Analysis of Static Information Display Requirements for the Advanced Automation System

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MITRE

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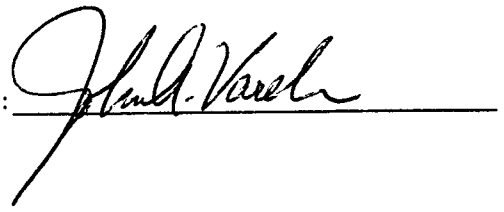
and Project Approval: 

ABSTRACT

The Advanced Automation System (AAS) for air traffic control is specified to include electronic displays of static data such as charts, approach plates and handbooks. The static information currently used by air traffic controllers is examined in the report and candidates for incorporation into the system are identified. Availability of digitized data required for establishing and maintaining a central data base is examined. Findings from controller interviews, including display requirements for static information, are documented and evaluated. Changes to the static display requirements delineated in the AAS System Level Specification (SLS) are suggested, and further extensions of the study are proposed.

Suggested Keywords: Aeronautical Charts, Display of; Advanced Automation System, Static Displays; Air Traffic Control, Static Information Displays for; Cartography, Digital; Digital Data, Display of; Displays, Cartographic; Displays, Static Information; Graphics Information, Display of; Static Information for ATC Display

FOREWORD

This report is intended for distribution to MITRE and FAA personnel and Advanced Automation System (AAS) contractors concerned with static information displays in the AAS. Therefore, it is presumed that readers are familiar with the terminology and concepts of the AAS.

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EXECUTIVE SUMMARY

This definition, evaluation, and specification study of static display information was conducted in support of the Federal Aviation Administration's Advanced Automation Program (AAP). Static information is defined as data updated less frequently than monthly. This continuing study was initiated in June 1985 in response to a request from the Advanced Automation System Design Competition Phase contractors to clarify the data collection responsibilities and the available form (hard copy vs. digital) of future static display data. Revised requirements for such displays, to be given in the System Level Specification (SLS)* for Advanced Automation System (AAS) facilities, are presented. Preliminary results of the ongoing study were presented in a MITRE working paper.**

To determine the present use and future needs of static display information at Air Route Traffic Control Centers (ARTCCs), Terminal Radar Control (TRACON) facilities and Air Traffic Control Towers (ATCTs), visits were arranged to the Washington National, Washington Dulles and BWI airports and also to the Washington Center, the Denver Center, the Salt Lake Center, and the New York Center. Through observations of operations and interviews with air traffic controllers a spectrum of general and locally specific displays was identified at these diverse facilities.

Interviews were conducted to solicit expertise within FAA for views regarding static information to support ATC operations. FAA Headquarters personnel that were questioned, briefed, and shown laboratory display demonstrations represented the AAS Requirements Assessment Team (AASRAT), the Sector Suite Requirements Validation Team (SSRVT), the National Flight Data Center (NFDC), and the AAP Requirements Review Committee. Repeated discussions with the National Ocean Service (NOS), the principal producer of official FAA aeronautical charts and other navigational materials, revealed information about their current chart production and future plans with respect to digitization of charts and textual/tabular material.

*FAA/DOT, "Advanced Automation System, System Level Specification, Design Competition Phase," FAA-ER-130-005F, November 20, 1985.

**"AAS Static Display Information Evaluation," MITRE Working Paper WP-85W00518, December 1985.

From the ATC operational facility visits, Controller Charts, Approach Plates, and Sectional Aeronautical Charts were observed to be the most frequently used static display graphics and, therefore, should be prime candidates for future displays. Multicolor Sectional Aeronautical Charts (commonly called "Sectional" or "Visual" Charts by controllers, cartographers, and pilots) are utilized predominantly in ARTCCs possessing mountainous terrain in the control region. Backlighted 20-in. by 30-in. sections of Controller Charts and Sectional Charts are mounted overhead at radar control positions, predominantly in the ARTCCs, less frequently at TRACONs.

Some vector and alphanumeric overlays, e.g., sector boundaries or tables of radio frequencies, prepared by ARTCC cartographers or by NOS when specially ordered by TRACONs, are superimposed on the Controller Charts. Also, locally required Approach Plates are stored at controller stations in plastic folders. Other needed charts, e.g. En Route Charts, are available in hard copy.

NOS produces charts for FAA based on input data from the National Flight Data Center. Within the total of approximately 7000 charts are 55 Controller Charts and over 5200 Approach Plates. All charts are now available only in hard copy. However, NOS is planning to digitize the monochrome Controller Charts and Approach Plates, probably in vector form, and make the data available by 1988. Sectional Aeronautical Charts, characterized by multiple colors and fine detail, are not presently scheduled for digitization by the National Ocean Service. However, NOS indicated a willingness to convert, under contract, any charts or textual/tabular material into digital form per requests by FAA.

NOS is acquiring raster scanning equipment for digitizing monochrome linear graphics masters and text. Additionally, 20 editing stations for vector tagging and other editing procedures will be acquired. Geographic points to be utilized in charting of vectors are presently available within NOS in tables and on magnetic tapes.

All the static digital information to be used in the AAS is expected to be stored in a central data base located at the FAA Technical Center, Atlantic City. The data subsets required at individual control facilities (estimated for each as approximately 15 percent of the total data base) would be transmitted to those facilities as required. Scheduled updates and interim changes would also periodically be transmitted from the central data base. Current plans would prohibit local input of static information directly into data bases at individual Air Traffic Control centers. Changes initiated locally at facilities would be transmitted to the central data base for monitoring and checking prior to controlled input to the central data base before retransmission back to the user(s).

Based on the MITRE study findings recommendations were submitted through a Document Change Request (DCR) to revise the specification listings of required static information for AAS display.

For the AAS static display the following graphics and textual/tabular selections to be available within each Area Control Computer Complex (ACCC) and Initial Sector Suite System (ISSS) shall be:

Graphic

1. Controller Charts, including local facility overlays
2. Sectional Aeronautical Charts
3. Instrument Approach Procedures (IAP)
4. STARs/Profile Descent (Standard Terminal Arrival Routes)
5. SID/Departure Procedure (Standard Instrument Departures)
6. North Atlantic Route Charts
7. Pacific Route Charts
8. Substitute Routing

Textual/Tabular

1. Airman's Information Manual
2. "Air Traffic Control," FAA Order 7110.65
3. Other Static Display Textual/Tabular Categories
    a. Standard Operating Procedures (SOP)
    b. Letters of Agreement
    c. Position Check Lists
    d. NAVAID/Sector Frequencies

The list of static display selections to be available in the Tower Control Computer Complex (TCCC) is somewhat modified to:

Graphic

1. Instrument Approach Procedures (IAP)

2. Low Altitude IAP (Published by DOD for military terminals)

3. Visual Flight Rules (VFR) Terminal Area Charts (similar to Sectional Aeronautical Charts but for terminal controlled airspace)

4. STARs/Profile Descent

5. SID/Departure Procedure

6. Controller Charts

7. Control Zone Obstruction Charts

8. Noise Abatement Zones

9. Other Static Display Graphics Categories

    a. Airport Layouts

    b. Circling Approach Area Charts

    c. Airport Visibility Checkpoints

Textual/Tabular

1. Airman's Information Manual

2. "Air Traffic Control," FAA Order 7110.65

3. Other Static Display Textual/Tabular Categories

    a. Standard Operating Procedures (SOP)

    b. Letters of Agreement

    c. Position Check Lists

    d. NAVAID/Sector Frequencies

    e. Sunrise/Sunset Tables

An area of major concern, yet requiring resolution, is the mode of display of static information at the Sector Suite in the ACCC/ISSS and at the TCCC Position Console (TPC). Since Controller Charts must be displayed continually, with only short interruptions acceptable, dedicated auxiliary displays must be used for static information. However, auxiliary display (and also main display) viewing areas are smaller than available on current backlighted overhead displays. Chart size reductions have been ruled out since experiments have shown that readability of electronically displayed charts, even on high resolution monitors, is not sufficient when charts are reduced to a scale smaller than that of the original hard copy. Although Controller Charts (except Alaska) and Approach Plates are monochrome, the use of color displays would allow highlighting of certain portions of the charts (e.g., J-routes, V-routes, NAVAIDs) and thus would enhance readability.

Air traffic control specialists emphasized that a total sector must be observable at a glance. For larger sectors such a requirement can be satisfied only by using two adjacent auxiliary displays for the presentation of Controller Chart information. This solution has been determined to be generally acceptable to the controller.

Firm estimates for the total static digital data cannot yet be provided since the final selection of static information (charts and text) remains to be made; and the digital representation of data base inputs (raster vs. vectors) has not been selected by NOS for most of the material. Based on currently available data a rough estimate of storage requirements for Controller Charts to be displayed per sector is approximately 5 to 10 Megabytes (MB) depending on the size of the sector. Storage requirements for multicolor Sectional Aeronautical Charts are estimated to be between 35 MB and 150 MB for each sector, again depending on the size of the sector. For Approach Plates, SID and STAR Plates, text, and other graphical material, and also overhead/housekeeping, an additional 27 to 32 MB is estimated. The present rough estimate for the total storage requirement for displaying static information per sector ranges between 70 and 200 MB. Details on the storage estimates are presented in Section 3.8.

1. INTRODUCTION

This MITRE Technical Report describes the activities and results of a study of static display information with the focus on design ramifications for the Federal Aviation Administration's Advanced Automation System (AAS). The study was performed by members of the System Development Department of MITRE, for the Advanced Automation Program Office of the FAA.

1.1 General Background

Static information is defined as data that does not change more frequently than once a month. Among static display candidates, the most frequently used by air traffic controllers today are Controller Charts, Sectional Aeronautical Charts, and Approach Plates. Controller Charts and Sectional Aeronautical Charts are mounted currently in 20-in. by 30-in. backlighted overhead windows at controller stations while Approach Plates are available to the controller in hard copy. The System Level Specification (SLS) for the Advanced Automation System (AAS) requires that static information must be displayed electronically at Sector Suites in the AAS.

The AAS will replace all existing FAA en route and terminal air traffic control systems. The en route and approach control air traffic controller workstation in AAS will be the Sector Suite. Each Sector Suite will comprise one to four Common Consoles. Each Common Console will have a 20-in. by 20-in. Main Display and optionally, an Auxiliary Display with at least 160 square in. of display surface. Both will be color displays. The consoles to be installed in the towers are called TCCC Position Consoles (TPCs). Monochrome display units within the TPC will contain at least 100 square in. of display surface.

This study was prompted by inquiries from the AAS Design Competition Phase (DCP) contractors regarding FAA requirements for electronic display of static information. Specific evaluations were precipitated by AAS contractor-originated Requests for Action (RFAs). Ensuing FAA responses to these RFAs delineated the government-contractor responsibilities in collecting, handling, and storing static data and promised a clarification of the following issues, provided by this technical report:

1. the set of static data to be used within the AAS;

2. the source(s) of the information;

3. the form in which such data will be supplied;

4. data update schedule.

1.2 Definition of Static Display Information

As defined in the AAS SLS, the Static Information Display is a "logical display....[containing] data that change infrequently, on the order of months". The SLS presents examples of data that are candidates for static display by means of the Area Control Computer Complex (ACCC), the Initial Sector Suite System (ISSS) and the Tower Control Complex (TCCC). The items required by the SLS to support Air Traffic Control (ATC) operations are categorized as either "Graphic" or "Tabular" materials. However, the graphic materials--for instance, the various series of aeronautical navigation charts--frequently contain tabular information as well, e.g., radio frequencies for air-ground voice communications. Furthermore, materials classified as tabular are often predominantly textual.

1.3 Scope of Study

In response to the needs of the DCP contractors, the scope of this report is twofold:

1. Identify, describe and evaluate static information (graphical, textual, and tabular) currently used by air traffic controllers.

2. Identify and describe additional static information candidates for digital retrieval and electronic presentation.

Also, information acquired during the study regarding sources of static data and the data characteristics is used to estimate preliminary digitization requirements necessary in developing a data base of AAS static information. Finally, requirements changes are suggested for sections of the AAS SLS governing static displays.

2. OBJECTIVES OF THE STUDY

2.1 Initial Objectives

The original purpose of the study, in response to Requests for Action submitted by the AAS DCP contractors, was to identify and characterize possible AAS static display candidates. The results, obtained primarily from the NOS, are summarized in the Static Display Table, Appendix A.

Static data characteristics of interest include the following:

1. Source

2. Presently available form (e.g., hard copy chart, table of geographic points, text in a published handbook)

3. Publication schedule; frequency of intermediate updates

4. Charted detail density (e.g., high when multiple visual chart overlays are superimposed; low for many linear graphics displays)

5. Monochrome or color original

2.2 Expanded Objectives

Progressively developing needs of the contractors dictated that the original work be expanded to include:

1. Derivation of possible revisions to candidate data items presently in the SLS. Display requirements are to be based on static display findings and suggestions obtained from ATC site visits and discussions with specialists in ATC and in aeronautical cartography; selection of static data items for the AAS hinges on such factors as observed frequency of use of current data and the (somewhat subjective) importance that controllers ascribe to the material and to its rapid retrieval.

2. Determination of the likely digitized form of the data to be supplied to the AAS static information data base.

3. Compilation of information from which contractors might estimate preliminary requirements for data storage capacities in early planning studies; planning factors or other measures of required data storage capacity in the central AAS static data base at local facilities and at consoles are to be developed.

4. Laboratory demonstration of digitized Controller Chart information at variable scales on a high resolution color monitor.

3. FINDINGS

3.1 Currently Used Static Information

Visits to FAA facilities such as the Washington, Denver, Salt Lake, and New York Air Route Traffic Control Centers (ARTCCs) and TRACONs and ATCTs serving Washington National, Dulles International, and Baltimore-Washington International Airports provided the opportunity to observe how "static" support material is being utilized today by air traffic controllers. NOS* produces, publishes, and updates the majority of the static aeronautical information. (Appendix A, a table of static display data candidates, conveys brief descriptions of graphic and textual/tabular data types.)

Most controllers at approach and en route control positions have segments of FAA Controller Charts (exemplified in Figure 3-1) available, displayed in backlighted overhead windows. They also utilize assorted Approach Plates (Figure 3-2), inserted in plastic pockets of small binders.

Segments of Controller Charts, about 20 in. high by 30 in. wide and placed in overhead display windows, are often supplemented by one or more overlays, either locally prepared by a facility cartographer or specially ordered from the Aeronautical Charting Division of NOS. The transparent overlays are line drawings on plastic and include charted features such as boundaries of the local airspace, runway centerlines, sector boundaries, and Navigation Aid (NAVAID) positions. At some facilities only the overlays, without the backup Controller Chart, are displayed and are often supplemented with tabulations of radio frequencies required for controller/pilot communications.

Approach Plates, utilized in terminal radar control, are pages extracted from appropriate Instrument Approach Procedures (IAP) volumes. Particular plates selected, varying between about three and 15 pages per controller position, depend upon areas of responsibility in controlling local and/or satellite airport approaches. On average, there are about ten Approach Plates per position.

*The National Ocean Service, Aeronautical Charting Division, within the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, supplies most of the aeronautical charts and documents, updating them in response to changes originating from the FAA National Flight Data Center.

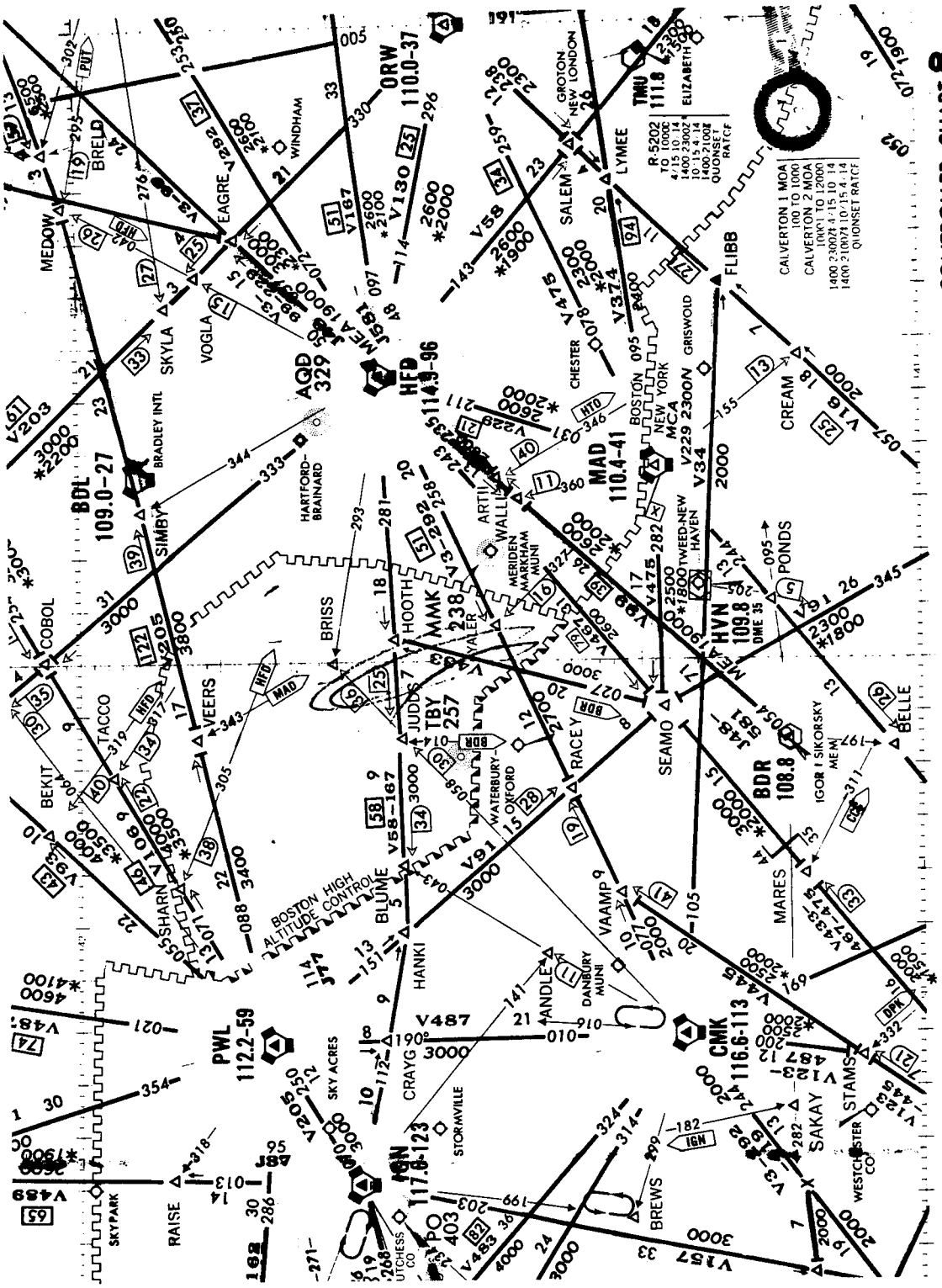

FIGURE 3-1
CONTROLLER CHART
(REDUCED IN SIZE)

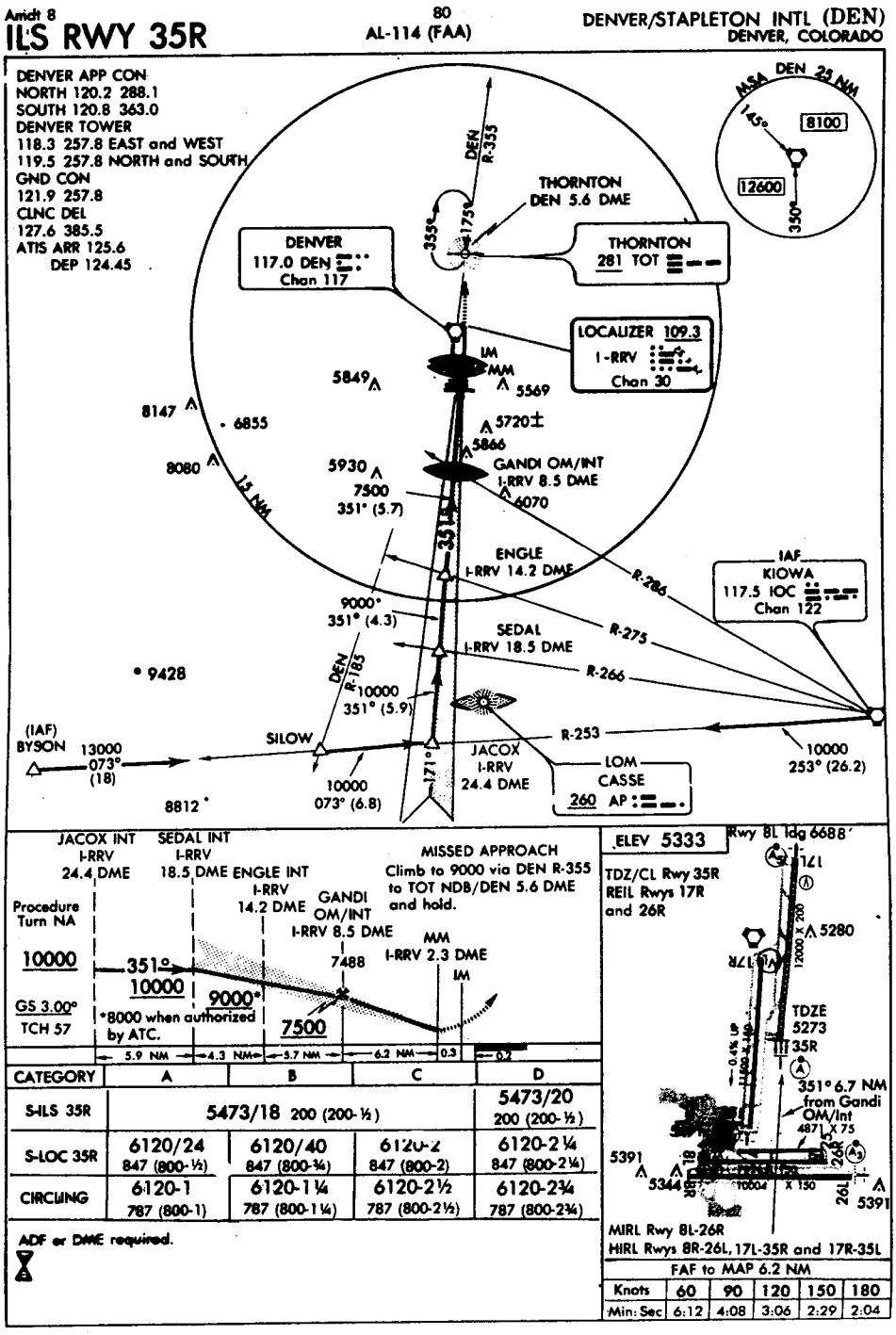

FIGURE 3-2
APPROACH PLATE (IAP)

In the ARTCCs with mountainous terrain in the control region, like Denver and Salt Lake City, Sectional Aeronautical Charts (exemplified in Figure 3-3) are of major importance and are frequently used to check on minimum flight altitudes and to guide lost aircraft.

The Sectional Aeronautical Charts are also produced, published, and updated by NOS, predominantly for use by pilots. These charts include topographic information to support visual navigation of slow/medium speed aircraft. Locally prepared overlays with added minimum flight altitudes are frequently used with the Sectional Aeronautical Charts.

No formally published static graphics are displayed at controller positions in tower cabs. Rather, tower controllers are more likely to refer occasionally to locally-prepared adaptation materials such as large-scale airport layout diagrams, visibility charts, helicopter navigation charts, operational procedures, or sunrise-sunset tables, all in hard copy.

The requirement most frequently stated by en route controllers was for continual display of Controller Charts. Since controllers lack time to divert their attention more than momentarily to the support items, broad-area information (even extending beyond sector boundaries) must be available at all times for memory support.

Current versions of hard copy information of all types, even though not available at controller positions, are posted or maintained on file in each facility. These include joined Controller Charts made into a wall chart for a given Center, Oceanic Charts, volumes of Approach Plates, volumes of standard arrival and departure routes, multicolor visual navigation charts, en route charts, handbooks, notebooks, manuals (e.g., Airman's Information Manual), directories, letters pertaining to operations, and letters of agreement.

3.2 Static Information Material Production

On visits to the NOS, information was collected on the current production, revision, and use of static display materials as well as techniques in digital cartography. These inputs have been analyzed and the findings are presented in this section.

NOS is the chief supplier of FAA aeronautical charts and documents. Several other charts, termed Flight Information Publications (FLIP charts), used by the FAA in air traffic control, are produced within the Department of Defense by the Defense Mapping Agency Aerospace Center. All specifications and guidelines for aeronautical mapping are controlled by the Interagency Air Cartography Committee, a group that includes representatives from FAA and the Departments of Defense and Commerce.

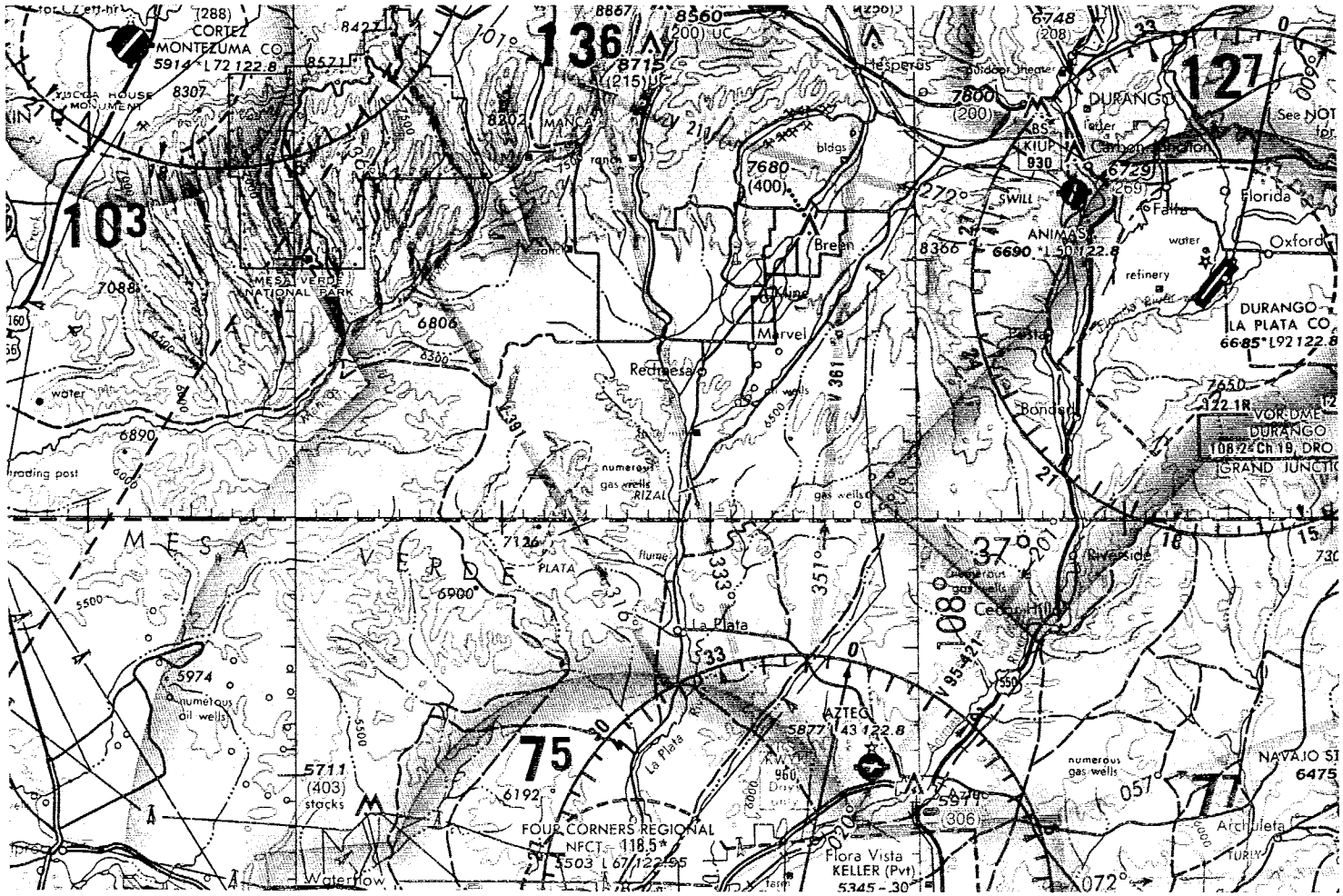

FIGURE 3-3
SECTIONAL AERONAUTICAL CHART

Currently, a 56-day chart publication cycle predominates, interspersed with scheduled, interim updates, e.g., the 28-day period for issuance of Change Notices following standard-cycle publication of Controller Charts. The publication cycles of the various data types, where these have been established, are tabulated in Appendix A.

The Aeronautical Chart Branch is planning to provide digitized Controller Charts and Approach Plates, which are monochrome, in vector form by CY 88. Some preliminary vectorization results are expected to be available for experimental purposes earlier.

Multicolor graphics such as Sectional Aeronautical Charts, used extensively by pilots for visual navigation, are not considered by NOS to be appropriate for digitization. A reason cited by NOS is that mixed inks rather than primary-pigment process inks are used in the five color printing, with inherent technical problems in multicolor digital scanning*. (An alternative would be to scan separate transparent overlays, printed in black, and arbitrarily assign colors to the scanned outputs.)

Most charts are produced from an overlay of separate plates. A Controller Chart, for example, comprises an overlay of four photo positives, ranging from solid black, on Plate 1, to light gray (a deeply screened representation of jet routes), on Plate 4. A Sectional Aeronautical Chart is produced via an overlay of data from about 40 separate plates.

NOS produces approximately 7000 different charts for the FAA. The major types and their numbers are shown in Table 3-1. By far the majority of the plates, over 5000, are in the 15 volumes of Instrument Approach Procedures (IAPs). Each plate (or page) of the IAP contains (1) a plan view of the approach path to a runway (at the top of the page), (2) a profile view of the approach path, and (3) a small-scale airport sketch. The latter two items appear side-by-side at the bottom of the page, along with tabular data. The entire plate is photo-composed from the overlay of two preliminary plates--one conveying detail in solid black, the other screened to a tone of gray. The various segments of the Approach Plate can be digitized and stored in separate data files to permit flexibility in displaying

*Filter-scanning of isolated colors could not be accomplished, according to NOS, because a "blue" line or area, for example, might have some gray, yellow, brown, and green mixed with it. Thus, the particular element would be repeatedly sensed incorrectly. For example, when scanning for "green", the "blue" would erroneously be digitized as well.

TABLE 3-1
NUMBER OF FAA CHARTS PRODUCED BY NOS

Product	Number
Instrument Approach Procedures (IAP) Plates	5241
Standard Instrument Departure (SID) Plates	457
Airport Diagrams	286
Standard Terminal Arrival Route (STAR) Plates	161
FAA Controller Charts	55
Sectional Aeronautical Charts	37
En Route Low Altitude Charts	28
VFR Terminal Area Charts	25
En Route High Altitude Charts	4

the information on physical displays. A likely display option would be to change from the taller (vertical) arrangement, as presented currently on the page, to a wider (horizontal) format. Also, explanatory information (symbols and text) at the front of the IAP should be put in a separate file for on-line reference by the controller while utilizing Approach Plates.

The Controller Charts, printed on large sheets (approximately 3-ft by 5-ft), are numerically ranked fifth among the published products (Table 3-1). Fifty-five Controller Charts cover the conterminous U.S., plus Alaska, Hawaii, and Puerto Rico.

The NOS map-making personnel are heavily engaged in a continuing revision of these charts. For example, in a typical 56-day publication cycle, on the order of 20 percent of the Approach Plates are revised, i.e., about 1000 plates. Such updates are primarily in response to inputs from the FAA National Flight Data Center that are released in the National Flight Data Digest.

3.3 AAS SLS Analysis

Altogether, 17 data items are listed in the AAS SLS for static display, as shown in Table 3-2. Among the data items, 12 are "graphic" (but frequently accompanied by tabular and/or textual material) and five are classified as "tabular" (but frequently contain much supplemental textual and some graphics materials).

Among the specified graphics (Table 3-2) the following are currently not periodically published for distribution to the FAA as formal materials:

1. Item 3, Sector Charts -- NOS produces these only by special request.

2. Item 4, Special Area Maps -- These are NOS-produced video maps, selected by panel keys on the main display (PVD) -- not a static display.

3. Item 6, Military Training Routes -- These are depicted on local, made-to-order overlays placed on overhead displays.

4. Item 7, Holding Pattern Airspace -- Designated airspace superimposed on Controller Charts from NOS digital data file.

5. Item 9, Airport Layouts -- FAA cartographers frequently draw these at enlarged scales for local operational use.

TABLE 3-2
SLS-REQUIRED STATIC DISPLAYS

Type	Where Utilized	Publication Cycle
Graphic	(a) ACCC/ISSS and/or (b) TCCC	
1. Approach Plates	Both	56 days
2. Controller Charts	"	56 days
3. Sector Charts	"	None
4. Special Area Maps	"	N/A
5. STARs/Profile Descents	"	56 days
6. Military Training Routes	"	56 days
7. Holding Pattern Airspace	"	56 days
8. SID/Departure Procedures	"	56 days
9. Airport Layouts	TCCC	None
10. Circling Approach Area Charts	"	None
11. Airport Visibility Check Points	"	None
12. Control Zone Obstruction Charts	"	None
Tabular		
1. Standard Operating Procedures Manual	Both	None
2. Letters of Agreement	"	None
3. "Air Traffic Control," Order 7110.65	"	2.5 years
4. NAVAID/Sector Frequencies	"	None
5. Position Checklists	"	None

6. Item 10, Circling Approach Area Charts -- Terminal facilities prepare and utilize these locally.

7. Item 11, Airport Visibility Check Points -- To aid in locally identifying ranges of visibility.

8. Item 12, Control Zone Obstruction Charts -- These are produced at some local facilities to support their operations.

Similarly, several static display information items listed in the SLS as "tabular" (Table 3.2) are not currently published as formal documents:

1. Item 1, Standard Operating Procedures Manual -- SOPs are currently facility-specific.

2. Item 2, Letters of Agreement -- These letters are customarily maintained in notebooks by parties to specific agreements.

3. Item 4, NAVAID/Sector Frequencies.

4. Item 5, Position Checklists.

Publication of most of the SLS-required static display information recurs at 56-day cycles; however, nine types of data listed in the SLS are not formally published, and the Special Area Maps (Graphics Item 4) are not a static display.

None of the charts listed in the previous table are currently available to the FAA in digitized form. Requirements must be established by the FAA for digitization of whichever of the above graphics or tabular items are needed for static information displays. Since NOS has indicated, as already mentioned, that some of the charts will be digitized before 1988, the FAA should closely coordinate with NOS to contribute to planning activities related to the digital cartography.

Other current hard copy candidates for static display are shown in Table 3-3. These are not now listed in the SLS but observed to be widely available for use in FAA facilities as well as recommended by ATC specialists as being useful. (These supplemental items are also briefly described in Appendix A). While certain of the additional data types are pilot-oriented, controllers have expressed the importance of rapid retrieval of common reference materials (i.e., the same navigational charts referred to in the cockpit and at the controller position).

TABLE 3-3
OTHER STATIC DISPLAY CANDIDATES

Type	Where Utilized	Publication Cycle
Graphic		
1. Area Charts	TCCC	56 days
2. Airport Obstruction Chart	"	As req'd.
3. En Route Low Altitude - U.S. ("RF Chart")	ACCC/ISSS	None
4. En Route High Altitude - U.S.	"	56 days
5. Sectional Aeronautical Chart	Both	6 months
6. VFR Terminal Area Chart	TCCC	6 months
7. North Atlantic Route Chart	ACCC/ISSS	24 weeks
8. Pacific Route Chart	"	-
9. Noise Abatement Zones	TCCC	-
10. Airport Search and Rescue Chart	"	-
11. Helicopter Control Chart	"	-
12. Minimum Altitude Floors	ACCC/ISSS	-
13. Low-Altitude IAP	TCCC	-
Tabular		
1. Airport/Facility Directory	Both	56 days
2. Airman's Information Manual	"	16 weeks
3. Location Identifiers, Order 7350.5	"	112 days
4. Facility Operation and Administration, Order 7210.3	"	2.5 years
5. Emergency Operations Manual	"	-
6. Sunrise/Sunset Table	TCCC	-

3.4 Operational Requirements for the Display of Static Data

Based on field observations during the visits to the previously described facilities and interviews with controllers, supervisors, and FAA Headquarters personnel the following operational requirements for the display of static data are recognized.

3.4.1 Continual Controller Chart Presentation

Controller Charts, applicable segments of which are now displayed in backlighted 20-in. by 30-in. overhead windows, are used by the air traffic controllers as quick reference. The controllers use the charts as "memory support" whenever specific questions or uncertainties arise. This information includes:

1. High-and Low-Altitude Air Routes
2. Minimum Flight Altitude
3. NAVAIDs and their Radio Frequencies
4. Fixes
5. Intersections

Different controllers seek differing types of Controller Chart information in a nearly random manner. While the applicable portions of Controller Charts for sector control must be displayed continually, it would be acceptable, according to the controllers interviewed, to replace the Controller Chart display for short periods of time with other static information when needed (e.g., Sectional Aeronautical Charts, Approach Plates).

3.4.2 Controller Chart Display of Whole Sector

An air traffic controller must have the whole sector (and surrounding area) displayed at all times for quick reference, not knowing in advance which portion(s) might be of concern. According to the air traffic controllers interviewed on the subject, scrolling the Controller Chart to cover a whole sector is not acceptable because time to divert attention from the situation display is often limited.

Different sectors, with different maximum dimensions utilize charts of predetermined scales. In areas that are mountainous or characterized by low traffic densities, sectors with close to 300-nautical-mile (nmi) maximum dimensions are not uncommon. On a 1:1,000,000-scale Controller Chart 300-nmi horizontal (East-West)

dimensions would require a display with at least a 22-in. horizontal width. The backlighted 20-in. by 30-in. window is large enough to satisfy this requirement. Neither of the display units presently suggested for the AAS Common Consoles would qualify. (The display units will be discussed in Section 3.5.)

3.4.3 Retention of Controller Chart Information

As previously stated, at a given time air traffic controllers might use any of the information displayed on the Controller Charts for quick reference. Thus, only minimal decluttering of chart detail can be considered. Only information pertaining to special use areas, military routes, and grid lines may be deleted from the charts and placed on separate overlays, per guidelines from the AAS Requirements Assessment Team (AASRAT) specialists. However, these overlays should be possible to call out any time when needed. Some sectors also utilize supplemental overlays possessing a high density of information. These overlays, prepared today by the center cartographer, would be stored separately and displayed when required.

3.4.4 Scale of Controller Chart Display

In order to increase the displayed geographic area on the common consoles, a reduction in Controller Chart size has been considered. However, experiments performed at the MITRE laboratory showed that even a small image reduction to two-thirds the original linear scale reduces the size of the alphanumerics too much to be readable. Increasing the size of the plotted alphanumerics on the printed originals would be difficult in most cases because of lack of space on the already crowded Controller Chart masters. The 1:1-scale display, the same as presented today on the overhead display, not only is readable but it can be enhanced by assigning colors to selected point or line information. Furthermore, controllers become accustomed to estimating distances and locating features on charts of familiar (1:1) scale. (This observation is also an argument against zooming of Controller Charts.)

3.4.5 Sectional Aeronautical Chart Displays

Per discussion with ATC specialists, Sectional Aeronautical Charts should be displayable on demand, i.e., substituted briefly for the continually displayed Controller Charts. The electronic display units must present the cartographic image in moderate-fidelity color, closely corresponding with tones and shadings of the hard copy original charts. For operationally acceptable readability, zooming will be required; otherwise, fine detail such as topographic contour intervals would be illegible at the typical console viewing distances. (In fact, finest details on today's hard copy charts are

not legible at viewing distances much greater than one ft., necessitating that controllers stand to read such information from current overhead displays.) Furthermore, to cover an entire sector, plus margins, the Sectional Aeronautical Chart displays should be scrollable, according to the specialists.

3.4.6 Instrument Approach Plate Displays

As for the case of the Sectional Aeronautical Charts, Instrument Approach Plates should be displayable on demand. This applies similarly to the display of SIDs and STARs. The electronic monochrome displays will supersede the current use of extracted pages of plates stored in folders and averaging about 10 plates per the typical position responsible for TRACON or satellite airport operations. It was also discussed with air traffic controllers and accepted by them that the plates could be logically segmented for digital storage in separate files, allowing increased flexibility in display formatting.

3.4.7 Textual/Tabular Material Displays

Textual/Tabular materials would be stored, page by page, in alphanumeric character form and, similar to the preceding charts and plates, would be available for display on demand, briefly displacing the Controller Chart displays. A scrolling capability is specified in the SLS for pages of textual/tabular materials.

3.5 Available Display Units in a Sector Suite

To present static information two types of display units will be available at a Sector Suite: (1) a 20-in. by 20-in. main color display in each Common Console (where one to four Common Consoles make up a Sector Suite) and (2) a 19-in. diagonal auxiliary color display for each Common Console.

The auxiliary display, a 19-in. color monitor mounted at an angle above the main display, has a viewing area 11.3 in. high by 14.2 in. wide. The viewing distance to a seated controller is approximately three ft. The auxiliary display units must continually display sector information from Controller Charts, with only short interruption, and must present sector images in their entirety. Table 3-4 shows the range of geographic scales at which Controller Charts are currently mapped and published. Table 3-5 shows, as a function of chart scale, the nautical miles of chart that can be displayed in the horizontal and vertical direction on each display screen. As can be deduced from Table 3.5, to display a large sector approximately 300 n mi wide, typical of the Denver center, which

TABLE 3-4
SCALES OF CONTROLLER CHARTS

Scale	Number of Charts	Example
1:200,000	1	Caribbean
1:500,000	39	Most Centers
1:1,000,000	4	Denver, Low Altitude
1:1,500,000	4	Alaska
1:1,700,000	3	Denver, High Altitude
1:2,000,000	4	Puerto Rico and Caribbean
	55	

TABLE 3-5
MAXIMUM RANGES ON SECTOR SUITE DISPLAY UNITS

Controller Chart Size		Approximate Maximum Range (n mi)		
		19" Auxiliary Display (11.3" x 14.2")		Main Display (20" x 20")
Scale Ratio	Equivalence	Horizontal	Vertical	Horizontal/Vertical
1:200,000	1" = 2.74 n mi	39	31	55
1:500,000	1" = 6.85 n mi	97	77	137
1:1,000,000	1" = 13.7 n mi	195	154	274
1:1,500,000	1" = 20.55 n mi	292	232	411
1:1,700,000	1" = 23 n mi	325	260	460
1:2,000,000	1" = 27.4 n mi	390	309	548

Notes

Of 395 Sectors in 20 En Route Centers:

- 121 Sectors (31%) in 20 Centers need two auxiliary display units for horizontal coverage.
- 36 Sectors (9%) in 10 Centers need expanded coverage in the vertical direction. Of these,
  - 26 Sectors (6.5%) in 10 Centers must be split into north and south portions for display on two auxiliary units.
  - 10 Sectors (2.5%) in 5 Centers cannot be displayed in their entirety even on two auxiliary monitors.

uses a 1:1,000,000-scale Controller Chart, would require two 19-in. auxiliary display units mounted atop adjacent Common Consoles. One-half of the sector would be displayed on each monitor simultaneously. Interviewed controllers generally accept this solution. Using the 20-in. by 20-in. main display on a Common Console for static displays would require one dedicated unit for the Controller Chart only. In most cases this implementation would necessitate a third Common Console to handle the total display load. To satisfy the requirement of continually displaying one entire large sector, using two auxiliary displays would be the less costly solution.

For presentation of the multicolor Sectional Aeronautical Chart (at a scale of 1:500,000) the same 19-in. auxiliary display units on the Common Consoles would be utilized. The controller must be able to see at least one entire sector on a Sectional Aeronautical Chart, also. However, the entire sector need not be presented simultaneously. A continuous scrolling function specified by the SLS for the static information display, would appear to satisfy controllers' needs and is generally considered acceptable.

3.6 Available Form of Machine-Readable Static Information

To reiterate, Controller Charts, Sectional Aeronautical Charts, and all other graphic static information currently exist in hard copy only. NOS is planning to digitize monochrome Controller Charts and Approach Plates and make the digital data available to the FAA by 1988. Present intentions are to store these data in vector form, defined by geographical points, rather than digitizing these charts via raster scanning.

In addition to pursuing vectorization of charts, NOS would conduct continuing raster scanning experiments. Such scanning procedures are potentially applicable to the tabular portions of an Approach Plate or the fixed portion (the geographic background) of a chart.

Reasons why NOS cartographers currently prefer vector digitization of linear graphics to raster scanning of the material include:

1. Data storage is significantly less for vectorized than for raster data, even with compression of raster-type bit data.

2. Maintenance of highly accurate cartographic data bases is fast and easy when the data are stored in vector form.

3. Conversion from raster data to vector data is difficult and time-consuming; but the reverse is trivial, the capability often inherent within computer firmware.

In regard to Item 3, NOS personnel have expressed concern about extensive editing requirements known to be associated with raster-to-vector conversion of graphics. This concern is supported by observed raster-scanning activities conducted by the Map Digitization Facility, U.S. Geological Survey (USGS). The USGS, using multicolor scanning, has been engaged in digitizing topographic map separates, masters produced in black and white but superimposed with manually applied color editing symbols. Following two hours of raster scanning (obtaining 30 points per mm from a 2-ft by 3-ft map) the map data file is vectorized at an editing station, on operation requiring 30 to 60 hr of labor for each separate overlay. This latter time-consuming effort is accomplished at the pixel level at editing station monitor screens.

Raster and vector data (e.g., Sectional Aeronautical Charts and overlay plates containing linear graphics) can be readily merged when their files are stored in separate levels of the data base. Sets of corresponding geographic points are used to register the overlays (or, alternatively, relative positions of different points must be expressed mathematically).

The material on an IAP page should be subdivided for digitizing. That is, the tables and approach curves can be stored in separate files, thereby providing flexibility in relative placements of groups of data on physical displays.

While vectorized chart data are expected to be available for FAA system applications by 1988, NOS anticipates having preliminary vector data, suitable for experimental applications, available sooner. Tables of geographic points and other characteristics of NAVAIDs are currently available through the National Technical Information Service, Springfield, VA.

Because NOS map makers suggested that there would be technical problems in raster scanning the NOS-produced multicolor charts, Intergraph equipment was tested to determine whether raster scanning of a Sectional Aeronautical Chart produces a satisfactory color display. Intergraph raster scanned, at 250 lines per inch resolution, a portion of a NOS hard copy chart. To capture the charted colors, three passes of the scanner were required, one each using a red, a green, and a blue filter. The three resultant files were combined into a single composite data file depicting shades of gray. These data elements were then manually color-corrected by successively adjusting color values in a 256-entry stored table until reasonable color agreement with the original hard copy was achieved.

From observations of the raster scanned display on an Intergraph work station color monitor (at the conventional 1280-by 1024-pixel resolution planned for AAS auxiliary displays) it was concluded that Sectional Aeronautical Charts can be raster scanned in color. Also, after manual color matching procedures the displayed digitized data possess a moderate color fidelity.

It was apparent, however, in these demonstrations that image resolution is a far more serious problem than the matching of colors. Fine map details were difficult or impossible to discern on a 100-pixel-per-in. color display. Only at enlargements, achieved by effectively zooming to about a 2:1 scale, screen-to-hard copy, could the image detail be read. At increasing image amplifications, greater fractions of the 250 scanned points per in. are utilized, improving the legibility of small alphanumerics and contour lines. On the other hand, zooming reduces the geographic area observable at a glance, potentially degrading the observer's sense of position identification and thereby slowing image recognition/information retrieval.

During the Intergraph demonstration, filling the work station screen with a single frame of graphics required up to half a minute to transfer the data. This indicates a need for local frame buffers.

For cartographic production tasks NOS is currently procuring major components which could, in part, fulfill the needs of raster color scanning, viz., a main computer and work stations. The major remaining items needed for color scanning would be a large drum scanner (approximately 260,000 dollars), a graphics processor (approximately 30,000 dollars), and various graphics software packages.

3.7 Static Information Management

For the required storage, distribution, and update of static information used in the different ATC facilities a centralized data base would best serve the purpose.

An advantage of a central AAS data base is its potential for sound data management and data maintenance. Centralized authority and assigned responsibility assure the accuracy of stored digital data. Also, the data base provides a focal point for all changes and controls data dissemination. A disadvantage of centralized storage of the composite static data lies in the vulnerability of a single source; a static data base failure in the SSCC would disrupt the

dissemination of data to all ATC facilities. However, the consequences are considered as minor for static data. The facilities would still have available the latest information transferred preceding a failure within the SSCC; and static data (by definition) are only infrequently updated.

Digitized data for all of the candidate information selected for static display is recommended for central storage. About 15 percent of that total static data base capacity will be provided to local ATC facilities (ACCC/ISSS) for their own routine operations. On the order of one-tenth the estimated ATC facilities allocation--or about 1.5 percent of the total AAS static display data base--would be transmitted to the typical TCCC.

3.8 Storage Estimates

Firm estimates of total storage in the central data base are yet impossible since the scope, formats, and digitization of static information used for display have not been determined. However, rough estimates were obtained for the total information content of the 55 Controller Charts. A portion of Controller Chart No. 8, assumed as representative of the typical Controller Chart, was checked to determine numbers of line segments, points, and alphanumerics. The resultant densities of these map details were, in turn, extrapolated to the entire 13-sq-ft area of the Chart and then multiplied by 55 for the total of U.S. Controller Chart areas. Approximate counts of data elements for the total collection of Controller Charts are as follows:

1.	Line segments	170,000
2.	Symbols	160,000
3.	Numerical characters	800,000
4.	Alphabetic characters	470,000

These counts exclude lines of latitude and longitude and graticules. Air Route Traffic Control Center boundaries are also not included.

Based on these data, estimated storage requirements for Controller Charts to be displayed per Sector Suite are approximately 5 to 10 megabytes (MB), depending on the size of the sector. (When NOS completes digitization of Controller Charts, the accuracy of these estimates will be considerably improved.)

Storage requirements for a Sectional Aeronautical Chart are estimated as follows: For a scanning resolution of 250 lines (or pixels) per in., one Sectional Aeronautical Chart with an area of 40 in. by 50

in. requires 125 MB of storage (40 X 50 X 250 X 250 = 125 MB, assuming that a pixel of color information can be represented by eight bits).

One Sectional Aeronautical Chart covers a geographical area of about 342 n mi by 274 n mi. Large En Route Centers (e.g., Denver, Salt Lake, and others) require three to four charts to cover the whole Center area plus a 50-n mi to 100-n mi margin. The storage requirements for four charts would be about 500 MB. Small Centers would need only one or two Sectional Aeronautical Charts for coverage. Storage requirements for Sectional Aeronautical Charts at sector positions depend on the size of the sector. For large sectors an entire Sectional Aeronautical Chart, or even more, may be needed; for small sectors a fraction of the information on a single chart may be sufficient. The storage requirement per sector position may vary between approximately 35 MB and 150 MB.

As per the above analysis for an entire chart, to store Sectional Aeronautical Chart information presently displayed in a 20-in. by 30-in. backlighted overhead window would require approximately 38 MB if raster scanned at 250 lines per in. If a scanning resolution of only 125 lines per in. were used, the storage requirement would be reduced to 25 percent of the previous values. However, this lower resolution may not be acceptable if the image were zoomed.

Intergraph has successfully scanned an 11.75-in. by 12.75-in. portion of a Sectional Aeronautical Chart with a resolution of 250 lines per in. and has verified that the above storage estimates are the right order of magnitude.

Based on inputs received from Jeppeson Sanderson, Inc., the estimated storage requirements for one Approach Plate is 0.1 MB. A similar estimate is considered applicable to a Standard Terminal Arrival (STAR) plate and also a Standard Instrument Departures (SID) plate.

With a total of 5241 Approach Plates, 161 STAR plates and 457 SID plates, the estimated storage requirements for all plates amounts to approximately 600 MB. Assuming that each sector position uses 15 Approach Plates and 5 SID/STAR's the storage needed for these plates to be displayed at a Sector Suite would be approximately 2 MB.

It is further assumed that 1000 pages of textual information needs to be stored for each sector. If one standard document page contains an average of 7000 characters (with one character requiring one byte), the estimated storage requirement per Sector Suite for textual material would be 7 MB.

The total storage needs per sector depends on the size of each sector and is estimated as follows:

Controller Charts	5-10 MB
Sectional Aeronautical Charts	35-150 MB
Approach Plates, SID, STAR	2 MB
Textual Material	7 MB
Other	3 MB
Overhead and Housekeeping	15-20 MB
ESTIMATED TOTAL	67-192 MB

It is the responsibility of the FAA to determine improved measures for estimating total storage capacity requirements for static information. The measures may include, in addition to a count of line segments, points, and alphanumerics, per se, supplemental inputs (e.g., tagging) required to produce digital displays. Estimates also need to include information generated locally for ACCC/ISSS and TCCC applications.

4. CONCLUSIONS

In its present form, the AAS SLS includes a number of static information items that are now available to air traffic controllers and will be needed in the future. However, certain types of static data not presently included in the SLS are of importance in air traffic control, as revealed in site visits and interviews; conversely, some SLS-listed candidate items are not standard static display publications today and/or are not required by controllers.

From the study findings reported in Section 3.1 it was concluded that Sectional Aeronautical Charts should be added as a requirement to the SLS because these charts, published and distributed nationwide by the NOS, are used today in many centers. The charts have special importance in centers with mountainous terrain, providing quick reference for minimum flight altitudes, particularly in guiding small aircraft.

Oceanic charts should also be included in the SLS because of the importance of these NOS-published maps for guiding and separating oceanic flights. Displays of these maps would be frequently utilized by centers with oceanic control responsibilities.

The Airman's Information Manual should be added to the list of tabular static information in the SLS on recommendation of the AASRAT members and many air traffic controllers because they felt that this manual, mostly used by pilots, should be available to controllers and supervisors as a common operational reference with quick and easy access.

The requirement to display Sector Charts as part of static information should be deleted from the SLS because these charts are not officially published for nationwide use. Individual Centers may provide sector boundary coordinates for this type of chart in order to produce electronic overlays for Controller Charts.

The Special Area Maps should also be deleted from the SLS because they are presently provided as video maps on the situation display and can be called out via PVD key. (Map displays on the PVD include supplemental graphics such as controlled airspace and emergency airports.)

For most effectively managing static data and distributing the information to the ACCC/ISSS and TCCC a central data base should be established at the SSCC, Atlantic City.

Based on these conclusions a Document Change Request (DCR) was prepared pertaining to the static information lists presented in the AAS SLS. Sectional Aeronautical Charts, Oceanic Charts, and the Airman's Information Manual have been added to the lists because of the frequent use, as indicated by controllers and members of AASRAT. Sector Charts and Special Area Maps have been deleted from the lists.

Table 4-1 presents the new list of recommended static information for the ACCC/ISSS, and Table 4-2 lists the static information for the TCCC. Both listings have been submitted in the DCR.

TABLE 4-1
STATIC INFORMATION FOR ACCC/ISSS

GRAPHIC

1. Controller Charts including local facility overlays:

   - Military Training Routes
   - Holding Pattern Airspace
   - Sector Boundaries
   - Special Direct Routes

2. Sectional Charts
3. Instrument Approach Procedures (IAP), with each chart including:

   - A plan view
   - A vertical profile
   - An airport sketch

Also included in the IAP are pages of:

   - Airport diagrams for selected airports
   - IFR take-off minimums and departure procedures

4. STARs/Profile Descent (Standard Terminal Arrival Routes)
5. SID/Departure Procedure (Standard Instrument Departures)
6. North Atlantic Route Chart
7. Pacific Route Chart
8. Substitute Routing

TEXTUAL/TABULAR

1. Airman's Information Manual
2. "Air Traffic Control," FAA Order 7110.65
3. Other Static Display Categories:

   a. Standard Operating Procedures (SOP)
   b. Letters of Agreement
   c. Position Checklists
   d. NAVAID/Sector Frequencies

TABLE 4-2
STATIC INFORMATION FOR TCCC

GRAPHIC

1. Instrument Approach Procedures (IAP)

2. Low Altitude IAP (Published by DOD for military terminals)

3. VFR Terminal Area Charts (Similar to "Sectional Aeronautical Charts" but for terminal control area airspace)

4. STARs/Profile Descent (Standard Terminal Arrival Routes)

5. SID/Departure Procedure (Standard Instrument Departures)

6. Controller Charts

7. Control Zone Obstruction Chart

8. Noise Abatement Zones

9. Other Static Display Categories:

    a. Airport Layouts
    b. Circling Approach Area Charts
    c. Airport Visibility Checkpoints

TEXTUAL/TABULAR

1. Airman's Information Manual

2. "Air Traffic Control," FAA Order 7110.65

3. Other Static Display Categories:

    a. Standard Operating Procedures (SOP)
    b. Letters of Agreement
    c. Position Checklists
    d. NAVAID/Sector Frequencies
    e. Sunrise/Sunset Tables

5. RECOMMENDATIONS

The recommendations include AAS specification changes/clarifications and suggested areas for further technical analysis.

5.1 AAS System Level Specification Changes

Updated operational requirements and static data base management concepts are recommended.

5.1.1 Operational Requirements for Static Data Display

For the display of static data the following requirements revisions are recommended.

1. Controller Chart segments, associated with sector positions, must be displayed continually.

2. An entire sector of a Controller Chart must be readable at a glance.

3. Nearly all of the information presented currently on Controller Charts must be retained in the active data base for future electronic display; i.e., little editing of chart detail will be possible.

4. Controller Chart electronic displays must maintain the scale of the original hard copy charts.

5. Sectional Aeronautical Charts must be displayable on demand, must be displayable at moderate color fidelity, and must be capable of being enlarged (zoomed) and scrolled.

6. Instrument Approach Plates, STARs, and SIDs must be displayable on demand, and their digitized files must be segmented to allow electronic display flexibility.

7. Textual/Tabular materials must be displayable on demand, briefly replacing the Controller Chart displays.

5.1.2 Static Information Central Data Base

Based on the Findings and Conclusions, MITRE recommends that the SSCC at the FAA Technical Center, Atlantic City, maintain a single central AAS static display data base. All machine-readable data and all revisions should be stored in this data base. The centralized data base will disseminate static display data to local data bases in ATC facilities nationwide.

The recommended flow of information in the handling of static data is depicted in Figure 5-1. It is anticipated that the FAA will provide inputs of graphical, textual, and tabular static data to NOS for incorporation into Controller Charts, Approach Plates, and other display items.

NOS would also be the recipient of map sketches prepared by local ATC facilities and would produce the locally used charts. The static information (charts and textual/tabular data) produced by NOS would also be digitized by NOS. (As of this writing it is assumed--but not agreed upon--that NOS will also digitize Sectional Aeronautical Charts.)

As shown in Figure 5-1, it is recommended that digital inputs of static display data to the SSCC central data base be supplied either from NOS or, in the case of some revisions to alphanumerics, directly from data terminals at the FAA local ATC facilities. This procedure is in lieu of providing direct inputs to local storage at local facilities; data can be entered only through the central data base at SSCC.

It is recommended that the NOS prepare and provide the bulk of the inputs (both original material and subsequent revisions), and that these be on machine-readable storage media. Personnel at the local ACCC/ISSS would manually enter small local changes, via a data terminal, for transmission to the SSCC for subsequent entry into the central data base. Such changes, after storage in the central AAS static display data base, would be transmitted back to the data base(s) of the originator as well as to any other specified users.

It is recommended that software for data checking, correction, and handling in the SSCC and for data transfer to the local ATC facilities be provided by the AAS contractor. Also, software for all functions related to the local display of the static information should be provided by the contractor.

5.2 Needs For Further Analysis

The MITRE surveys and findings have identified several important areas requiring further analyses, beyond the scope of the current study. These areas include: (1) input and output formats of the static data and (2) the specific display of static data at TCCC Position Consoles.

5.2.1 Digital Data Input/Output Formats

Requirements regarding types and formats of digital inputs to the central AAS static information data base and static data display procedures must be further evaluated and, in some instances, clarified and expanded.

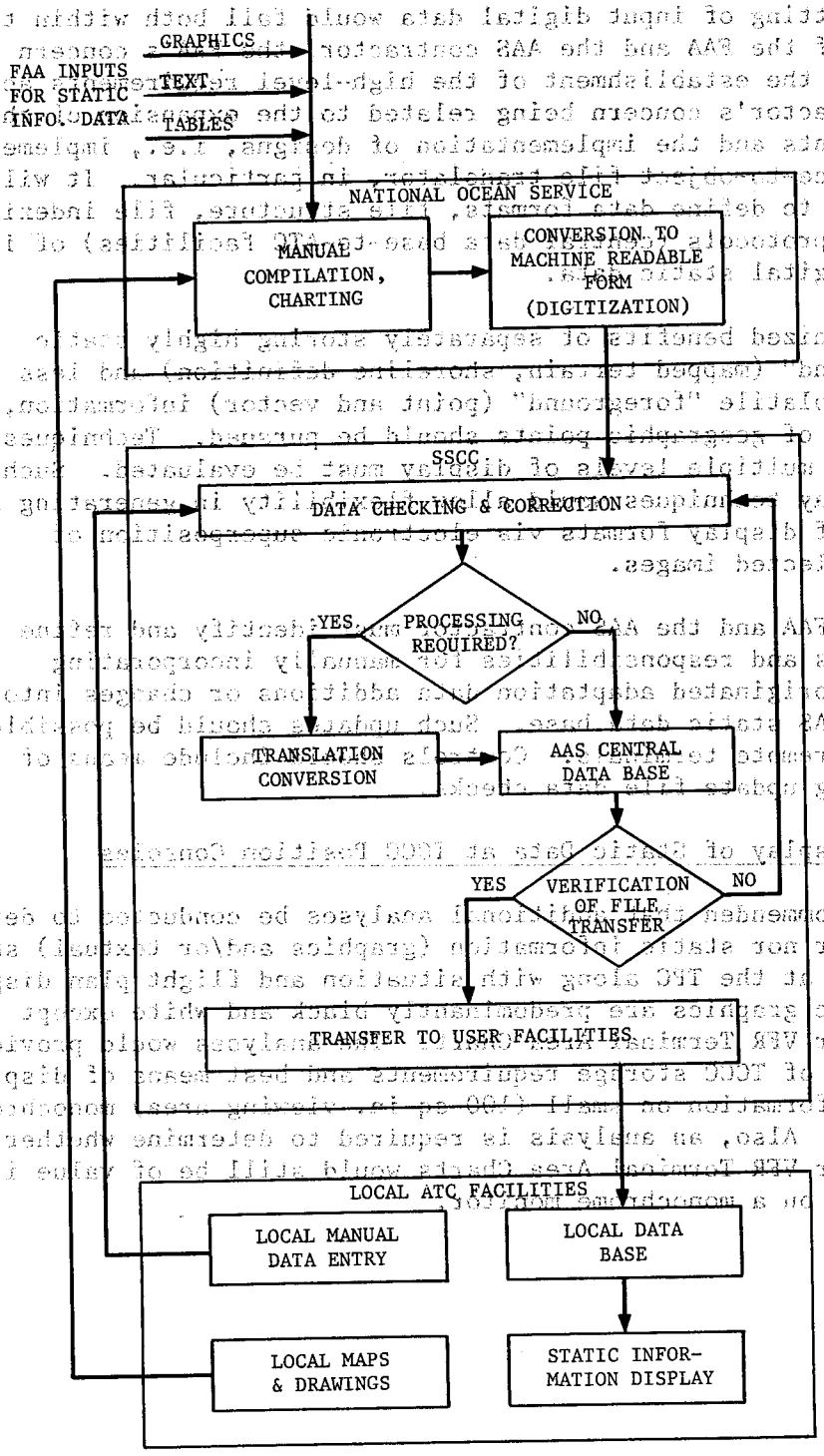

FIGURE 5-1
STATIC INFORMATION DATA HANDLING

The formatting of input digital data would fall both within the purview of the FAA and the AAS contractor, the FAA's concern being primarily the establishment of the high-level requirements and the AAS contractor's concern being related to the expansion of the requirements and the implementation of designs, i.e., implementation of a source-to-object file translator, in particular. It will be necessary to define data formats, file structure, file indexing, and transfer protocols (central data base-to-ATC facilities) of input and output digital static data.

The recognized benefits of separately storing highly static "background" (mapped terrain, shoreline definition) and less static or more-volatile "foreground" (point and vector) information, entered as tables of geographic points should be pursued. Techniques for achieving multiple levels of display must be evaluated. Such storage and display techniques would allow flexibility in generating a breadth of display formats via electronic superposition of viewer-selected images.

Both the FAA and the AAS contractor must identify and refine the procedures and responsibilities for manually incorporating facility-originated adaptation data additions or changes into the central AAS static data base. Such updates should be possible to enter at remote terminals. Controls should include means of conducting update file data checks.

5.2.2 Display of Static Data at TCCC Position Consoles

It is recommended that additional analyses be conducted to determine whether or nor static information (graphics and/or textual) should be displayed at the TPC along with situation and flight plan displays. The static graphics are predominantly black and white except for the five-color VFR Terminal Area Chart. The analyses would provide estimates of TCCC storage requirements and best means of displaying static information on small (100-sq-in. viewing area) monochrome monitors. Also, an analysis is required to determine whether or not multicolor VFR Terminal Area Charts would still be of value if displayed on a monochrome monitor.

APPENDIX A

CANDIDATES FOR STATIC DISPLAY

DATA TYPE	SOURCE	CURRENT FORM	NUMBER	PUBLISH CYCLE	REMARKS
Minimum-Altitude Floors	FAA	Hard Copy	-	-	Locally produced by cartographic personnel; Controller Charts are the base maps.
Standard Operating Procedures Manual (SOP)*	FAA	Handbook	1 per facility	-	Individual operational support tools for use at given facilities--not standardized, nationwide.
Letters of Agreement (LOA)*	FAA	Letter file, often bound	-	-	Maintained in notebooks by parties to specific agreements. Some letters in effect for only brief periods.
"Air Traffic Control", Order 7110.65*	FAA	Controllers' Handbook	1	Republication, as req'd, at approx. 2-1/2-yr interval, with 112-day updates.	Prescribed procedures and phraseology for air traffic controllers.
NAVAID/Sector Frequencies*	FAA	-	-	-	Depicted by NOS on selected chart series but not tabulated or updated separately on regular basis. On special request from en route facilities NOS customizes tabulation for overhead display.
Position Checklists*	FAA	Tabular Card	1 per position	-	Includes long-standing operational procedures at start of shift; instructions locally prepared and applicable to given controller position.

DATA TYPE	SOURCE	CURRENT FORM	NUMBER	PUBLISH CYCLE	REMARKS
En Route Low Altitude Chart ("RF Chart")	NOS	Hard Copy	28 Plates	56 days	1" = 12 n mi scale--about half that of a CC. A blueline, with MOAs and Military Training Routes in brown. For en route navigation (IFR) in the low altitude stratum. (Area Charts, above, are part of this series but show terminal data at a larger scale). Useful to controllers, and often placed for overhead viewing at radar positions.
En Route High Altitude Chart	NOS	Hard Copy	4 Plates-- 2 each, per chart	56 days	1" = 38.6 n mi Similar to the "En Route Low Altitude Charts", above, but for IFR navigation above 18,000' MSL.
Sectional Aeronautical Chart	NOS	Hard Copy	37 for conterminous U.S.	Semi-annually	1:500,000 scale. Topographic information to support visual navigation of slow/med.-speed aircraft. Five-color, for elevations, plus shading for relief. Charted from an overlay of about 40 plates. Frequently used in mountainous centers.

DATA TYPE	SOURCE	CURRENT FORM	NUMBER	PUBLISH CYCLE	REMARKS
"Airport/Facility Directory" (A/FD)	NOS	Regional volumes	7	56 days	A pilot's operational manual on ground-and sea-based facilities. Set covers conterminous U.S., Puerto Rico, and U.S. Virgin Islands.
"Airman's Information Manual"	NOS	Handbook	1	16 weeks	Operational instructions for pilots.
"Location Identifiers", Order 7350.5	FAA	Handbook	1	112 days	A listing of U.S. airspace fix designators and procedure codes. The identifiers substitute for the name and location of airports, NAVAIDs, weather stations, and manned ATC facilities.
"Facility Operations and Administration", Order 7210.3	FAA	Handbook	1	Approx. 2.5 yr, with 112-day updates	Instructions, standards, and guidance for operating/managing air traffic service facilities.
Emergency Operations Manual	FAA	Binder	1 per facility	-	Site-specific collection of emergency operational procedures.
Sunrise/Sunset Table	FAA	Sheet	1	-	To be used only in terminal facilities

* Static Display Candidate listed in AAS System Level Specification.

DATA TYPE	SOURCE	CURRENT FORM	NUMBER	PUBLISH CYCLE	REMARKS
VFR Terminal Area Chart	NOS	Hard Copy	Order of 25	Semi-annually	Five-color charts, 1:250,000 scale. The use and format similar to that of "Sectional Aeronautical Chart", above, but for terminal control area airspace. TCCC use.
North Atlantic Route Chart	NOS	Hard Copy	1	24 weeks	1:5,500,000 scale. For use by Air Traffic Controllers in monitoring oceanic flights. Five-color, depicting land areas, routes, control boundaries.
Pacific Route Chart	NOS	Hard Copy	1	N/A	Publication pending.
Noise Abatement Zones	NOS	Hard Copy	-	-	TCCC use. For compliance with noise regs. Not a regular publication.
Airport Search and Rescue Chart	NOS	Hard Copy	1 per airport	-	1 in. = 2 stat. mi. Multi-color chart. TCCC use.
Helicopter Control Chart	FAA	Hard Copy	Several at some towers	-	Routes and altitudes vs zones. TCCC use.
Low-Altitude Instrument Approach Procedures	DOD	Books	-	-	Similar to IAP (with approx. 80% NOS overlays). Pertain just to military terminals, not civil and joint-use. Cartography standards are consistent in each.

DATA TYPE	SOURCE	CURRENT FORM	NUMBER	PUBLISH CYCLE	REMARKS
Special Area Map	NOS				NOS-Produced video map backgrounds selected by panel keys on the present Main Display (PVD). Not a Static Display.
Standard Terminal Arrival Routes (STARs)/Profile Descents	NOS	1 book	161 Plates	56 days	Preplanned Instrument Flight Rule (IFR) arrival procedure in graphic and textual form. Controller utilization of STARs slightly decreasing with time per Air Traffic Service.
Military Training Routes (MTR)*	DOD	Digitized Geographic Points (GP) of route centerlines, in NOS file	-	56 days	Prepared locally by center cartographers as overlays for Controller Charts. Published by NOS on some visual charts (e.g., en-route low altitude).
Airport Layouts*	FAA	Hard Copy	-	-	Not an official chart series. Frequently drawn by FAA cartographers at enlarged scales for local use at terminals.
Airport Diagrams	NOS	Hard Copy (in IAP)	286 plates	56 days	Previously termed "Airport Taxi Charts" are included in IAP produced by NOS. Mostly used at TCCC.
Circling Approach Area Chart*	-	-	-	-	Not identified as a formal NOS published product. Terminal facilities prepare and utilize locally. Placed in operational handbooks.

DATA TYPE	SOURCE	CURRENT FORM	NUMBER	PUBLISH CYCLE	REMARKS
Holding Pattern Airspace*	NOS	Digitized GP	-	56 days	Superimposed, using the NOS digital data file, on most series of charts, e.g., Controller and En Route Charts and Approach Plates. ACCC/ISSS use.
Standard Instrument Departures (SID)/ Departure Procedures*	NOS	2 books	457 Plates	56 days	Preplanned IFR Departure procedures in graphic and textual form. Contained in two books: Eastern and Western U.S. Used infrequently by controllers. Available at Centers in hard copy.
Airport Visibility Checkpoints*	FAA-drawn/ NWS-certified	Map	1 per tower	As req'd	Used in TCCC. Drawn by Tower Controllers on selected base maps for identification, in hazy conditions, of features still visible and their distances from the tower.
Control Zone Obstruction Chart*	FAA	-	-	As req'd	Used in TCCC, produced by some local terminal facilities to support local operations. Near-terminal obstruction are formally published by NOS via plotting GP's on IAP Plates.
Airport Obstruction Chart	NOS	Hard Copy	743 Plates	As req'd (Typ. 2-5 yr.)	Has potential use in TCCC. Layouts based on High-precision NOS surveys. Major application in airport planning.

DATA TYPE	SOURCE	CURRENT FORM	NUMBER	PUBLISH CYCLE	REMARKS
Instrument Approach Procedures (IAP), Approach Plate* (Black & White)	NOS-- Natl. Ocean Service	15 books (CONUS)	5241 Approach Plates	56 days; 28-day Change Notice (CN)	Portray Aeronautical Data which is required to execute an instrument approach to an airport; three distinct areas are shown on the chart: - A plan view with terminal routes, holding pattern, minimum safe altitude, reporting points/fixes, obstacles - A vertical profile - An airport sketch Other information contained in IAP books: - Airport Diagrams (see below) - IFR take-off minimums and departure procedures Infrequently used now in en-route ATC. En-route controllers as well as terminal controllers often maintain binders of local IAPs.
FAA Controller Chart (CC)* (Black & White) (Except Alaska)	NOS	Paper Chart; translucent, for backlighting	55 Charts incl. AK, HI, Puerto Rico	56 days; 28-day CN	Most frequently used chart by en-route controllers includes air routes, NAVAIDs, and NAVAID radio frequencies, intersections, fixes, minimum en-route altitudes, distance between NAVAIDs. Locally prepared overlays can be called out by the controller, e.g., military training routes, holding pattern airspace, sector boundaries, special direct routes.

DATA TYPE	SOURCE	CURRENT FORM	NUMBER	PUBLISH CYCLE	REMARKS
FAA Controller Chart (cont.)					Comes in different scales; most frequent: 1:500,000 high and low altitude routes combined on most charts. Three separate charts for high altitude only at 1:1,700,000. Chart printed from four photo plates in black and shades of gray.
Sector Chart*	NOS, by special request	Transparency	1 Conterminous US	4-5 per year	Generally prepared locally as line overlays on controller charts. NOS produces as transparency a low-, a high- and an ultra-high-altitude sector boundary chart for the contiguous United States with four to five updates per year. Distributed to all En-route facilities but not normally used by controllers.
Area Charts-U.S.	NOS	Foldout plate	1 sheet of 13 charts	56 days	Blueline/brownline detailed chart of selected terminal areas, similar to Controller Charts but increased detail; little used in current control; primarily an aid to navigation in the air. Supplements En-route Low Altitude-U.S. Charts. Scale: 1" = 5 to 8 n mi; includes radio freqs. at terminals.

APPENDIX B

INFORMATION SOURCES

Author contacts to obtain static display information included the FAA, NOAA/NOS, the USGS, and the Intergraph Corporation.

Federal Aviation Administration (FAA)

Points of contact within the FAA included:

1. National Flight Data Center (NFDC) -- David Thompson, Cartographic Standards Section. (Data origination; recommended subsequent contacts associated with flight data preparation.)

2. Air Traffic Service (ATR) -- John White, ATR-150. (Nationwide overview of controller support material.)

3. AAS Requirements Assessment Team (AASRAT) -- (Joint observations and suggestions regarding controller "static" support materials vis-a-vis AAS specifications on Static Display Information.)

4. ATC Facilities -- Washington National Airport, Dulles International Airport, Baltimore-Washington International Airport Terminals; Washington Center, Denver Center, Salt Lake Center and New York Center. (Observation of "static" displays and materials and their operational use.)

National Oceanic and Atmospheric Administration - National Ocean Service (NOS)

Contacts within the Aeronautical Charting Division, NOAA/NOS, included:

1. Aeronautical Chart Branch -- Ronald Bolton, Chief. (FAA chart compilation, production, digitization.)

2. Office of Charting and Geodetic Services -- Cdr. David Goehler, Chief, Requirements and Technology Staff. (Advanced cartographic technology in chart digitization, including laser optical disks.)

United States Geological Survey (USGS)

The office visited within the USGS was:

1. Eastern Mapping Center -- Gary Fairgrieve and Eileen Doughty, Map Digitization. (Multicolor raster scanning of U.S. quadrangle maps, followed by digital conversion to a vector representation.)

Intergraph Corporation

Corporate hosts included:

1. McLean, Virginia Office -- Douglas Whall, Federal Account Manager. (Display of color raster scanned Sectional Aeronautical Chart segment for observation by FAA ATC specialists and MITRE Corporation personnel.)

2. Huntsville, Alabama headquarters -- Heidi Schweikart, Scanning and Image Processing; Nora Evans, Scanned Data Processing. (Description of the color raster scanning process and preliminary presentation of output images on an Intergraph work station monitor.)