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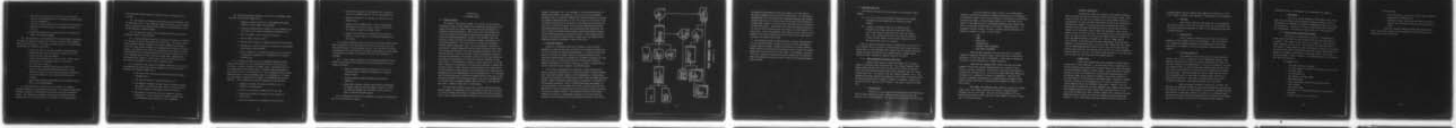
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**RADC-TR-79-179, Vol IV (of five)
Final Technical Report
September 1979**

**AUTOMATED AIR INFORMATION
PRODUCTION SYSTEM, PHASE I
Charting Subsystem**

Synectics Corporation

J. Late
A. DiPasqua

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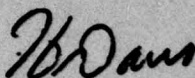
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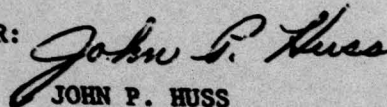
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report details developmental efforts in providing the initial phase of a fully automated Air Information Production System (AAIPS) for the Defense Mapping Agency Aerospace Center. The system is used to produce DOD Flight Information Publications (FLIPS); Navigation/Planning and Special Purpose Charts; Special Products; and the Automated Air Facility Information File. The requirements, functional design and operational considerations of the AAIPS Charting, Air Facilities, and Publishing Subsystems are presented. The principal purpose of the three subsystems is the reduction of the labor (Cont'd)		

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(manual) required for the revision and publication of information critical to flight operations and logistical planning. Improvement of response time between receipt of changes to air navigation/air facilities data and the dissemination of new data to all users, is also provided. The Publishing Subsystem permits publications to be produced on electronic equipment and extends the power and flexibility of digital manipulation to the updating and reformatting of publications. The Air Facilities Subsystem provides maintenance of the AAFIF data bases, selective data base retrieval, special report generation and generation of formatted tape files for film negative output. The Charting Subsystem provides capture, revision and output of graphic data appearing throughout the DMAAC Flight Information Publications, through preservation of data in digital form and providing techniques to simplify alteration of the data.

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TABLE OF CONTENTS

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
I	INTRODUCTION	1-1
1.0	Background	1-1
1.1	Purpose	1-1
II	CHARTING SUBSYSTEM FUNCTIONAL REQUIREMENTS	2-1
2.0	Capacity and Capabilities	2-1
III	SUBSYSTEM DESIGN	3-1
3.0	Design Criteria	3-1
3.1	Structure Overview	3-2
3.2	Subsystem Data Base	3-5
3.2.1	Digitizing/Editing Station Disk Files	3-5
3.2.2	Electron Beam Recorder Tape Library	3-9
3.3	Subsystem Personnel Functions	3-11
3.3.1	Aeronautical Information Analyst - (ADD)	3-11
3.3.2	Production Control Supervisors	3-12
3.3.3	Equipment Room Supervisors	3-13
3.3.4	Charting Subsystem Compilers	3-14
3.3.5	AAIPS Data Librarian	3-15
3.4	Subsystem Software	3-16
3.4.1	Interactive Graphic Software	3-16
3.4.2	EBR Drive Tape Creation Software	3-21
3.4.3	Chart/Publishing Data Merge Software	3-22
IV	OPERATIONAL CONSIDERATIONS	4-1
4.0	General	4-1
4.1	Development Phases	4-1
4.2	Production Phase	4-2
V	CONCLUSIONS AND RECOMMENDATIONS	5-1
5.0	General	5-1

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
5.1	Volume Capacity	5-1
5.2	Revision Time	5-2
5.3	Output Device	5-2
5.4	Recommendations	5-3

LIST OF FIGURES

<u>FIGURE NO.</u>	<u>TITLE</u>	<u>PAGE</u>
2-1	FLIP PRODUCTION WORKLOAD	2-2
2-2	CHARTING SUBSYSTEM FUNCTIONS	2-3
3-1	FLIP PRODUCT FLOW	3-3

SECTION I

INTRODUCTION

1.0 Background

The Charting Subsystem of the Automated Air Information Production System (AAIPS) is tasked with the capture, revision and output of graphic data appearing throughout the DMAAC Flight Information Publications (FLIP's). A Pilot system was implemented to demonstrate the proper handling of 1/15 (or better) of the annual production workload up to the point of final film negatives ready for the creation of production press plates.

1.1 Purpose

The principal purpose of all three subsystems of AAIPS is the reduction of the labor required (by manual methods) for the revision and republication of information critical to flight operations and logistical planning, in view of the anticipated growth both of types and volumes of information. A by-product of that reduction of labor is the improvement of response time between receipt of changes to air navigation/air facilities data and the dissemination of the new data to all users. For the Charting subsystem graphic data, the labor saving was achieved primarily by the preservation of data in digital form, which is more amenable to alteration than hard-copy paper or film form, and providing techniques to effect that alteration. Furthermore, establishing a digital data base provides a foundation for future direct electronic transmission of data to users, reducing the time for dissemination to virtually zero. This type of dissemination would be more appropriate for textual information than for graphics, however.

SECTION II

CHARTING SUBSYSTEM FUNCTIONAL REQUIREMENTS

2.0 Capacity and Capabilities

The Charting Subsystem is designed to be capable of handling the FLIP production workload as summarized in Figure No. 2-1. The Charting Subsystem supports the creation and maintenance of a FLIP graphic data base, which is exploited to generate the FLIP products called for in the Data Volume Summary (Annex I) of the SOW. Further, the Charting Subsystem accepts data from the Publishing and Air Facilities Subsystems, merges charting data with textual data from the Publishing Subsystem, and generates final film negatives that are ready for production through the Charting output device (EBR). The basic functionality of the Charting Subsystem is depicted in Figure No. 2-2.

In the Charting Subsystem, the following capabilities are available:

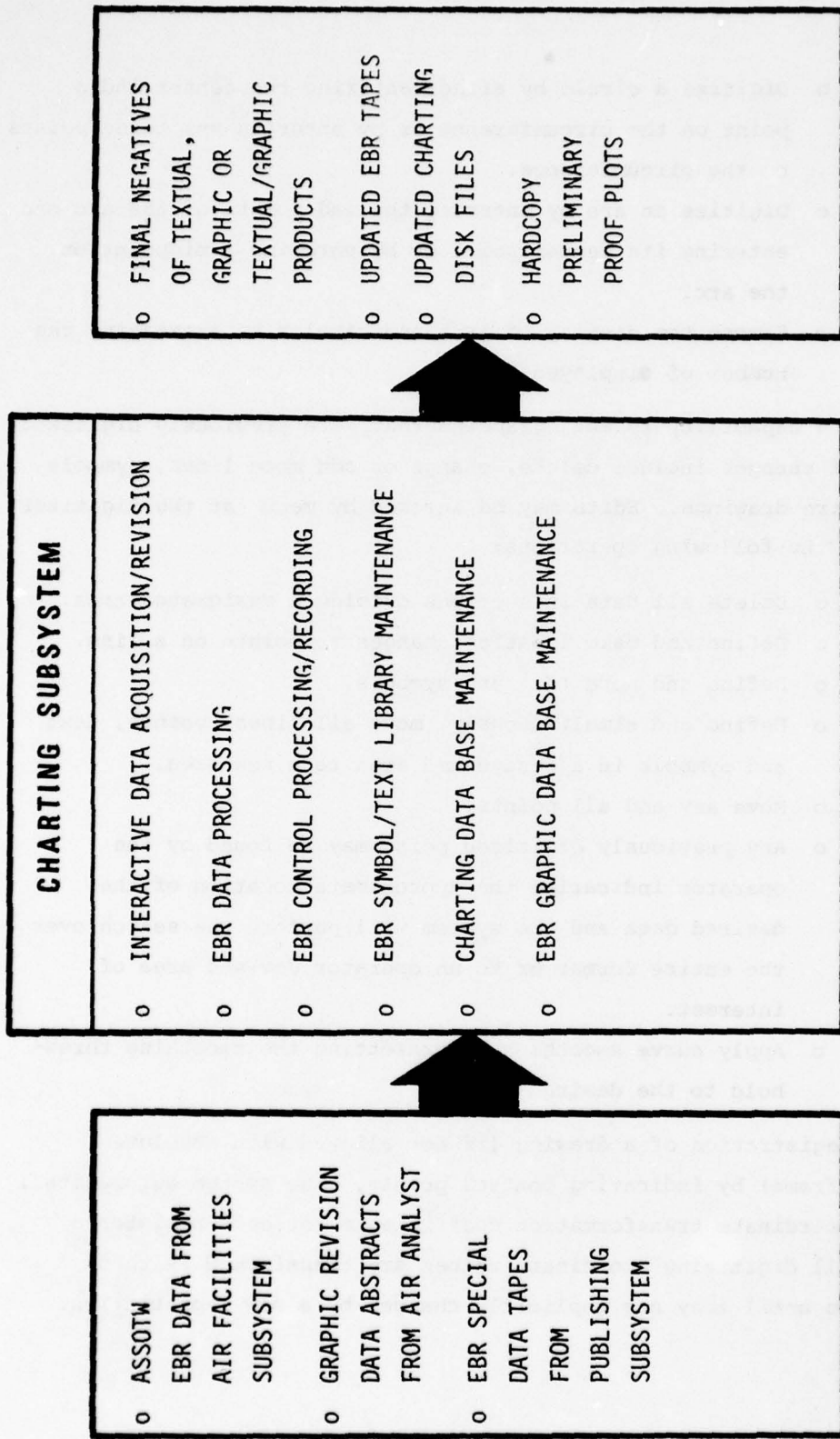
- (1) A digitization capability that will permit a smooth finished quality graphic to be produced from a rough hand drawn sketch. An operator may perform the following operations:
 - o Define a single line between two points at a scale determined by the operator.
 - o Trace free form lines while the system records the line points.
 - o Construct lines, arcs and circles as dots, dashes or solid lines.
 - o Designate one or multiple straight line segments by digitizing only the end points.
 - o Intermix straight line segments and trace data to define a complete feature.
 - o Digitize a rectangle by entering the diagonally opposite corners.

PRODUCT TYPE	NO. OF GRAPHICS	ANNUAL PUBLICATION CYCLES	ANNUAL ISSUES (NO. X CYCLES)	ANNUAL REVISION VOL. (ESTIMATED)	1/15 ANNUAL REVISION VOL. (ESTIMATED)
ENROUTE HI & LOW ALTITUDE	82	13	1066	800	53
TERMINAL	530	13	6890	1630	109
IAP'S HI & LOW ALTITUDE	2675	7	18725	4500	300
SID'S	1260	7*	8830*	1500	100
U. S. VFR SUPPLEMENT CHARTLETS	1725	2	3450	300	20
ENROUTE SUPPLEMENT CHARTLETS	420	7	2940	200	13
PLANNING CHARTS	100	13	1300	700	47
AREA AND GENERAL PLANNING	210	13	2730	30	2

FLIP PRODUCTION WORKLOAD

FIGURE 2-1

*Annual publication cycles vary with the area of the world; seven has been assumed as an average.



CHARTING SUBSYSTEM FUNCTIONS

Figure No. 2-2

- o Digitize a circle by either entering the center and a point on the circumference or by entering any three points on the circumference.
- o Digitize an arc by entering the end points of the arc and entering its center point or by entering a midpoint on the arc.
- o Smooth the display of arcs and circles by increasing the number of displayed points.

(2) The capability to edit graphics that were previously digitized. The types of changes include delete, change or add more lines, symbols, text or entire drawings. Edits may be invoked by menu at the digitizer and include the following operations:

- o Delete all data in sections outside a designated area.
- o Define and make location changes to points on a line.
- o Define and move text and symbols.
- o Define and simultaneously move all lines, points, text and symbols in a designated area to a new area.
- o Move any and all points.
- o Any previously digitized point may be found by the operator indicating the approximate location of the desired data and the system will perform the search over the entire format or to an operator devised area of interest.
- o Apply curve smoothing by presetting the smoothing threshold to the desired value.

(3) Registration of a drawing (if not aligned with absolute coordinate frame) by indicating control points. The system automatically generates coordinate transformation coefficients for each registered drawing. All digitizing coordinate values are transformed by these coefficients until they are implicitly changed by a new registration.

The coordinate transformations correct for scale, translation and rotation.

(4) The ability to digitize the drawing origin if different from the digitizer origin. The coordinate frame for all data in the drawing file is relative to the drawing origin rather than the absolute origin and the absolute coordinate frame.

(5) The ability to select the recording resolution by allowing different levels of grid spacing.

(6) A graphic display capability to permit the operator to display the contents of either the drawing or scratch file. The current image of the original drawing remains on the screen (despite new changes) until the erase control mechanism is activated which clears the display screen. The operator may select any rectangular area within the registered drawing file by cursor pointing and the area is brought into view on the display scaled to span the whole screen area. Alternatively, the operator may indicate a single point and the neighborhood of the point will be displayed on the screen at drawing scale.

(7) An efficient text entry and placement capability by utilizing the digitizer for positioning and the keyboard for text entry which includes the following capabilities:

- o The size of the text may be varied explicitly through a keyboard entry.
- o The text string may be rotated through $\pm 360^{\circ}$.
- o For symbols containing variable text, the system requests the operator to enter the text, which is then positioned within the symbol at the proper relative position.
- o The display of text over the whole screen is operator selectable. The text display is disabled automatically if the drawing scale renders the text unreadable.

(8) Efficient symbology creation, selection and placement which includes the following capabilities:

- o Support a symbol file of up to 500 symbols and permit selection of any symbol for placement.
- o Digitize finished quality symbols for the operator's own user symbol file without disturbing the drawing file.
- o Vary the symbol scale by operator selection.
- o Rotate symbol through $\pm 360^{\circ}$.
- o Generate mirror images of symbols about the vertical axis.
- o Provide five levels of nesting for creation of new symbols which contain other symbols.
- o Allow a symbol to be repeated between any two points and/or along area boundaries or circumferences of circles automatically.

(9) A flexible and efficient file management mechanism which permits the operator to have simultaneous access to three files at all times: drawing, scratch, and symbol files. The drawing file is the repository for the drawing that is currently being manipulated. The scratch file is the repository for a new or temporary symbol, while permitting data in the main drawing file to be undisturbed. A symbol file can contain a maximum of 500 symbols (300 standard and 200 user symbols). The following file handling capabilities are provided:

- o Segregate drawings into layers (subfiles) up to a maximum of 32 separations.
- o Select a new drawing or symbol file at any time.
- o Selectively display the contents of the drawing or scratch file.
- o Clear the contents of the drawing or scratch file.

- o Convert the contents of the drawing file or scratch file into a symbol and store it into the symbol file.
- o Retrieve a symbol to the drawing or scratch file for modification.
- o Generate on the hardcopy unit a list of coordinates and status of all arcs, lines, circles and text for the drawing, scratch and symbol files.
- o Permit a new drawing to be digitized while another drawing is being output to the Charting Subsystem output device.

(10) Output processing that can search the Charting Subsystem data base at product cut off time and retrieve only those files that have been revised since the last product cut off. For each chart retrieved, a hardcopy printout consisting of the chart identification, total number of revisions, and number of revisions for each color separation is provided.

(11) A final output capability via the Charting Subsystem output device which produces final composite ready-for-production film negatives as follows:

- o Accepts formatted magnetic tape data files from the Publishing and Air Facilities Subsystems to produce textual output.
- o Produces graphic output prepared by the Charting Subsystem.
- o Merges data from the Charting and Publishing Subsystems to produce combined text and graphic outputs, in which the text and graphics may be either side by side on a page or entirely separate pages.

(12) A restricted access log-on procedure to assure only authorized use of the digitization stations.

SECTION III
SUBSYSTEM DESIGN

3.0 Design Criteria

The primary, controlling precept in the design of the Charting Subsystem was that it must support the acquisition, modification, and output of any and all graphic image data occurring throughout the spectrum of FLIP publications. While many of the FLIP products are or can be treated as pure graphics (and therefore handled entirely within the Charting Subsystem), several of the document types are primarily textual and must be processed by special techniques in the Publishing Subsystem. This situation then created the additional Charting design requirement that a data and procedural interface be established to merge components from two widely dissimilar data bases. The solution derived was to have the Publishing Subsystem be the controlling process, calling for graphic inserts (previously created by Charting and residing in the Charting data base in EBR tape format) to be merged with Publishing text which has also been converted to EBR tape format. The possibility of adding a second tape drive to the EBR PDP-11 controller and modifying the controlling software to combine the two data sources in real time was rejected because of the difficulties of maintaining the proper sequence and synchronization of data from two subsystems which act independently until data-merge time. In the method used, Charting data may be retrieved randomly from the disk unit so that the order dictated by the Publishing tape at run time is accomplished. In the event that a requested graphic does not exist in the Charting data base, a default "empty box" is substituted.

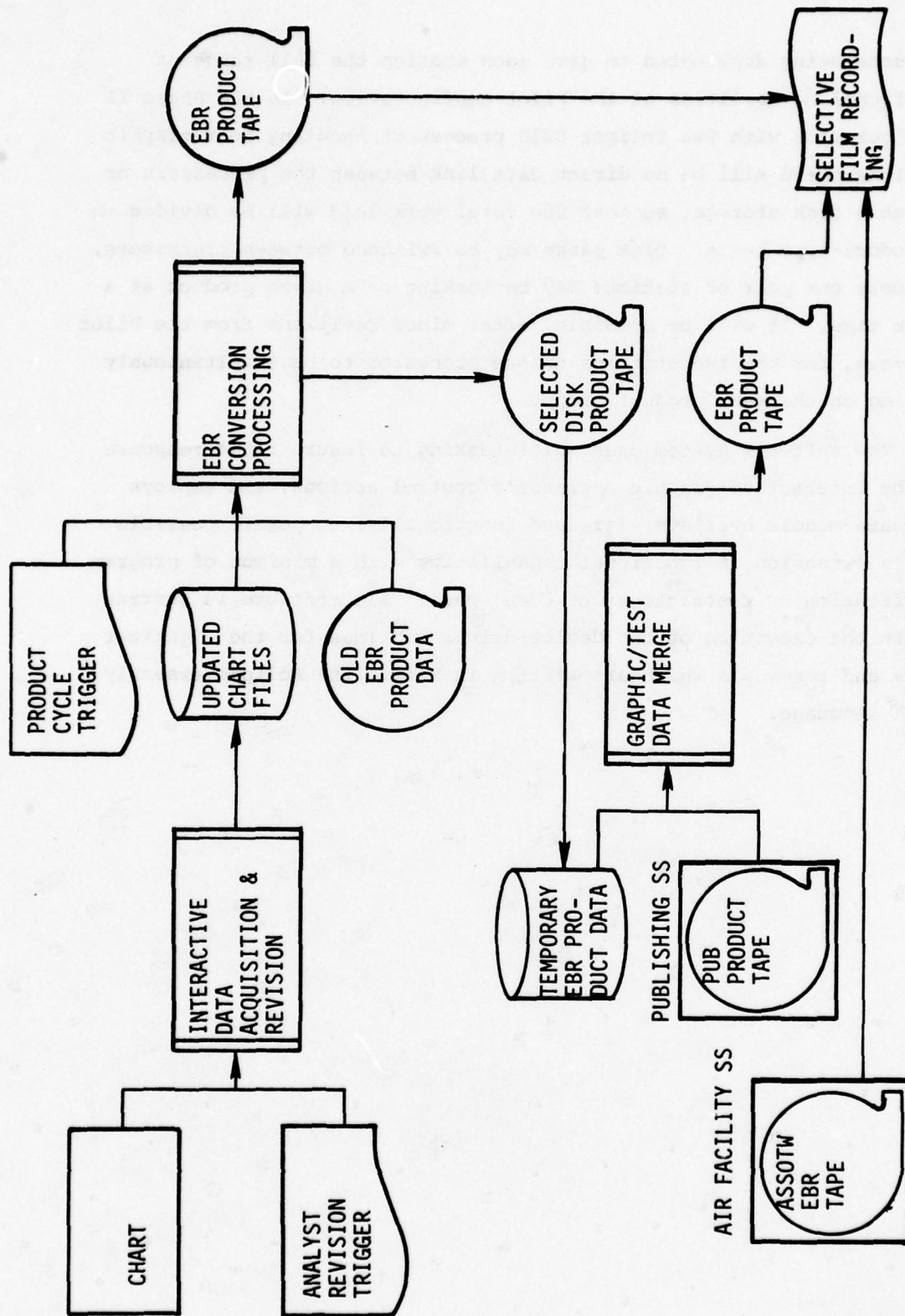
The second major design criteria was that the Charting Subsystem must be capable of supporting the full production work load (see figure 2-1) with a minimum replication of hardware (beyond the Pilot configuration) while supporting subsidiary processes with any system resources

(memory, disk space, etc.) not required by the principal function of graphic data capture and revision. Also, execution of subsidiary processes must not noticeably degrade the principal function by causing the graphic-compiler/operator to wait for service any more than if the subsidiary function was not executing. This design goal was only partially met in the Pilot system; of the two main subsidiary processes, Charting/Publishing Data Merge and Charting-EBR Data Conversion, the latter cannot be executed during graphic acquisition/editing because the core memory required is slightly too high. This problem will be solved in the Phase II effort both by adding more core memory and by modifying software techniques to require less core.

3.1 Structure Overview

Figure 3-1 illustrates functional structure of the Charting Subsystem in terms of data flow and depicts the points-of-contact with the Air Facilities and Publishing Subsystems. It should be noted that there is no direct or formal interaction between Charting and Air Facilities except through an Aeronautical Information Analyst; the link shown in figure 3-1 only implies that the Electron Beam Recorder, commonly considered to be part of Charting, is used to produce one of the Air Facilities output products, the ASSOTW report.

In the Pilot configuration of Charting, a single graphic work station consisting essentially of a digitizing table, a display screen, and a hard copy terminal operates in the Foreground of a Data General Eclipse S230 processor with 64K words of memory under the MRDOS operating system. While interactive graphic work is in progress, the system can do Background processing, such as Charting/Publishing Data Merge, or utility processes, such as backup file saves, providing not more than 28K words of core are required and do not involve the product directory in use at the graphic station. The software system for the graphic station was designed to accommodate expansion to two work stations operating in the Foreground with most subroutine modules being shared



FLIP PRODUCT FLOW

Figure No. 3-1

and some being duplicated to give each station the full range of functional capabilities of the Pilot configuration. In the Phase II configuration with two Eclipse S230 processors handling four graphic stations there will be no direct data link between the processors or sharable disk storage, so that the total work load will be divided on a product-type basis. Disk packs may be switched between processors, but only one pair of stations may be working on a given product at a given time. It will be possible, after minor revisions from the Pilot software, for the two stations on one processor to be simultaneously working on the same product group.

The software system uses multi-tasking to insure rapid response to the interactive-graphic operator's control actions, and employs software module overlays (grouped functionally) to permit possible future extension of functional capabilities with a minimum of program modification or restrictions of core space. All software is Fortran V with the exception of two device-driver routines for the digitizer table and terminals which are written in Macro, the Eclipse assembly-level language.

3.2 Subsystem Data Base

The Charting Subsystem Data Base exists in two distinct forms, namely:

- (a) the set of files on disk packs containing chart imagery or supporting the acquisition or revision of chart imagery
- (b) a library of magnetic tapes in the Electron Beam Recorder drive format containing chart data current to the last previous publication date for each product type. This library exists solely to avoid re-conversion of data (to EBR format) which has not changed since the last publication cycle of a product.

Only the general structure and use of these files will be given in this document since the details on record formats and content are discussed fully in the Programmer User's Manual for the Charting Subsystem. Except as noted, all disk files are random access, variable-length logical records, accessed by physical block of 512 bytes.

3.2.1 Digitizing/Editing Station Disk Files

Physical disk space is logically divided into a variable number of sub-areas known as directories. The primary directory (DZ0) holds several utility files which are used for all types of products, while the sub-directories each contain files pertaining only to a single product type (e.g., low enroute, high IAP, general planning, etc.). The subsystem structure supports the addition of any number of sub-directories and each sub-directory can expand or contract as required, limited only by the total disk capacity of 192 M Bytes. The types of data files used are:

o Drawing Files

These are random access files located within sub-directories, each of which comprises a single graphic entity such as one SID, one chartlet for the VFR Supplement, one side of an enroute chart and so forth.

The first physical record (Block 0) is a fixed-length parameter record which maintains information pertaining to the digitization/editing process (chart origin coordinates, registration co-efficients, selected line weight, selected symbol number, etc.) such that a work session on the drawing may be interrupted temporarily and resumed later with all conditions established by the operator remaining intact. All subsequent records (Blocks 1 through n) contain logical descriptors of features, variable in length, in six classes:

- PATH
- AREA
- FIXED TEXT
- VARIABLE TEXT
- STANDARD SYMBOL REFERENCE
- USER SYMBOL REFERENCE

PATH and AREA (boundary) data are both lineal in nature, composed of absolute coordinate points, vector strings, or arc/circle specifiers, all of which may be intermixed. Vector data is generally acquired by tracing features of a complex character.

FIXED TEXT and VARIABLE TEXT (latter used only with USER SYMBOLS) record types specify characteristics of a string of text: Position, angular orientation, justification (horizontal and vertical), color/screen, and Font style. In the Pilot system four font styles are available, but a maximum of 254 may be accommodated. Multiple-line strings are handled automatically by stepping along the normal to the base-line angle each time a carriage-return character is found in the text string.

USER SYMBOL and STANDARD SYMBOL reference records are similar except that a User Symbol reference may contain a Standard Symbol reference but not vice versa. Both call for the placement of a pre-defined "mini-drawing" within the final (film) image at a point, along a path, or filling an area.

o Revision Index Files

One Revision Index file exists in each product directory. They are random access files, blocked 32 words per logical record. Each record contains the name of one drawing file in the product directory, a single-word "bit map" of which color/screen groups in the drawing have been edited or added to since the last previous publication cycle, a cumulative time (minutes) expended creating or editing the particular drawing, and a cumulative count of revisions performed. Also, if the drawing is not one which has been newly created since the last publication date, the logical record also carries the magnetic tape reel number (on which the EBR-format data is stored) and a list of "image numbers" (file numbers) of the various color/screen separations within the tape. Whenever a new publication cycle is run, the reel number and image number list is updated appropriately and all bits in the C/S bit map word are cleared indicating that the archival tape contains the latest information. Further editing of any part of a drawing again sets bits in this word such that the next run will re-process the changed portions.

o Symbol Files

These files reside within the sub-directory USYMB and are collections of "mini-drawings" in the same data format as described for the main drawing files except that the first block is an index correlating a particular symbol number to a disk address. Their purpose for standard symbols is solely the displaying of an approximate representation of a pre-defined image on the operator's terminal, since later creation of the film image on the EBR uses only the symbol number (stored in a symbol reference record in the main drawing file) to access a library of precision images stored on the EBR/PDP-11 disk units. However, since the operator has the capability to create compound "user symbols" incorporating both standard symbols and other linework for repetitive recall, he is also given the ability to create personal symbol files (stored in the same USYMB directory) to retain such work for subsequent editing/digitizing sessions. In the Pilot AAIPS system each symbol file may contain 300

standard symbols and 200 compound user symbols, and there is no limit on the number of symbol files residing in USYMB except total disk space.

- o Log File

This file is used only for logging on to the subsystem and gaining access to files, not for identifying any link between data files and a particular operator or group, or for establishing any sort of system security.

- o Message File

This is simply an external list of most of the error messages and help prompts used in the subsystem. Use of an external file instead of embedding messages within subroutines allows easy modification of formats and use of any message by multiple program modules.

- o Grid Area Index File

To accommodate rapid editing access to any particular feature, this file is a tabulation of disk address for feature lines passing through each of 10080 grid areas (120 columns x 84 rows, one half inch spacing in both dimensions). The file is blocked at 15 words per logical record, to allow 7 block/word address pairs for each grid area, plus an overflow link in case more than 7 features pass through any grid square. Overflow records are also 15 words long, so that a grid containing parts of more than 14 features would overflow to a third record and so on. Typically, few grids contain more than 7 features and therefore, each usually requires only one block.

When an operator initiates a search for a feature (for editing) the coordinate location of the cursor establishes the grid area and therefore the chain of index blocks to be used for candidate features. Each feature is examined in detail for a match to a color/layer mask and search tolerance (distance) established by the operator; any feature meeting these criteria are listed on the station Dasher terminal

(parameters and x, y coordinates) until aborted by the operator.

o Font Files

Similar in use and structure to the symbol files, these font files exist only for the digitizer operator's display terminal presentation of alphanumeric strings in approximate proper size, style, and orientation. A total of 254 font or symbol files may be employed by the subsystem. Each font file may contain up to 128 characters.

3.2.2 Electron Beam Recorder Tape Library

This library is maintained to avoid the reprocessing of graphic data which has not been altered since the last publication of a product. Each graphic entity which is to appear on a separate film image comprises one tape file. All records in the file are fixed at 2048 words in length except the last, which may be as short as necessary. The first three words of each record are control words identifying image number (file number), page number (a selectable subset of an image), and record number (within the page). The remaining words in each record fall into two categories:

✓ Command words

- Set beam intensity (64 steps)
- Set line weight (6 microns to 6138 microns, 1023 steps)
- Set font number
- Set character size
- Set character (string) angle
- Enter ASCII mode
- Enter Incremental Vector Plot mode (not used in Pilot system)
- Enter Vector mode
- Set Point x & y (Move with beam off to new absolute position)
- Relative move x & y (with beam on)

✓ Data strings

- ASCII characters, two per word, output under conditions established by command words.
- Incremental Vector steps, four per word, six micron steps in eight possible directions (not used in Pilot system)

Note that standard symbols are ASCII characters within Font 1 in the Pilot system, and that additional symbol fonts may be established if the need arises.

3.3 Subsystem Personnel Functions

This section describes possible AAIPS personnel roles and lines of responsibility for the production environment, as applicable to the Charting Subsystem. It is apparent that some personnel changes will be necessary and, in fact, some have already been accomplished. It is important to note that the personnel roles that are created to operate AAIPS will not change the current lines of responsibility and authority within the AD organization. The ultimate source of authority and responsibility over the correctness of the FLIP products and accuracy of the AAFIF information will rest entirely with the Aeronautical Information Specialist in ADD. The function of AAIPS personnel is to operate the equipment and execute the automated production procedures to support the Air Analyst's mission.

3.3.1 Aeronautical Information Analyst - (ADD)

The Air Analyst will perform his job in the automated production environment in the same way that he did before AAIPS existed. He is still totally responsible for the accuracy of information for the products generated within his geographical area of interest. As such, he will perform the final quality control check on all products prior to distribution and printing. He will continue to evaluate all source information and determine whether or when product changes are necessary. He will also manually maintain Air Intelligence Source Records for each airfield in his geographical area. An automated record of all AAFIF airfield changes organized chronologically for his area of interest will be provided during Phase II. This file, together with the cross reference list of all FLIP products effected by changes to airfields will help the Air Analyst to more easily determine and keep track of what FLIP products are to be revised and when data abstracts should be issued. He will continue to authorize changes and submit data abstracts and rough graphic sketches to the AAIPS production group in order to cause product changes to take place.

ADA forms will no longer be necessary to fill out, because all FLIP publication revisions (text and graphic) will be performed in-house.

3.3.2 Production Control Supervisors

Production control supervisors will be required to manage the work performed in each of the AAIPS subsystems areas. They will provide the primary interface between the Air Analysts in ADD and the production personnel in the AAIPS environment. As such all change requests would be routed to the production control managers from ADD.

Organizationally, they will belong to the Automated Division (ADA) and will comprise the management backbone of the AAIPS environment. They will perform the basic line management functions necessary for their respective subsystem areas. They will assign production tasks to the equipment users in their groups. They will plan, allocate and monitor the production activity in their area of specialty. Establishment of correct procedures, training and consulting, intermediate proofing of products, and making critical decisions with regard to the production process fall within the domain of the AAIPS production control supervisor. The number of production control supervisors required will depend upon the strategy for organizing the production control teams. For instance, teams could be organized according to a particular type of product. One team would maintain all Enroute Supplements, another would maintain all IAP's, etc. An alternative would be to organize the teams according to geographical areas as the air analysts are organized in ADD. All publications covering a certain area of the world would be the responsibility of the associated AAIPS Production team.

3.3.3 Equipment Room Supervisors

The role of the equipment room supervisor is to assure smooth operating conditions exist at all times in the AAIPS facility for the production users. It is important to note that the equipment room supervisor is entirely divorced from any direct responsibility for the production activity, which falls within the domain of the production control supervisor. The equipment room supervisor, on the other hand, is more attuned to the actual performance of the system and utilization of its resources. He is responsible for ordering supplies and spare parts; scheduling preventive maintenance for the equipment; monitoring the computer environment for the detection of hardware failures; ordering corrective maintenance as required; attending to the needs of general computer operations such as cleaning tape drives, formatting disk packs, changing line printer ribbons, etc. When conflicts over the unavailability of terminals or stations arise, the equipment room supervisors will arbitrate solutions based on production priorities and otherwise maintain order within the AAIPS facility.

In the total AAIPS production environment at least two equipment room supervisors will be needed; one for the Air Facilities and Publishing Subsystems area and the other for the Charting Subsystem and EBR area. The equipment room supervisor in the Air Facilities area will have an additional responsibility of maintaining a secured repository for the AAFIF data base. Depending on the volume of production activity, the equipment room supervisors may also be responsible for managing computer operators in their respective subsystem areas if the need for dedicated computer operators arises. In the Charting Subsystem a part-time operator for the EBR during the post cutoff processing period of the production cycle is recommended. Again, the duties of the EBR operations may belong entirely to the Charting Subsystem Equipment Room Supervisor if the volume of production cannot be used to justify the additional manpower.

3.3.4 Charting Subsystem Compilers

The Charting Subsystem compilers will perform all of the interactive functions at the Charting stations to create the graphic portion of the FLIP products. Each compiler will belong to a production team managed by a production control supervisor. Team members will support one another by performing intermediate proofing checks of the other compiler's work.

The chart compiler/digitizer operator selects that chart which requires revision and prepares it for the digitizing station where interactive data acquisition and revision is effected. The FLIP in question may not exist and will be digitized completely at the digitizing station. Compilers will transact frequently with the AAIPS data librarian to retrieve charting data files from the archives and to return the original and updated files when editing is completed. Routine disk pack exchanging and tape handling (mounting and dismounting) operations will be performed and shared by all of the Charting Subsystem compilers.

When the product cut-off time arrives, both the current FLIP files and the current EBR product tapes are brought together in the post-processing to produce new EBR product tapes. The selection of files to be processed is automatic and the operator need not specify which files he wants processed. Update flags are maintained for just this purpose. If the EBR product tape consists strictly of charts, it then goes directly to the EBR for selective film recording. The product tape maintains all files for a product, but only records them on film if there has been a revision on the chart. In the instance where an EBR product tape contains charts which are to be merged with the Publishing Subsystem text documents, the merging process occurs before film recording. The EBR data tape is temporarily brought into the disk and the merging of that data with the Publishing EBR tape produces a final EBR product tape which can then be recorded on the EBR.

EBR operations will normally be handled by a single person (ie. either the Charting Equipment Room Supervisor or a dedicated computer operator) due to the specialized handling of the film and attendant film processing. Intermediate proofing of all EBR final output will be performed by the production control supervisor, prior to releasing the final film negatives to the Aeronautical Information Analyst for the final quality control check.

3.3.5 AAIPS Data Librarian

The data librarian will be responsible for the control and safekeeping of the Charting and Publications Data Bases and the previous production cycle's EBR tape files. The maintenance of a secured centralized repository for all digital FLIP products is mandatory. The librarian will ensure that sufficient backup tape files exist for all current products in the archives. Strict control of access to the product files will be exercised. Only authorized users with a specific need will be allowed to sign out for a product file. All data files used will be returned to the library when processing is finished. All disk packs and tapes will be properly labeled and numbered. Sequence numbers will be assigned only by the data librarian. A formal system of records will be maintained accounting for all authorized use of the product files. The original film negatives when no longer needed by the printing contractor will be returned to the AAIPS Data Library for temporary safekeeping or destruction as required.

3.4 Subsystem Software

The Charting Subsystem software consists of three packages to perform:

- o Interactive graphic data acquisition and revision
- o Conversion of graphic data to Electron Beam Recorder drive tape format.
- o Merging of graphic data with Publishing Subsystem textual data to produce a single EBR drive tape.

3.4.1 Interactive Graphic Software

The first of these packages, for interactive graphic manipulation, consists of a main (executive) routine and 88 sub-routines organized functionally into 23 overlay modules and one group of core-resident utility routines. Detailed documentation and flow-charts for all subroutines can be found in the subsystem Programmer's Manual, and will not be repeated here. The major functions of the 24 groups are as follows:

- o Executive module accomplishes
 - Digitizing table servicing including recognition and interpretation of cursor keys and cursor x,y position.
 - Correlation of cursor key/position to desired function.
 - Overlay module load and call (execute)
- o Log On module
 - Accepts User identification and password character strings.
 - Verifies legitimate identifiers or aborts station initialization.

- o Directory/File Initialization module
 - Accepts directory (product type) name, file (drawing) name, and symbol file name.
 - If directory and file named exist, copies that file to a temporary (working) version and builds a grid area feature index.
 - If directory and/or file do not exist (and operator confirms that new desired) establishes new symbol file with no content.
- o Registration control module functions
 - Menu origin select
 - Chart origin select
 - Registration correction computation
 - Registration verification
- o Resolution control module
 - Establishes grid round-off and trace resolution spacing.
- o Path type control module
 - Line type select
 - Line thickness select
- o Shading control module
 - Area, text, path, and symbol shading select

- o Text type control module
 - Font style select
 - Variable text on/off select
 - Font size select
 - Horizontal & vertical justification select
- o Text rotation control module
 - 0° , $+90^{\circ}$, or -90° rotation select
 - Manual rotation select (any angle)
 - Analog rotation select (any angle)
- o Symbol rotation control module
 - 0° , Manual, or Analog rotation select
- o Symbol type control module
 - Symbol scale select
 - Mirror on/off select
- o Edit control (three overlay modules)
 - Layer/separation select
 - Search tolerance select
 - Locate feature
 - Display and list feature
 - Modify feature header
 - Delete feature/text
 - Move text
 - Move point symbol
 - Delete point symbol

- Delete inside section
- Delete outside section
- Move section
- Modify root, prefix, or suffix segment of feature
- o Separation/Layer control module
 - Separation and layer select for digitizing
- o Display/List control module
 - Circle/arc roundness select
 - Text display on/off select
 - Grid display on/off select
 - Layer/separation (display/list) select
 - Window area select (1:1 or auto-scaled)
 - Trigger hard copy of screen content
 - Cased text on/off select
- o Job close control module
 - Close files and log-off on fatal error or operator command (confirmed)
- o Symbol display module
 - Display point, left-path, right-path, left-area, right-area symbols
 - Handle nesting of user symbols, with or without variable text.

- o Digitizing control (two overlay modules)
 - Select/establish feature type: path, area-left, area-right, fixed or variable text, point symbol, path symbol left or right, area symbol left or right.
 - Select/effect data type: trace, rectangle, circle, cw arc, ccw arc, line/point, polynomial smoothing of degree 2, 3, or 4
- o File control (four overlay modules)
 - Clear work file
 - Clear scratch file
 - Store work or scratch file as symbol, and clear
 - Recall symbol to work file, normal or shifted position.
 - Recall symbol to scratch file, normal or shifted position.
 - Store current drawing file and open/establish new
 - Establish new symbol file
 - Display work or scratch file
 - List drawing, scratch, or symbol files

All of the interactive graphic software is written in Fortran 5 with the exception of two routines which handle communications with the digitizing table, Tektronix display terminal, and station Dasher hard-copy terminal.

3.4.2 EBR Drive Tape Creation Software

The EBRDC software package consists of a main (executive) routine and 49 subroutines organized functionally into 20 overlay modules. Each execution of the package processes all drawings in a single product directory. Eight of the modules are considered "level 1" functions and perform one-time-per-run or one-time-per-drawing operations such as:

- o Initialize output magnetic tape, and input tape if operator indicates an archival tape exists from a previous run.
- o Initialize program arrays/areas/variables, initialize directories, and open files applicable to entire product directory.
- o Build a temporary image index file for product directory.
- o Examine each drawing file and create a temporary index to features within the drawing.
- o Copy images of a drawing (color/separation) which have not been altered since a previous run against the directory.
- o Cycle through each drawing calling "level 2" modules to convert data within the drawing to EBR format.
- o Wrap-up a run, outputting final data blocks, closing files, deleting temporary files, etc.

The level 2 software consists of 12 overlay modules, three of which process line-path, area, and textual data to EBR form. A fourth level 2 module is basically a dispatcher routine to load and call one of the nine remaining modules, each of which processes one to

three of the 11 classes of symbols currently being used on FLIP products.

The entire EBRDC package is written in Fortran V and requires slightly less than 30K words of memory and at least one tape transport for execution.

3.4.3 Chart/Publishing Data Merge Software

This package is actually two sequential processes: the first, known as EBRLOAD, transfers the contents of an archival EBR tape to the S/230 disk drive in a product directory specified by the operator. The names of the disk files created correspond to the sequence in which the files are found on the input tape. Other than system library routines, only one small subroutine is used. The input tape is dismounted and replaced by the tape from the Publishing Subsystem, and the second-phase process is executed to perform the merge and write a complete output tape with both text and graphics.

The second phase, EBRMERGE, consists of a main routine and six subroutines. Together this software:

- copies textual data records from input to output tape until a "graphic call" record is found in the input tape.
- opens the appropriate disk graphic file and determines from the "call" record what scale, rotation, and origin shift is to be applied to the graphic. (Scale and rotation are constant for a product type).
- if the requested graphic does not exist for any reason, one subroutine is used to substitute a "null" empty box at the specified location

- two subroutines create or alter EBR command data words as they buffer the graphic data to the output tape

All of the software for the merging process is in Fortran V.

SECTION IV
OPERATIONAL CONSIDERATIONS

4.0 General

Techniques and procedures used during system development phases often differ appreciably from those required for an integrated production system. When discrete steps or functions are to be proven, short-cuts and/or synthesized data are usually more appropriate than attempts to use large volumes of live data through a full series of processes. Many of the production phase operational considerations have been stated or implied in a preceding section (3.3) of this document which discussed personnel functions; effective division of labor and responsibility is the key to successful operation of AAIPS for FLIP production.

4.1 Development Phases

Considerable flexibility in the use of both manpower and equipment is necessary during system development since no practical level of pre-analysis can predict all of the nuances of procedure in a complex system. As an example, consider just the Charting Subsystem digitizing-station operator role. It was originally assumed that a person could and should be an on-line compiler of graphic files working from rough sketches and materials generated by the Air Information Analyst, provided that the functional tools available to the operator were adequate for the task. While this approach is still possible, experience with the AAIPS pilot phase has shown that it results in a high percentage of wasted man and machine time simply because the AIA does not prepare his directives in a form that meshes efficiently with the data base structure. The two obvious solutions to the problem are to:

- (1) Educate the AIA as to the best way for AAIPS to accept his data, and attempt to gain his cooperation in revising his job. This is likely to be met by mild to strong opposition

depending on the individual; few Analysts would be enthusiastic about changing procedures simply for the possibility of more efficient production.

- (2) Institute an intermediate role between the AIA and the station operator to perform the information reorganization/preparation. During developmental phases this task would best be performed by the same personnel who will execute the actual graphic data acquisition or revision, in order to evolve an understanding of what degree of preparation is necessary for the latter function, and determine what ratio of number of compiler-translators to equipment operators is optimum.

Therefore, during developmental phases all personnel should be able and willing to assume a variety of roles and maintain an analytical viewpoint of operations. As of the completion date of the Pilot phase, there is still considerable latitude for adaption of new processes and procedures to circumvent critical restrictions to volume production.

4.2 Production Phase

By the time full production is to commence, all operational roles and procedures must be well defined. The graphic data base (of the Charting Subsystem) must be completed, or nearly so, since the AAIPS is geared toward maintenance and re-publication of FLIP products rather than initial or one-time publication of documents. However, since the data structures and processes were developed (in the Pilot phase) with product-class and geographic area segregation in mind, it will be possible to initiate production of limited sub-sets of the DMAAC/AD FLIP publications in gradual stages.

Although equipment scheduling for production processing will have the highest priority, allocations must also be made for preventative maintenance, unscheduled down time, training (of new personnel) and some relatively small percentage for installation of enhancements and/or correction of latent problems. If some limited degree of production is initiated during the Phase II period (ending 31 Jan. 80), the training and enhancements/corrections can be accomplished to a large extent on new equipment which has not yet been accepted by the government and released to the production operation. Statistics derived from subsystem testing (see Section 5 of this document and the Charting Subsystem Test Report) will be projected to full production time requirements and used to create equipment and manpower schedules.

SECTION V
CONCLUSIONS AND RECOMMENDATIONS

5.0 General

With specific tests defined and performed, the Charting Subsystem achieved all test objectives. These tests showed that all required hardware existed and functioned as specified; the pilot font/symbol library existed and was utilized in product film recording; the complete set of digitizing functions were exercised and shown to perform as intended. Data base integrity was verified by digitizing new data, storing it on disk and retrieving it for display. Integrity was also shown by shutting off the power to the computer system while digitizing and retrieving the data again for display/proof. Finally, the pilot workload was demonstrated by original data acquisition and revision. This test met the objective of timely data revision cycles.

5.1 Volume Capacity

The enroute chart "L6" requires about 800 disk records and the 5" by 8" charts about 50 disk records each, where each record is 512 bytes long. "L6" is by far one of the most "feature complex" files available in the enroute series. Since each file can be a maximum of 65535 disk records, the likelihood of reaching this limit with any file available at DMAAC/AD is very slim.

The total capacity of the disk is 192 megabytes (MB) and the disk structure in Charting is such that the only limit on the number of directories and files is the physical size (192MB). Note that the disk structure also allows for multiple disk packs without jeopardizing the total Charting concept of "product directory".

DMAAC/AD's total holdings (Phase II) consists of 95 "20 by 45" charts and 3834 "5 by 8" charts encompassing all Charting products for Europe-North Africa-Middle East, Pacific-Australasia-Antartica, Caribbean-South America, Africa and Alaska. Using the latest figures mentioned above, the "20 by 45" charts would take up 39MB or 20.3% of

the disk, while the "5 by 8" charts would take up 98MB or 51.0% of the disk. This is a net result of only 71.3% of the disk space.

5.2 Revision Time

Although the revision test performed for the Pilot System promises timely data update/revision, it should be noted that all the level of experience in using the digitizing station by current personnel was in the order of a few months. Both total understanding and creative methodology for digitizing has increased to a level where revision times and complete Charting data capture has immensely improved. The Phase II testing should show this new level of timeliness.

The revision cycle tests showed that the Charting Subsystem is capable of 23 revisions per hour and complete data capture averaged 88 minutes for the 5" x 8" charts. The "L6" chart required approximately 80 hours to capture.

5.3 Output Device

The output device used to record film was the Electron Beam Recorder (EBR). The recording of chart data is a two-phase operation: post-processing of digitized data and actual EBR recording.

Post-processing was performed on all the Low IAP's and the "L6" enroute chart. Currently, it requires an average of three (3) minutes to process an IAP and about two (2) hours to process the current "L6" enroute chart. The times should be reduced significantly when the production mode of archival storage and re-processing only those data of a particular color/screen is instituted. This process allows for direct copying of archival data to the new EBR data tape being post-processed. The EBR recording of all post-processed Charting data showed that the "5 by 8" charts averaged about 105 seconds and the "L6" enroute chart about 20 minutes.

The quality of the EBR film recording was excellent. Prints were made of the "L6" and various Low IAP's. These products were of high quality and comparable if not better than manually produced charts.

5.4 Recommendations

During the course of both original data capture and testing/revision, it was discovered that certain enhancements to the Charting Subsystem software would be desirable. These include:

- o Function for orthogonality of straight lines.
(Line would result to be either horizontal or vertical)
- o Variable leading of multi-line text.
- o Limited set of text manipulation functions.
(Change/Delete/Add characters)
- o Morse Code Input via text function. (Operator enters Alphanumeric and subsystem translates to Morse Code)
- o Mask editing which would allow "cutting" of sections of a chart.
- o Maintain the Feature Type currently set such that function need not be selected each subsequent time.
- o Method by which a feature can be cancelled while in the graphic mode.
- o Charting Data Post-processing (EBRDC) capability to select a single file for processing instead of a complete set from a product directory.
- o Generate rectangles from two corner points at variable angular orientations.