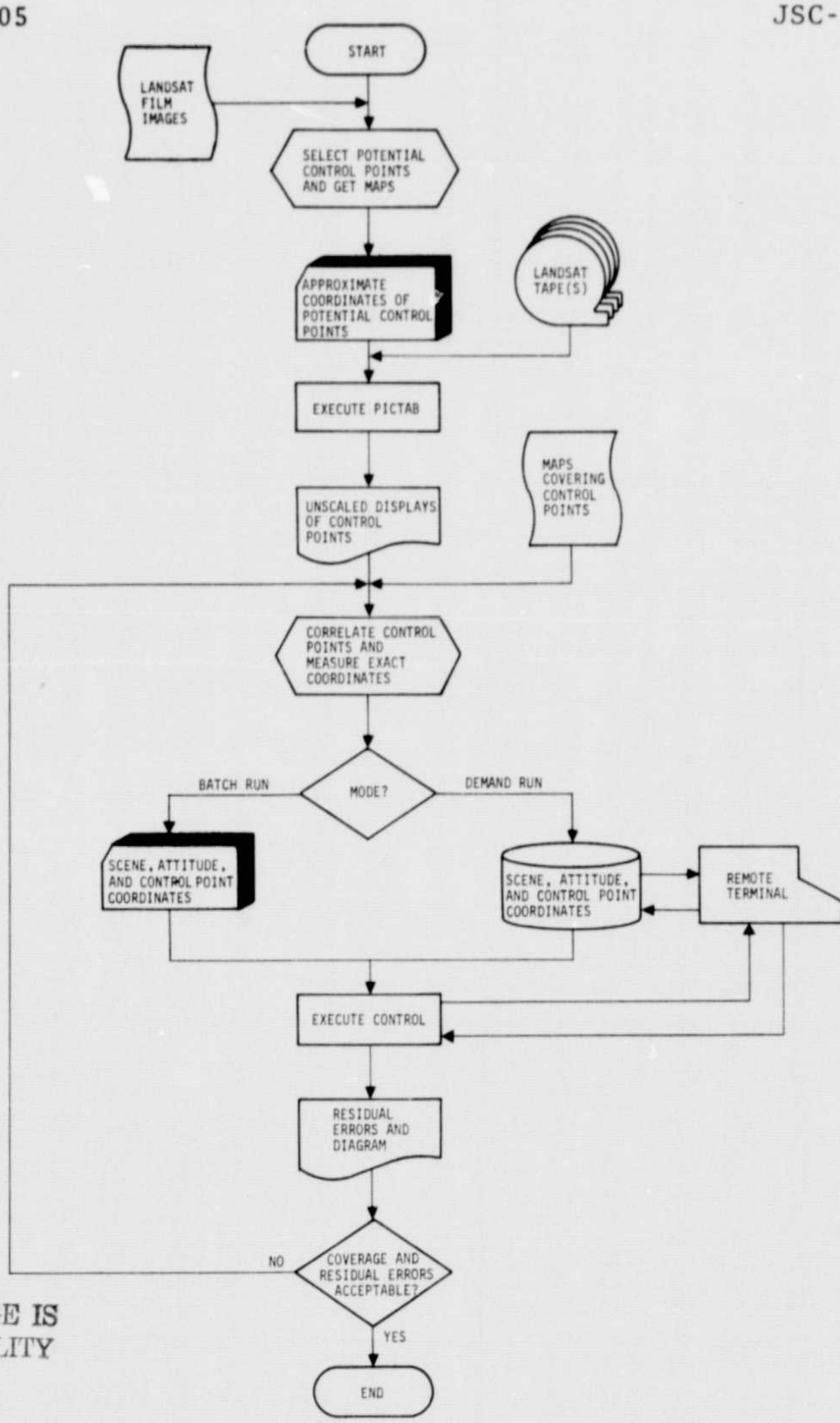
e. Measure the exact scanner coordinates of each point from the computer-generated display.

f. Measure the exact Earth coordinates of each point from the map.

g. Perform computer adjustment of network and evaluate residual errors.

h. Correct coordinates for any points with unacceptable residual errors and then re-adjust the network.

The flow chart in figure 3 summarizes this process of establishing a control network. For a detailed explanation of the process, see volume 3.



ORIGINAL PAGE IS OF POOR QUALITY

Figure 3.— Establish control network.

4. DETERMINE SPECTRAL LIMITS

The CLASSIFY program requires a set of spectral limits which defines the reflectance characteristics in the Landsat channels of the material to be detected and mapped.

4.1 WATER

Predefined spectral limits for water are stored in the symbolic element DAM.WATER-LIM (see volume 2). When utilizing these spectral limits, all picture elements (pixels) representing water, regardless of turbidity, will be classified as water. Pixels at the edges of water bodies, representing mixtures of water and other materials, will not be classified as water. Based on the 79- by 79-meter instantaneous field-of-view of the Landsat MSS, water bodies with least dimensions less than 79 meters usually will not be identified; those with least dimensions between 79 and 168 meters may be identified; and those over 168 meters generally will be identified. Test evaluations indicate that virtually all water bodies greater than 4 hectares (10 acres) correspond to 3 or more contiguous pixels identified as water.

4.2 OTHER MATERIALS

Not yet implemented.

Figure 4.— (Reserved for future use.)

5. SPECIFY COMPUTER MAP CHARACTERISTICS

Each Landsat scene covers almost 35,000 square kilometers. Hundreds of conventional maps, in a variety of scales and formats, ranging from 7.5-minute quadrangles (150 square kilometers) to 1°-by-2° sheets (10,000 square kilometers), may be required to cover this area.

In most applications, computer-generated maps from Landsat data will be compared with conventional maps or used to update them. It is important that the computer-generated maps be at the same scales as the conventional maps and be formatted to conform with the same sheet boundaries and tick intervals.

The flow chart in figure 5 illustrates the manual process of determining map characteristics and punching their specifications on cards. Employing simple, English-like commands,[1] the user specifies (individually or by map series) the characteristics for as many as 999 maps within one Landsat scene. These commands are punched on cards. The output of this manual process is a deck of cards used as input to the computer programs which generate the maps.

The remainder of this section discusses the considerations involved in specifying the various map characteristics.

5.1 COPIES

The same number of copies (normally one) of every map will be produced. As many as five copies may be specified.

---

[1] See volume 2 for the exact form of these commands.

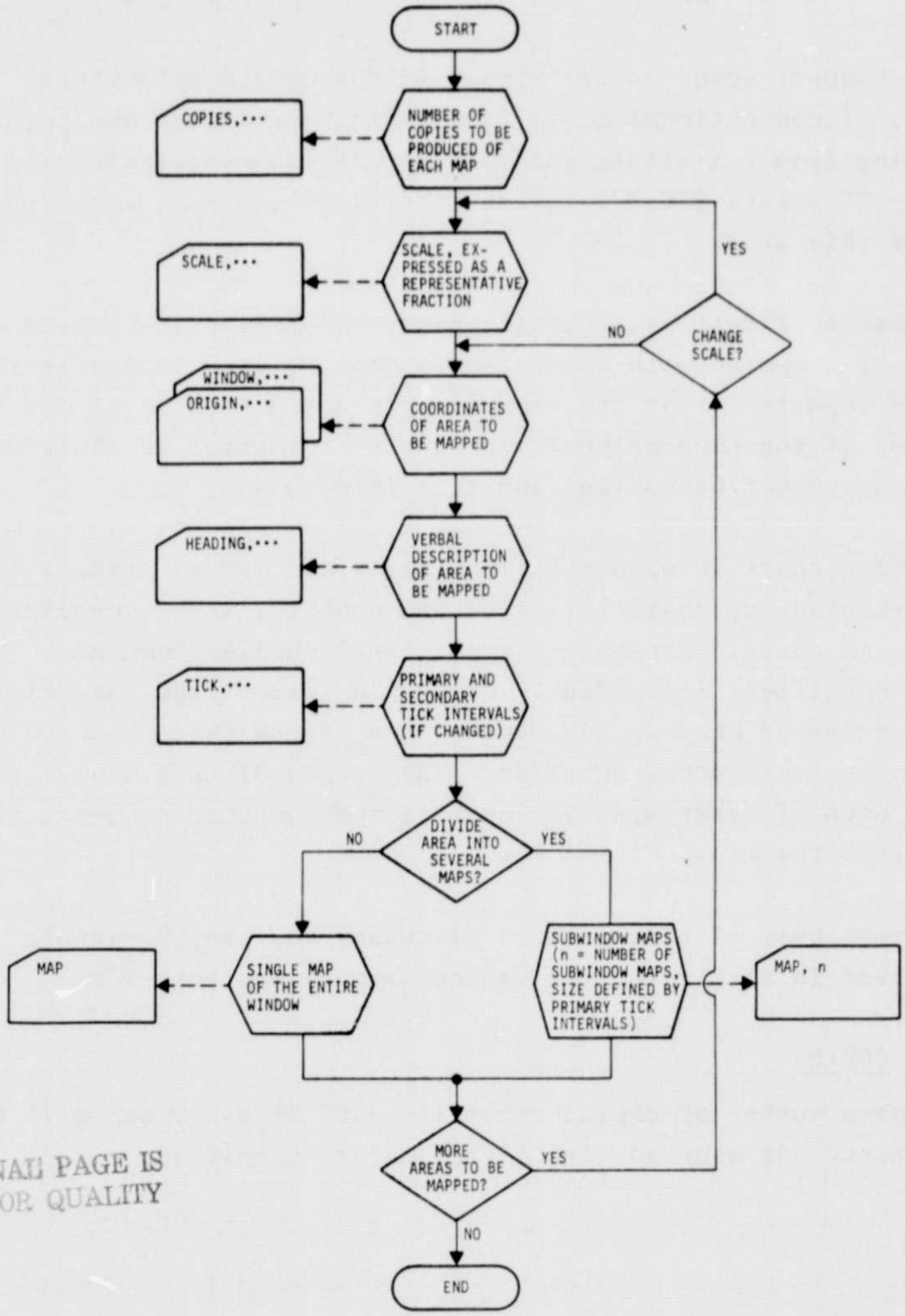


Figure 5.— Specify computer map characteristics.

5.2 SCALE

Once specified, the map scale remains the same until changed. This makes it convenient (although not mandatory) to group the maps by scale. Any scale between 1:20,000 and 1:260,000 may be specified.

5.3 AREA TO BE MAPPED

Two characteristics define the area to be mapped: a window of specified size (usually rectangular) and the coordinates of its origin (in North America, usually the latitude and longitude of its southeast corner). Once specified, the window size remains the same until changed.

This makes it convenient to group areas by window size. Then, all areas with a given scale and window size differ only in their origin coordinates.

5.4 HEADING

Once specified, the heading remains the same until changed. This heading is printed at the top of each map. Names of the corresponding conventional map sheets are normally used for headings.

5.5 TICK INTERVALS

The coordinate intervals for both the primary and secondary ticks must be specified. (The programs will generate ticks at all locations whose coordinates are exact multiples of these intervals.) When matching the format of conventional maps, primary ticks should correspond to the map corners and secondary ticks to the interior ticks. Once specified, tick intervals remain the same until changed.

5.6 NUMBER AND FORMAT OF MAPS

The area to be mapped and its characteristics have been defined above. This area may be covered with a single map or alternatively, divided into a series of separate maps each covering a part of the area (a subwindow). Subwindow maps, if specified, are the size of the current primary tick intervals and contain one primary tick at each corner. This subwindow capability makes it especially easy to generate a series of maps in standard quadrangle sheet format covering all or part of a scene. However, all of these subwindow maps will contain the same heading.

5.7 OTHER CHARACTERISTICS

The process (fig. 5) should be repeated until specifications for all desired maps have been produced and punched on cards.

Maps may be generated on either a line printer or a pen plotter. See the descriptions of PRTCLASS and PLTCLASS in volume 2 for complete information on available commands and map characteristics.

6. GENERATE COMPUTER MAPS

The flow chart in figure 6 summarizes the computer processing required to generate maps. This processing occurs in a single computer run (typically batch, see volume 2).

User input to this processing is comprised of control network (on cards or disk), Landsat MSS digital data (on tape), classification specifications (on cards), and computer map characteristics (on cards).

6.1 COMPUTER PROCESSING

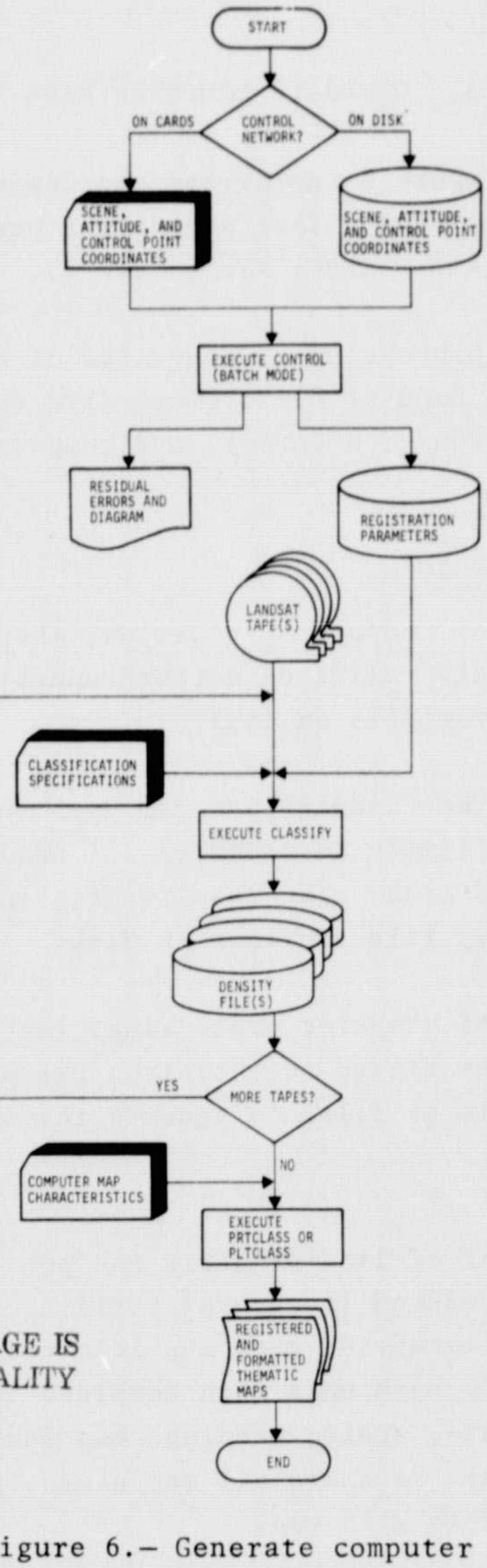
In the first stage of computer processing, the CONTROL program adjusts the previously validated network and stores the resulting registration parameters on disk.

In the next stage, the CLASSIFY program uses the previously determined spectral limits to classify all Landsat data lying within the specified area. The results of this processing are stored in the density file or files on disk.

In the final stage of computer processing, the PRTCLASS or PLTCLASS program uses stored registration parameters and data from the density file or files to produce the specified maps.

6.2 MAP ASSEMBLY

The size restrictions of line printers and pen plotters dictate that most maps be produced in several sections or units. The programs automatically divide each map into the required number of units and identify each unit with complete information on scene, processing date, scale, heading, map number, and unit number. The user must separate all map units, group them by map, trim them, and assemble each map.



ORIGINAL PAGE IS OF POOR QUALITY

Figure 6.— Generate computer maps.

6.3 MAP INTERPRETATION

Each map includes a symbol legend and a table which lists the scanner coordinates, geographic coordinates, Universal Transverse Mercator (UTM) coordinates, and output coordinates for each tick. Primary ticks are always plotted in their correct positions on the map. However, secondary ticks are plotted only if they do not conflict with other symbols. Omitted secondary ticks may be reconstructed from their coordinates as given in the tick table.

Computer-generated maps are most readily compared with conventional maps by overlaying them on a light table. Areas within the Landsat scene that were covered by clouds or cloud shadows should be delineated since the classification in these areas will not be correct. In regions with steep terrain, shadows cast by the terrain will also cause classification problems. Such areas may be located from the contour spacing and orientation shown on the conventional maps.

7. RESOURCES REQUIRED

The DAM package is designed for both occasional and production use by personnel without extensive computer training.

7.1 EQUIPMENT

No specialized computer hardware or offline equipment is required. The DAM software will run on any Univac 1100 series, Exec-8 computer system. Other equipment required includes a light table for overlaying maps, a tube magnifier (10X) for inspecting Landsat film transparencies, DAM package graphic devices (see volume 3), and a keypunch.

7.2 COSTS

Each Landsat scene covers an area equivalent to approximately 250 quadrangle maps of the U.S. Geological Survey (USGS) 7.5-minute series. Total charges to generate 250 classified, registered, and formatted maps for one Landsat scene are typically:

a. Computer time: 2.5 standard unit of processing (SUP)[1] hours at $150 to $300 per hour

b. Manpower: 7 man-days

7.3 IMPLEMENTATION

All software is furnished in both source form and machine code on computer tape, together with complete implementation instructions. Implementation on any Exec-8 computer system typically requires less than one day's work by a systems analyst familiar with local installation standards.

[1]SUP — a Univac composite measure of system usage, including the central processing unit (CPU), input/output devices, etc.

User training is brief, typically one or two days. Beginning users execute all programs from an interactive terminal, guided by conversational features in the [illegible] software. Once proficiency is achieved, most programs are exec[illegible] in batch.