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Air Traffic Display Data Recording and Recreation

H. B. Rossach et al.

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16. Abstract

This paper presents existing and potential technologies for recording, reprocessing and dynamically recreating radar data and flight data information displayed to an air traffic controller. Descriptions, costs and schedules of enhanced and new techniques are presented. Retrack, which is currently available for ARTS III, ARTS IIIA, New York TRACON, EARTS, and TAMPA/SARASOTA, is described. New technologies which are discussed include the Display Recording and Playback System of the Initial Sector Suite of the Advanced Automation System, the En Route radar display recording system (ERDIRS), direct video recording, and BRITE.

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EXECUTIVE SUMMARY

1. INTRODUCTION

The purpose of this paper is to present existing and potential technologies for recording, reprocessing, and dynamically recreating radar data and flight data information displayed to an air traffic controller. Descriptions, costs, and schedules of enhanced and new techniques are presented.

In the Administrator's recent memorandum on Federal Aviation Administration (FAA) accident/incident investigation policy, he specifically discusses the analysis of Automated Radar Tracking System (ARTS) III data in accident/incident investigations and the use of a program called Retrack.

The Administrator notes that, although the Retrack Program, available at the FAA Technical Center, is not specifically a tool for the dynamic recreation of ARTS-III radar data; the computer program may have accident investigation and aviation safety potential in certain situations. He further states that there is a need for reliable computer programs which can accurately and repeatedly display recreations of En Route and ARTS-II as well as ARTS-III radar data in a dynamic presentation and that these programs will be developed on a priority basis.

This paper describes the Retrack Program and presents alternative solutions to the development of techniques to record and dynamically recreate aircraft information that was displayed to the air traffic controller.

1.1 SUMMARY OF ALTERNATIVES

The Display Recording and Playback System (DRPS) of the Initial Sector Suite System (ISSS) of the Advanced Automation System (AAS) saves all data, including display control settings required for a complete display recreation for the En Route and Terminal environment. It provides the only technique which can completely satisfy the requirement for a recording and dynamic display recreation capability in either the Terminal or En Route environment.

A capability now exists in the Terminal area to record, reprocess and redisplay aircraft information. ARTS III, ARTS IIIA, New York TRACON, En Route Automated Radar Tracking System (EARTS), and Tampa/Sarasota all have a Retrack capability. The Retrack approach is extremely attractive since the software exists for most of the systems and only the documentation needs to be strengthened. Retrack does not have to be deployed at any field site and does not require any additional hardware purchases.

One potential interim solution in the En Route area is to purchase instrumentation recorders to collect live radar data from the field. This data, together with System Analysis Recording (SAR) data from the field could be used to recreate the En Route displays. The difficulties of replaying this data at either an Air Route Traffic Control Center (ARTCC) or at the Technical Center reduces the attractiveness of this alternative. Controller display settings are also not available using this technique.

The En Route Radar Display Recording System (ERDIRS) was investigated for use in both the En Route and Terminal environments. This system extracts data for recording from the display generator unit (DGU) which supplies the digital input to 6 Plan View Displays (PVD's). Two high density digital recorders operate in a sequential mode.

On playback, each recorded frame is repeatedly displayed until a new frame is retrieved from the recording. Each sampled frame is recreated exactly as it was originally presented to the controller.

It should be noted that currently the National Transportation Safety Board (NTSB) utilizes the National Track Analysis Program (NTAP) for accident/incident investigation in the En Route area. NTAP uses SAR tapes as input to prepare plots of selected areas, tracks, time intervals, geographical and weather data and untracked radar targets. A similar capability could be developed for the Terminal area using the data extraction tapes from the on-line systems as input to the plotter program. Unlike NTAP, the Terminal plotter routines would utilize the CALCOMP drum plotter rather than using a high speed printer for graphic output. It is estimated that a plotting capability for ARTS IIA could be provided, under contract, for $130,000 in a period of 11 months.

1.1.1 Terminal Transition to Terminal Advanced Automation System (TAAS)

Although the only complete solution to the recording and display recreation issue in the Terminal environment is TAAS, it appears that Retrack offers an attractive interim alternative. A comparison of cost and schedule for the ERDIRS versus the Retrack option is shown in table 5-1. As seen in the table, ERDIRS would not be cost beneficial in the Terminal environment. ERDIRS does provide controller settings while Retrack does not, but neither system is able to provide broadband information during display recreation. If cost is a major concern, the ARTS IIA plot capability combined with Retrack for the other Terminal areas and EARTS might be worth considering.

1.1.2 En Route Transition to ISSS

As in the case of the Terminal environment, the only complete solution to the recording and display recreation issue in the En Route environment is ISSS. Development of the ERDIRS would also provide the required capability in the En Route environment. Table 5-2 presents a comparison of the schedules and cost required to implement both techniques. As shown, ERDIRS could not be implemented in the En Route environment more than 1 year prior to ISSS.

The use of instrumentation recorders to collect live radar data together with the SAR data also provides a viable alternative in the En Route area. As noted above, controller display settings are not available. The difficulties of replaying these data at either an ARTCC or at the Technical Center reduces this option's attractiveness. However, as seen in table 5-2, the cost and implementation schedule for this option would suggest further study.

The alternative of using NTAP should not be overlooked for the En Route system. It is currently used by NTSB during incident/accident investigations and is already in place.

1.2 CONCLUSIONS

After review of the technologies discussed in this paper, it is obvious that the Initial Sector Suite System/Advanced Automation System (ISSS/AAS) technology will satisfy the display recreation requirement in the long term. The requirement is to bridge the gap with an interim solution between the present and the implementation of the ISSS/AAS displays which is scheduled for the 1993-1994 time frame.

The Terminal Advanced Automation System (TAAS) technology as specified in the requirement document will provide the required Terminal recording and display recreation in the long term. The Retrack technology is recommended for the transition period for the Terminal and En Route Automated Radar Tracking System (EARTS). Retrack is currently available for use for Automated Radar Tracking System (ARTS) III, ARTS IIIA, Tampa/Sarasota, New York TRACON and EARTS. The total cost of $610,000 and related schedule to upgrade the documentation for the existing Retrack software, upgrade Retrack for EARTS Mosaic,and develop Retrack for ARTS IIA and EARTS Mosaic are convincing arguments to utilize the Retrack technology in the Terminal area. It should also be noted that the NTSB has availed itself of Retrack to investigate previous incidents/accidents and NTSB has a current request for the FAA to redisplay the Air Mexico midair crash. If a static representation of data would be acceptable for ARTS IIA, a combination of a plot capability for ARTS IIA and Retrack for all

other Terminal Systems and EARTS might be the solution at a total cost of $240,000.

The ISSS technology as specified in the requirements document will provide the required En Route recording and display recreation capability in the long term. There are two technologies that are potential candidates to provide an interim solution for recording and display recreation. One technology is the installation of instrumentation recorders at the ARTCC's to collect radar data. The data could then be played back through the En Route system in conjunction with the corresponding SAR tapes to provide the display recreation. Further investigation of this technology is necessary to determine if adaptation shortcuts can be achieved and if state-of-the-art instrumentation recorders are more easily maintained than previously experienced. Cost and schedule ($2,800,000 and 18 months) make this approach worth further study. The other approach is the ERDIRS technology which satisfies the requirement and is more attractive from a user point of view. The entire En Route system is not needed to recreate the incident/accident. Only the playback hardware of the ERDIRS and a display is necessary. If the procurement cycle for this technology could be significantly reduced and personal computer (PC) type technology could be applied to this approach to shorten the development time, ERDIRS would be the way to go. The benefits of this approach warrant further study of technological advances to determine whether the schedule in table 5-2 could be significantly reduced. The cost and schedule figures for ERDIRS are $11,200,000 and 72 months. If a static representation would be acceptable, the NTAP program already in place would satisfy the requirement at no cost.

2. INTRODUCTION

2.1 PURPOSE

The purpose of this paper is to present existing and potential technologies for recording, reprocessing, and dynamically recreating radar data and flight data information displayed to an air traffic controller. Descriptions, costs, and schedules of enhanced and new techniques are presented.

2.2 BACKGROUND

In the Administrator's recent memorandum on Federal Aviation Administration (FAA) accident/incident investigation policy, he specifically discusses the analysis of Automated Radar Terminal System (ARTS)-III data in accident/incident investigations. In this memorandum, he states that FAA policy for the analysis and recreation of ARTS-III data in accident/incident investigations is as follows:

> "An automation investigative group will be established to perform a 'line-by-line' analysis of the radar data for the time in question and manually plot the radar data. The analysis of the radar and the manual plot of the data will be provided to the NTSB for inclusion in the public docket. Once this analysis is completed, the ARTS-III radar data will then be rerun through the 'Retrack Program' for the NTSB air traffic control group and the automation group to review."

The Administrator notes that, although the Retrack Program, available at the FAA Technical Center, is not specifically a tool for the dynamic recreation of ARTS-III radar data, the computer program may have accident investigation and aviation safety potential in certain situations. He further states that there is a need for reliable computer programs which can accurately and repeatedly display recreations of En Route and ARTS-II as well as ARTS-III radar data in a dynamic presentation and that these programs will be developed on a priority basis.

This paper describes the Retrack Program and presents alternative solutions to the development of techniques to record and dynamically recreate aircraft information that was displayed to the air traffic controller.

2.3 OVERVIEW

Before techniques to record, reprocess, and dynamically redisplay radar and flight data information can be discussed, the basic components of both the En Route and Terminal air traffic control (ATC) systems need to be introduced. As can be seen from figure 1-1, a simplified ATC system consists of a sensor component, i.e., radars, the computer complex, and a display component, i.e., the controller display area. The actual data presented on the displays is received from the sensor, processed by the computer complex, and presented to the controller. The presentation can be modified by the controller.

The data items which must be recorded to accurately recreate the aircraft situation include: primary radar data (untracked), correlated primary radar data (tracked), uncorrelated beacon data (untracked limited data block (LDB)), correlated beacon data (tracked LDB), identifying beacon data (tracked or untracked LDB), and full data block (FDB) (tracked) data. Keyboard data and interfacility data should also be recorded.

In addition, display console settings, which can be activated by the controllers to alter their displays, should be recorded. These include map centering keys, display filter keys, field select keys for FDB's, history, display range, and leader length from FDB to position symbol.

Basically, the further the recording point is from the display, the more reprocessing is needed to recreate the data and the greater the possibility for the introduction of deviations.

Figure 1-1 shows where recording can or does occur in the simplified ATC system. The magnetic tape symbol indicates where in the real-time operational system the required data are recorded. As shown in the figure, the live radar data from the sensor could be recorded prior to being fed into the computer complex. Data could be recorded as it is being processed in the computer complex. This is currently being done in both the Terminal and En Route systems. The data could also be recorded just prior to being fed to the displays. Finally, data could be recorded at the display itself.

If the data is not recorded just prior to the display or at the display itself, then the display console settings are not available and cannot be recorded.

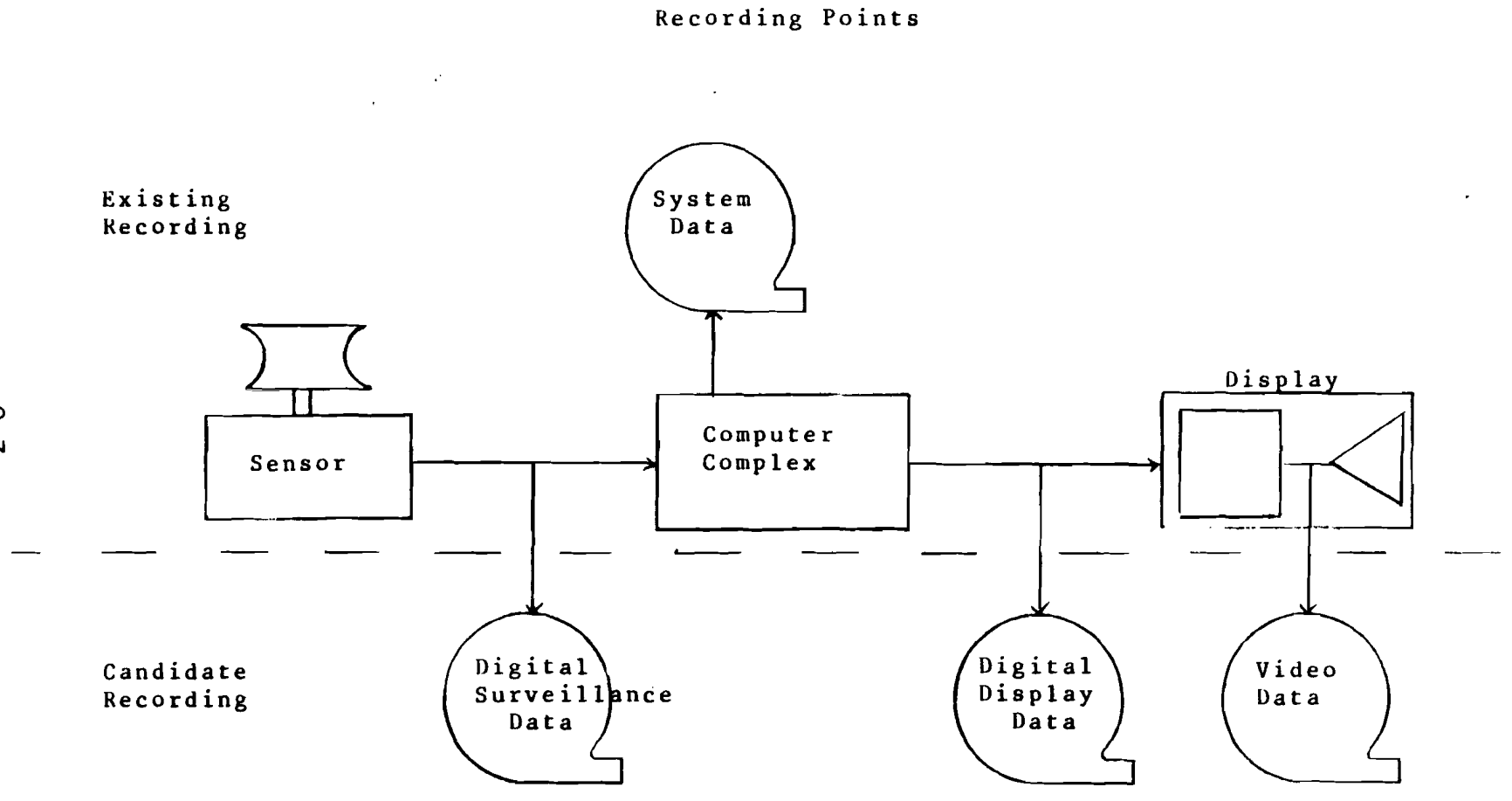

FIGURE 1-1. SIMPLIFIED AIR TRAFFIC CONTROL SYSTEM

In this paper several techniques that have the capability to record most of the required data, to reprocess these data, and then redisplay it on the controller's data display in a dynamic fashion will be discussed. Most of the techniques have limitations concerning display control settings. These limitations will be discussed in the individual descriptions of the various techniques.

2.4 RETRACK

During the development of the Terminal Minimum Safe Altitude Warning (MSAW) software, it was determined that there was a need for the capability to accurately repeat traffic situations during testing. An analysis of the recorded data revealed that it contained the information necessary to drive the system. The software program, Retrack, was developed to provide the driver capability. Retrack processes the recorded data, reformats it to the normal live input formats, and inserts it back into the operational program. The reprocessing and redisplay is accomplished by the operational program the same as during normal live operation. It must be emphasized that with the Retrack capability only digitized data can be played back. The broadband radar blips and beacon slashes that are normally displayed on ARTS II and ARTS III are not recorded and are not available for redisplay. Retrack uses system time as a reference for start time via keyboard entry. Retrack can selectively be run for any time on a given recording of tape or disk. The system has been used in the past by the National Transportation Safety Board (NTSB) for incident investigations and there is a current request to do more of the same. Retrack is introduced here because it is continually used in the Terminal environment and because it is frequently referenced in the following pages. A complete description of Retrack is provided in appendix A.

2.5 SCOPE

Section 3 of the report addresses the currently existing technologies such as Retrack which are available for providing dynamic recreations of aircraft information in the Terminal and En Route environment.

For each Terminal and En Route system the capabilities to record, to reprocess, and to redisplay the aircraft information are discussed. The tools available to assist the analysis of the data for each system are also discussed. These analysis tools are particularly pertinent for the En Route environment since there is currently no capability to fully recreate the display data from the recorded data.

Requirements necessary to bring each of the Terminal and En Route systems to the Retrack level are identified and quantified. Implementation costs and schedules for the upgrades are discussed as are other issues which should be considered before a decision to upgrade is made. A discussion on upgrading of plotting capabilities for the systems is also included.

Section 4 of the report discusses new technologies which could be employed to record, reprocess, and to redisplay the aircraft information. These technologies include a digital display recording and playback system referred to as En Route Radar Display Recording System (ERDIRS), a direct video recording technology, Bright Radar Indicator Tower Equipment/Digital BRITE (BRITE/DBRITE) recording and finally, the technology to be introduced by the Initial Sector Suite System (ISSS)/Advanced Automation System (AAS).

For each system a description of the technology is presented together with its requirements. The En Route or Terminal environment for which the technology would apply is then discussed. The cost of each is presented as is a schedule for its implementation. Finally, any constraints or limitations which should be considered are delineated.

Section 5 contains a summary of the report. The various alternatives are examined and compared. Cost, schedules, and risks associated with each approach are discussed together with their relationship to the ISSS/AAS schedule and requirements.

The final section contains conclusions.

3. SYSTEMS CAPABILITIES

3.1 OVERVIEW

This section of the report addresses the currently existing technologies such as Retrack which are available for providing dynamic recreations of aircraft information in both the Terminal and En Route environments. The systems discussed include: ARTS II, ARTS IIA, ARTS III, ARTS IIIA, New York TRACON, Tampa/Sarasota, ARTS IIIE, EARTS, EARTS Mosaic, Host, and the 9020 En Route.

The 9020 and Host En Route systems are discussed together since the methods of recording, reprocessing, and recreation of display data are the same for both. The difference is in the hardware in which the systems reside, i.e., an IBM 9020 computer versus an IBM 3083 computer. The controller displays and interfaces are the same for both systems.

In the first part of this section, the capabilities to record, reprocess, and redisplay the aircraft information for each system is discussed. The tools available to assist the analysis of the data for each system is also discussed. These analysis tools are particularly pertinent for the En Route environment since there is currently no capability to recreate the display data from the recorded data.

In the second part of this section, requirements necessary to bring each of the En Route and Terminal systems to the Retrack level are identified and quantified. Implementation costs and schedules for the upgrades are discussed as are other issues which should be considered before a decision to upgrade is made.

The third part contains a discussion on upgrading of plotting capabilities for the systems.

3.2 CURRENT DISPLAY RECREATION CAPABILITIES

3.2.1 Overview

The purpose of this section is to describe the "display recreation" and support capabilities that exist in current and planned systems.

"Display recreation" is defined as having three major components: recording, reprocessing and redisplay. Each of the ATC systems is examined to determine the presence of such capabilities. A fourth section lists available automated or manual analysis tools that aid in aviation accident and incident investigations. Although not a part of the display recreation function, the use of

these tools is included as part of the FAA policy established in the Administrator's letter.

Table 3-1 is a summary of the data presented in this section.

AIR TRAFFIC CONTROL FACILITIES

DISPLAY RECREATION CAPABILITIES	* ARTSII	ARTSIIA	** ARTS III	ARTSIIIA TYPE	NY TRACON ARTSIIIE	EARTS	EARTS MOSAIC	HOST 9020
A. RECORDING CAPABILITY	YES	1988	YES	YES	1988	YES	1988	YES
1. SENSOR DATA	YES	YES	YES	YES	YES	YES	YES	NO
a. PRIMARY	NO	NO	NO	YES	YES	YES	YES	NO
b. BEACON	YES	YES	YES	YES	YES	YES	YES	NO
2. TRACK DATA	YES	YES	YES	YES	YES	YES	YES	YES
3. KEYBOARD DATA	YES	YES	YES	YES	YES	YES	YES	YES
4. INTERFACILITY	YES	YES	YES	YES	YES	YES	YES	YES
5. DISPLAY SETTINGS	NO	NO	NO	NO	NO	NO	NO	NO
B. REPROCESSING	NO	NO	RETRACK	RETRACK	RETRACK	RETRACK	NO	NO
C. REDISPLAY	NO	NO	YES	YES	YES	YES	NO	NO
D. ANALYSIS TOOLS	NO	YES	YES	YES	YES	YES	YES	YES
1. AUTOMATED	*****	NO	NO	NO	NO	NO	YES	YES
2. MANUAL	*****	YES	YES	YES	YES	YES	YES	YES
E. NUMBER OF SITES	88	119	*** 23	****40	1	4	4	20

TABLE 3-1. CURRENT DISPLAY RECREATION CAPABILITIES

* ARTS II SCHEDULED TO BE REPLACED BY ARTS IIA SYSTEMS
** ARTS III CURRENTLY BEING REPLACED BY ARTS IIIA SYSTEMS
*** ARTS III SITES REMAINING TO BE CONVERTED TO ARTS IIIA SYSTEMS
**** ARTS IIIA SITES CURRENTLY OPERATIONAL INCLUDING NEW YORK TRACON AND TAMPA/SARASOTA
***** LIMITED CAPABILITY FOR DIAGNOSTIC PURPOSES

3.2.2 ARTS II

3.2.2.1 Implementation.

The ARTS II is currently implemented at 88 sites throughout the country. There is no planned expansion of the ARTS II system to other airports.

3.2.2.2 Recording Capability.

The ARTS II currently has a limited recording capability for diagnostic purposes.

3.2.2.3 Reprocessing.

The ARTS II does not have a reprocessing capability such as Retrack.

3.2.2.4 Redisplay.

The ARTS II does not have a redisplay capability.

3.2.2.5 Required Analysis.

There is a limited diagnostic analysis capability for the ARTS II.

3.2.3 ARTS IIA

3.2.3.1 Implementation.

The ARTS IIA is planned for implementation at 119 sites across the country. This includes implementation at all 88 existing ARTS II sites, and all 31 existing TPX-42 sites. Implementation of the ARTS IIA is scheduled to begin June 1987 and be completed May 1988.

3.2.3.2 Recording Capability.

The ARTS IIA will have the capability of recording system data onto data extraction tapes during normal operation. The system data recorded can include sensor data which consists of scan timing data and beacon target data, associated track data, controller keyboard messages, and interfacility input and output messages.

Display console control and switch settings are not and cannot be recorded. These include range scale, intensities, decentering,

character size, leader length, filters, field inhibits, and quick-looks.

3.2.3.3 Reprocessing.

The ARTS IIA will not have a reprocessing capability such as Retrack.

3.2.3.4 Redisplay.

The ARTS IIA will not have a redisplay capability.

3.2.3.5 Required Analysis.

There will be no automated analysis tools available for the ARTS IIA. Line by line analysis and manual plotting of recorded data will be available.

3.2.4 ARTS III

3.2.4.1 Implementation.

Of the 62 ARTS III sites which were originally commissioned, there are 39 sites which have been changed over to the ARTS IIIA. The remaining 23 sites are planned for changeover by late 1988.

3.2.4.2 Recording Capability.

The ARTS III has the capability of recording system data, during normal operation, onto data extraction tapes. The system data recorded can include sensor data which consists of scan timing data and beacon target data, associated track data, controller keyboard messages, and interfacility input and output messages.

Display console control and switch settings are not and cannot be recorded. These include range scale, intensities, decentering, character size, leader length, filters, field inhibits and quick-looks.

3.2.4.3 Reprocessing.

The capability exists to reprocess recorded ARTS III data using the Retrack program. Retrack is an off-line capability that drives the system during a non-operational time period. Retrack retrieves the recorded data from disc or tape and feeds (drives) it back into the operational system the same as if it were live data.

Retrack inserts the recorded data in the appropriate operational program input areas. These data that have been inserted by Retrack are processed and displayed by the operational system the same as if it were a "live" operation. A complete description of Retrack is contained in appendix A.

3.2.4.4 Redisplay.

The capability exists for the ARTS III to accept, process and display the reprocessed data the same as during normal live operation.

3.2.4.5 Required Analysis.

There are no automated analysis tools available for the ARTS III. Line by line analysis and manual plotting of system data are available.

3.2.5 ARTS IIIA Type Systems (ARTS IIIA, New York TRACON, Tampa/Sarasota)

3.2.5.1 Implementation.

The number of ARTS IIIA type systems currently in commission is 40. This includes the New York TRACON and 39 ARTS III sites which have been changed over to the ARTS IIIA type system. The remaining 23 ARTS III sites are planned for switchover to the ARTS IIIA system by late 1988 for a total of 63 ARTS IIIA sites.

3.2.5.2 Recording Capability.

The ARTS IIIA type system will have the capability of recording system data during normal operation onto Continuous Data Recording (CDR) discs or tapes, whichever is available. The system data recorded can include sensor data which consists of scan timing data, primary radar targets, beacon targets and radar reinforced beacon targets. In addition, associated track data, unassociated track data, controller keyboard messages and interfacility input and output messages can also be recorded.

Display console control and switch settings are not and cannot be recorded. These include range scale, intensities, decentering, character size, leader length, field inhibits and quick-looks.

3.2.5.3 Reprocessing.

The capability exists to reprocess (Retrack) recorded ARTS IIIA data consisting of sensor, track, keyboard and interfacility data.

3.2.5.4 Redisplay.

The capability exists for the ARTS IIIA System to accept, process and display the reprocessed data the same as live data received during normal operation.

3.2.5.5 Required Analysis.

There are no automated analysis tools available for ARTS IIIA. Line by line analysis and manual plotting of recorded system data are available.

3.2.6 ARTS IIIE

3.2.6.1 Implementation.

The ARTS IIIE is currently planned for implementation in early 1988 replacing the existing New York TRACON ARTS IIIA system.

3.2.6.2 Recording Capability.

The ARTS IIIE system will have the capability of recording system data, during normal operation, onto CDR discs or tapes, whichever are available. The system data recorded can include sensor data which consists of scan timing data, primary radar targets, beacon targets and radar reinforced beacon targets. In addition, associated track data, unassociated track data, controller keyboard messages, and interfacility input and output messages can also be recorded.

Display console control and switch settings are not and cannot be recorded. These include range scale, intensities, decentering, character size, leader length, field inhibits, and quick-looks.

3.2.6.3 Reprocessing.

The capability will exist to reprocess (Retrack) recorded ARTS IIIE data consisting of sensor, track, keyboard and interfacility data.

3.2.6.4 Redisplay.

The capability will exist for the ARTS IIIE to accept, process and display the reprocessed data the same as live data received during normal operation.

3.2.6.5 Required Analysis.

There are no automated analysis tools available for ARTS IIIE. Line by line analysis and manual plotting of recorded system data are available.

3.2.7 EARTS

3.2.7.1 Implementation.

The EARTS has been implemented and is operational at four sites. There is no plan to implement the EARTS at any additional sites.

3.2.7.2 Recording Capability.

The EARTS system has the capability of recording system data during normal operation onto CDR disc. The system data recorded can include primary radar targets, beacon targets, radar reinforced beacon targets, associated track data, unassociated track data, controller keyboard messages, and interfacility input and output messages.

Plan View Display (PVD) console control and switch settings are not and cannot be recorded. These include map centering keys, display filter keys, FDB field select keys, history, strobe length, range scale, leader length, and brightness controls.

3.2.7.3 Reprocessing.

The capability exists to reprocess (Retrack) recorded EARTS data consisting of sensor, track, and keyboard data.

3.2.7.4 Redisplay.

The capability exists for the EARTS to accept, process and display the reprocessed data the same as live data received during normal operation.

3.2.7.5 Required Analysis.

There are no automated analysis tools available for EARTS. Line by line analysis and manual plotting of recorded system data are available.

3.2.8 EARTS Mosaic

3.2.8.1 Implementation.

The EARTS Mosaic system is scheduled to complete system testing at the FAA Technical Center in May of 1987. Field implementation of the EARTS Mosaic program is currently being scheduled.

3.2.8.2 Recording Capability.

The EARTS Mosaic will have the capability of recording system data during normal operation onto CDR disc. The system data recorded can include primary radar targets, beacon targets, radar reinforced beacon targets, associated track data, unassociated track data, controller keyboard messages, and interfacility input and output messages.

PVD console control and switch settings are not and cannot be recorded. These include map centering keys, display filter keys, FDB field select keys, history, strobe length, range scale, leader length, and brightness controls.

3.2.8.3 Reprocessing.

No capability.

3.2.8.4 Redisplay.

No capability.

3.2.8.5 Required Analysis.

There will be a search and rescue function included in the system that uses the printer as a plotting device. This can be used for plotting aircraft positional data. Line by line analysis and manual plotting of recorded data will be available.

3.2.9 NAS En Route - Host/9020

3.2.9.1 Implementation.

The Host computer is currently being phased in to replace the existing IBM 9020 computers at all 20 ARTCC's. The 20th and last Host system installation is scheduled for January 1988. Since both the Host and the 9020 systems use the same software, playback capability developed for one system is directly applicable to the other.

3.2.9.2 Recording Capability.

The NAS En Route Systems record system data during normal operations onto System Analysis Recording (SAR) tapes. The type of data recorded is dependent on individual ARTCC site adaptations. The system data recorded can include short and long length primary radar data (untracked), correlated primary radar data (tracked), uncorrelated beacon data (untracked limited data block (LDB)), correlated beacon data (tracked LDB), identifying beacon data (tracked or untracked LDB), full data block (FDB) (tracked) data, and weather. In addition, keyboard data and interfacility data can be recorded.

In some cases when 9020 computer utilization is heavy and/or when response times to controller inputs is slow, all SAR recording on the 9020 systems is terminated. With the increased processing power of the Host, SAR recording is not expected to be a problem.

Control settings on the PVD's are not and cannot currently be recorded. These include map centering keys, display filter keys, field select keys for FDB's, history, PVD range, leader length from FDB to position symbol, and brightness controls.

3.2.9.3 Reprocessing.

The NAS En Route systems currently have no reprocessing capability such as Retrack.

3.2.9.4 Redisplay.

The NAS En Route systems do not currently have a redisplay capability.

3.2.9.5 Required Analysis.

The National Track Analysis Program (NTAP) for the NAS En Route systems is available which provides a means to analyze radar and flight data collected on SAR tapes. This program is used to assist ARTCC's in air search and rescue missions aimed at locating missing or suspected downed aircraft.

Graphic plots of selected areas, tracks, and time intervals can be generated on the IBM 9020s or 3083s. Plot selectivity can also include geographical positions, untracked radar targets, and high and low intensity weather data. Composite graphs of all the requested data within a selected geographical area and time interval can be provided. Data can be plotted in relation to vertical and horizontal axes (X/Y or latitude/longitude). Data positions on the plots have a resolution of at least +/- 1/8 nautical mile (nmi). Graphs are printed on the high speed printer (HSP) and provide a scale for relating inches to nmi.

Graph size is a function of the amount of data to be depicted and the time interval specified. Data targets are outlined using identifiable characters as target symbols.

Target data presented on the graphic plots can also be listed. These lists include: type of target, time of position, and position in X/Y or latitude/longitude coordinates. Targets are presented in alphabetical order or time sequence.

The following are three target lists which can be produced:

a. A listing of plot symbols, their X/Y coordinates, and the time sorted by plot character.

b. A listing of plot symbols, their X/Y coordinates, and the time in ascending sequence sorted by the X-coordinate.

c. A listing of plot symbols, time, and X/Y coordinates with the latitude/longitude conversion printed in time sequence.

3.3 EXPANSION OF CURRENT DISPLAY RECREATION CAPABILITY

3.3.1 Overview

This section identifies and quantifies what it would take to bring each of the ATC systems to the Retrack level. Each system is addressed in terms of the three defined components of display recreation which are recording, reprocessing and redisplay. Cost and schedule projections are discussed, along with any other pertinent information.

Table 3-2 provides the costs associated with developing a Retrack capability for En Route and Terminal systems. Both one time development and recurring costs are presented. In the case of ARTS IIIE, this development effort is already under contract, hence no data are provided.

Table 3-3 provides implementation time to develop the Retrack capability for En Route and Terminal systems. Three times are presented. These are: time from decision to proceed to contract award, time from contract award to available capability, and time needed for each incident/situation recreation.

In both Tables 3-2 and 3-3, ARTS III, ARTS IIIA type, EARTS, and EARTS-Mosaic costs and schedules are shown in a composite bar.

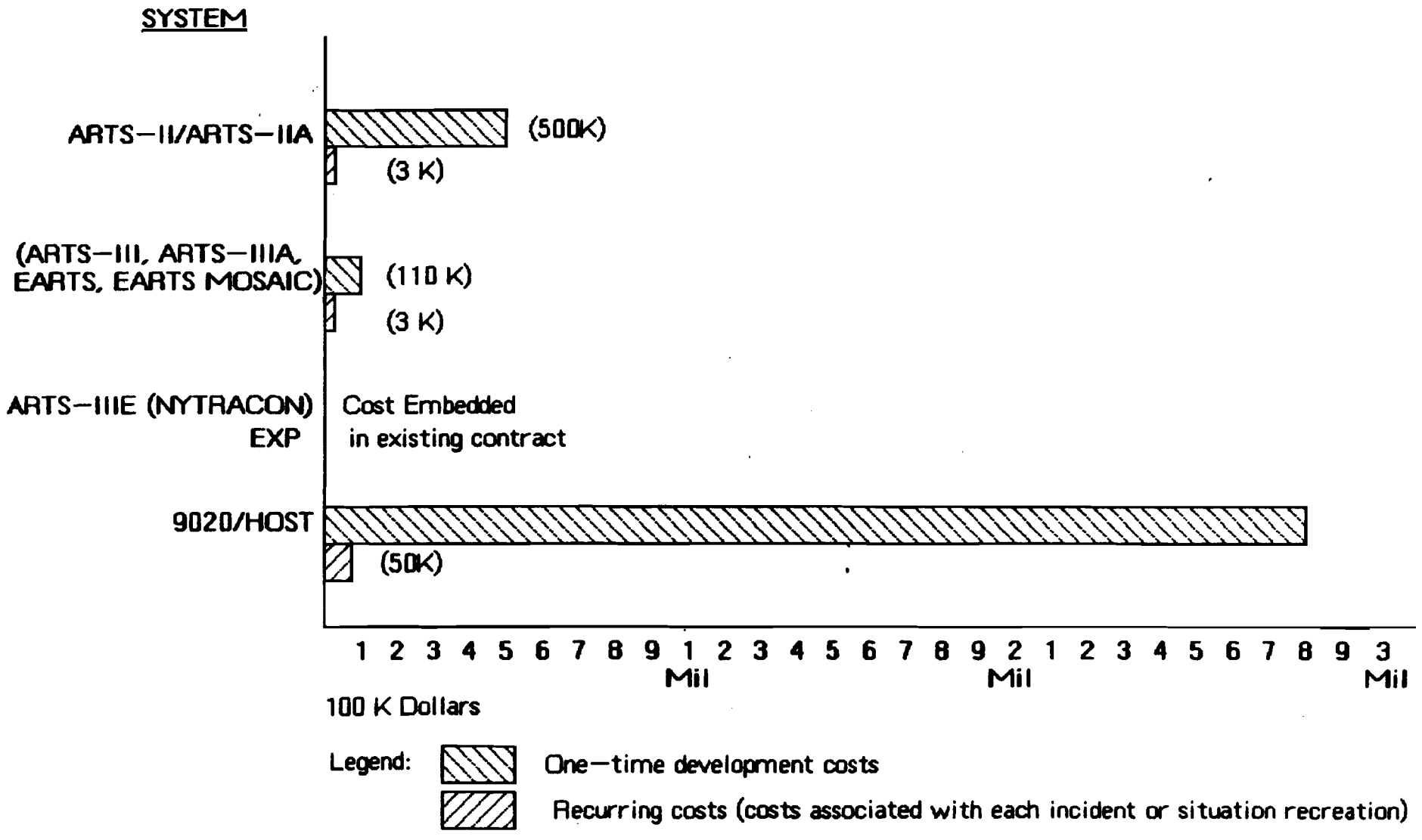

TABLE 3–2 RETRACK LEVEL UPGRADE COST

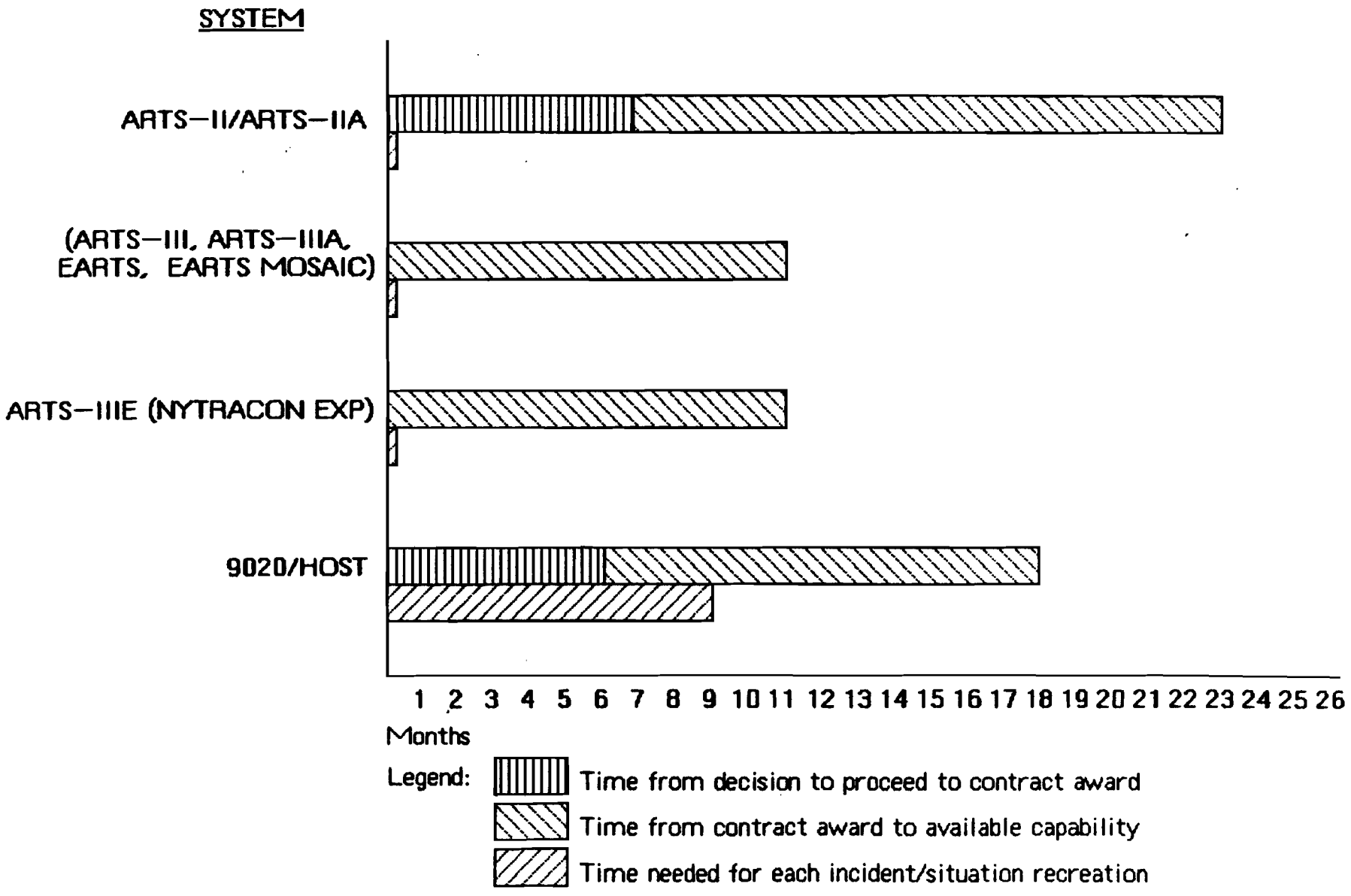

TABLE 3–3 RETRACK UPGRADE SCHEDULES

This is because it is an FAA in-house effort and the work for each system will be done serially. Therefore, the costs and schedules are additive.

3.3.2 ARTS II/IIA

The ARTS II is scheduled to be replaced by the ARTS IIA beginning in June 1987 and ending in May 1988. It would not be cost beneficial to do any development for ARTS II. Therefore, the remainder of this discussion will focus on ARTS IIA.

3.3.2.1 Requirements.

Providing the same or similar capability as the Retrack program for ARTS IIA would require time and resources. These would be dedicated to analysis, design, and development, and would satisfy the requirements which are identified below.

a. Recording. The ARTS IIA will have a recording capability which provides sufficient data types to support a reprocessing (Retrack) capability. It should be noted that display console control and switch settings cannot be recorded in ARTS IIA.

b. Reprocessing. There is currently no reprocessing capability such as Retrack for the ARTS IIA. Assuming the required recorded data are available, then the following activities would be necessary to provide a reprocessing (Retrack) capability.

   1. Analysis to determine if it is feasible to develop the capability for the ARTS IIA and if so how to interface with it.

   2. Design the reprocessing system which the results of the analysis recommend.

   3. Develop the reprocessing capability which includes code and debug.

   4. Document the reprocessing capability in accordance with FAA documentation standards. This would consist of a user's manual and coding specification.

   5. Test and verify the reprocessing system to ensure that the data replayed are accurate, repeatable and timely.

6. Site adapting the reprocessing software to provide compatability with the system to be driven will probably be necessary as it is with the current Retrack system. This depends on the system design and method of interface selected. This will apply to the system acceptance demonstration and any subsequent incident playback demonstration.

7. Demonstrate the replay of test or live recorded data as appropriate.

c. Redisplay. Assuming the reprocessing (Retrack) capability is developed, then the capability will exist for the ARTS IIA to accept, process and display the reprocessing data the same as during normal live operation.

3.3.2.2 Costs/Schedules.

Contracting costs to provide the Retrack capability for the ARTS IIA are estimated to be $500,000. This cost is distributed over the total development cycle and includes analysis, design, coding, documentation, testing, and verification. The total development time, including 7 months for procurement, is estimated to require 23 months.

When required to recreate data for an incident/accident investigation, recurring costs are required for site adaptation, checkout and demonstration. These costs are estimated at $3,000 per each unique Retrack program assembled and built. Unique Retrack programs are required for each site. When the operational software changes, the site adaptation changes or the site's operational program is rebuilt, then Retrack must be readapted, reassembled, and rebuilt for each affected site.

3.3.2.3 Other Considerations.

An analysis should be performed to determine if the recording device to be used in ARTS IIA will handle continuous data recording.

3.3.3 ARTS III

3.3.3.1 Requirements.

The ARTS III Retrack capability exists at the FAA Technical Center, but with minimal documentation. Complete documentation

including coding specification and an up to date user's manual need to be developed. The user's manual provides system operating procedures and information relative to the adaptation data requirements of Retrack which allow it to be used to drive any unique ARTS III site's operational program.

The following requirements must be satisfied to provide the capability of replaying ARTS III data which was recorded during live ARTS III system operation.

a. Recording. The ARTS III data recorded is sufficient to support the reprocessing (Retrack) capability for the ARTS III. It should be noted that display console control and switch settings are not and cannot be recorded in the existing ARTS III system.

b. Reprocessing. The capability exists to reprocess (Retrack) ARTS III data which were recorded during live ARTS III operation. The activities necessary to provide this capability and their current status are provided below.

   1. Analysis. Complete.

   2. Design. Complete.

   3. Development. Complete.

   4. Documentation. Minimal documentation exists consisting of a users manual which is not up-to-date.

   5. Testing and Verification. Completed. A more detailed verification is recommended for each new software version.

   6. Site Adapting. Retrack must be adapted to make it compatible with the version of the site's operational software that is to be driven. This need only be done once per site software version.

   7. Demonstration. Replay of each incident/situation to be reviewed constitutes the demonstration of the reprocessing (Retrack) capability.

c. Redisplay. Since the reprocessing (Retrack) capability does exist for the ARTS III, then the capability exists for the ARTS III to accept, process and display the reprocessed data the same as during normal live operation. This includes redisplay for both TRACON displays and tower BRITE displays.

3.3.3.2 Costs/Schedules.

The in-house cost to complete the Retrack capability for the ARTS III is estimated to be $40,000 for documentation. All other tasks have been completed.

The Retrack documentation for the ARTS III is minimal and is not up-to-date. To provide documentation consisting of a user's manual and coding specification would require approximately 4 months of in-house effort. The ARTS IIIA is in the process of being implemented in the field. It is estimated that all ARTS III sites will be converted to ARTS IIIA by late 1988. Therefore, development of documentation for the ARTS III Retrack is not warranted.

When required to recreate data for an incident/accident investigation, recurring costs are required for site adaptation, checkout and demonstration. These costs are estimated at $3,000 per each unique Retrack program assembled and built. Unique Retrack programs are required for each site. When the operational software changes, the site adaptation changes or the site's operational program is rebuilt, then Retrack must be readapted, reassembled, and rebuilt for each site affected.

3.3.3.3 Other Considerations.

None.

3.3.4 ARTS IIIA Type (ARTS IIIA, Current New York TRACON and Tampa/Sarasota)

3.3.4.1 Requirements.

The ARTS IIIA Retrack capability exists at the FAA Technical Center. Complete documentation including coding specification and user's manual is being developed. The user's manual provides system operating procedures and information relative to the adaptation data requirements of Retrack which allow it to be used to drive any unique ARTS IIIA site's operational program.

The following requirements must be satisfied to provide the capability of replaying ARTS IIIA system data which were recorded during live ARTS IIIA system operation:

a. Recording. The ARTS IIIA data recorded are sufficient to support the reprocessing (Retrack) capability for the ARTS IIIA. It should be noted that display console

control and switch settings are not and cannot be recorded in the existing ARTS IIIA.

b. Reprocessing. The capability exists to reprocess (Retrack) ARTS IIIA system data which were recorded during live ARTS IIIA operation. The activities necessary to provide this capability and their current status are provided below.

1. Analysis. Complete.

2. Design. Complete.

3. Development. Complete.

4. Documentation. Development of the Retrack documentation is in progress. This documentation applies to the Retrack for ARTS IIIA, Tampa/Sarasota and New York TRACON systems. The user's manual is complete, but some minor modifications might be desirable. The coding specification is in progress and is approximately 90 per cent complete.

5. Testing and Verification. Completed. A more detailed verification is recommended for each new operational software version.

6. Site Adapting. Retrack must be adapted to make it compatible with the version of the site's operational software that is to be driven. This need only be done once per site software version.

7. Demonstration. Replay of each incident/situation to be reviewed constitutes the demonstration of the reprocessing (Retrack) capability.

c. Redisplay. Since the reprocessing (Retrack) capability does exist for the ARTS IIIA, then the capability exists for the ARTS IIIA to accept, process and display the reprocessed data the same as during normal live operation. This includes redisplay for both TRACON displays and tower BRITE displays.

3.3.4.2 Costs/Schedules.

The cost to complete the Retrack capability for the ARTS IIIA type systems is estimated to be $20,000. This cost is associated with developing program documentation which is estimated to take 2 months to complete.

When required to recreate data for an incident/accident investigation, recurring costs are required for site adaptation, checkout, and demonstration. These costs are estimated at $3,000 per each unique Retrack program assembled and built. Unique Retrack programs are required for each site. When the operational software changes, the site adaptation changes or the site's operational program is rebuilt, then Retrack must be readapted, reassembled, and rebuilt for each site affected.

3.3.4.3 Other Considerations.

None.

3.3.5 ARTS IIIE (New York TRACON Expansion)

3.3.5.1 Requirements.

The ARTS IIIE Retrack capability will exist at the FAA Technical Center. Complete documentation including coding specification and a user's manual will be developed. The user's manual provides system operating procedures and information relative to the adaptation data requirements of Retrack which allow it to be used to drive the ARTS IIIE operational program.

a. Recording. The ARTS IIIE data recorded will be sufficient to support the reprocessing (Retrack) capability for the ARTS IIIE. It should be noted that display console control and switch settings are not recorded in the ARTS IIIE.

b. Reprocessing. The capability will exist to reprocess (Retrack) ARTS IIIE system data which was recorded during live ARTS IIIE system operation. This capability is being provided under contract FAA No. DTFA01-86-C-00006, New York TRACON Expansion System (ARTS IIIE).

c. Redisplay. Since the reprocessing (Retrack) capability will exist for the ARTS IIIE, then the capability will exist for the ARTS IIIE to accept, process, and display the reprocessed data the same as during normal live operation. This will include both TRACON displays and tower BRITE displays.

3.3.5.2 Costs/Schedules.

All activities are being provided under Contract FAA No. DTFA01-86-C-00006 New York TRACON Expansion System (ARTS IIIE). The Retrack capability will be included in the first stage of this system which is scheduled for commissioning in early 1988.

When required to recreate data for an incident/accident investigation, recurring costs are required for site adaptation, checkout and demonstration. These costs are estimated at $3,000 per each unique Retrack program assembled and built. Unique Retrack programs are required for each site. When the operational software changes, the site adaptation changes or the site's operational program is rebuilt, then Retrack must be readapted, reassembled, and rebuilt for the site.

3.3.5.3 Other Considerations.

None.

3.3.6 EARTS

3.3.6.1 Requirements.

The EARTS Retrack capability exists at the FAA Technical Center but no documentation exists. Complete documentation including coding specification and user's manual need to be developed. The user's manual provides system operating procedures and information relative to the adaptation data requirements of Retrack which allow it to be used to drive any unique EARTS site's operational program.

The following requirements must be satisfied to provide the capability of replaying EARTS data which were recorded during live EARTS operation.

a. Recording. The EARTS data recorded are sufficient to support the reprocessing (Retrack) capability for the EARTS. It should be noted that display console control and switch settings are not and cannot be recorded in the existing EARTS.

b. Reprocessing. The capability exists to reprocess (Retrack) EARTS data which were recorded during live EARTS operation. The activities necessary to provide this capability and their current status are provided below.

   1. Analysis. Complete.

   2. Design. Complete.

   3. Development. Complete.

   4. Documentation. There is no documentation in existence which can be identified as EARTS Retrack

documentation. However, the ARTS IIIA Retrack documentation does exist and can be used as a base for developing the EARTS documents. The ARTS IIIA user's manual can be used with some modifications and additions. The ARTS IIIA Retrack coding specification would require some modification but a good portion would be applicable to EARTS.

5. Testing and Verification. Completed. A more detailed verification is recommended for each new operational software version.

6. Site Adapting. Retrack must be adapted to make it compatible with the version of the site's operational software that is to be driven. This need only be done once per site software version.

7. Demonstration. Replay of each incident/situation to be reviewed constitutes the demonstration of the reprocessing (Retrack) capability.

c. Redisplay. Since the reprocessing (Retrack) capability does exist for the EARTS, then the capability exists for the EARTS to accept, process, and display the reprocessed data the same as during normal live operation. This includes redisplay for both control room displays (PVD's) and tower BRITE displays.

3.3.6.2 Costs/Schedules.

The in-house cost to complete the Retrack capability for the EARTS's is estimated to be $30,000. This cost is associated with an estimated 3 months for development of the documentation. All other tasks have been completed.

When required to recreate data for an incident/accident investigation, recurring costs are required for site adaptation, checkout and demonstration. These costs are estimated at $3,000 per each unique Retrack program assembled and built. Unique Retrack programs are required for each site. When the operational software changes, the site adaptation changes or the site's operational program is rebuilt, then Retrack must be readapted, reassembled and rebuilt for each affected site.

3.3.6.3 Other Considerations.

None.

3.3.7 EARTS Mosaic

3.3.7.1 Requirements.

There is no EARTS-Mosaic Retrack capability. This capability is yet to be developed. Complete documentation including coding specifications and a user's manual would also need to be developed. The user's manual provides system operating procedures and information relative to the adaptation data requirements of Retrack which would allow it to be used to drive any unique EARTS-Mosaic site's operational program.

The following requirements can be satisfied with relative ease and provide the capability of replaying EARTS-Mosaic data which was recorded during live EARTS-Mosaic operation.

a. Recording. The EARTS-Mosaic data recorded will be sufficient to support the reprocessing (Retrack) capability for the EARTS-Mosaic system. It should be noted that display console control and switch settings are not and cannot be recorded in the existing EARTS-Mosaic system.

b. Reprocessing. The capability exists to reprocess (Retrack) EARTS data which were recorded during live EARTS operation. The capability can be extended to the EARTS-Mosaic by modifying the existing EARTS Retrack to make it compatible with the EARTS-Mosaic system.

   1. Analysis. An analysis will be necessary determine what modifications, if any, would be required to make Retrack compatible with the EARTS-Mosaic. Major modification is not envisioned.

   2. Design. The design is obviously based on the outcome of the analysis and is uncertain at this time. However, major design changes are not expected to be necessary.

   3. Development. The development effort should be minor barring major design changes, which are not expected.

   4. Documentation. There is no documentation in existence which can be identified as EARTS-Mosaic Retrack documentation. However, the ARTS IIIA Retrack documentation does exist and can be used as a base for developing the EARTS and subsequently the EARTS-Mosaic Retrack documents. The ARTS IIIA Retrack user's manual can be used with some

modifications and additions. The ARTS IIIA Retrack coding specification would require some modification but a good portion would be applicable to EARTS and, subsequently, EARTS-Mosaic.

5. Testing and Verification. A more detailed verification is recommended for each new operational software version.

6. Site Adapting. Retrack must be adapted to make it compatible with the version of the site's operational software that is to be driven. This need only be done once per site software version.

7. Demonstration. Replay of each incident/situation to be reviewed constitutes the demonstration of the reprocessing (Retrack) capability.

c. Redisplay. If the reprocessing (Retrack) capability does exist for the EARTS-Mosaic, then the capability will exist for the EARTS-Mosaic to accept, process and display the reprocessed data the same as during normal live operation.

3.3.7.2 Costs/Schedules.

The in-house cost to provide the Retrack capability for the EARTS-Mosaic is estimated to be $20,000. This cost is distributed over the total development cycle and takes into consideration that the EARTS Retrack will be the baseline for the EARTS-Mosaic Retrack. This cost includes analysis, design, coding, documentation, testing and verification. The estimated time to complete is 2 months.

When required to recreate data for an incident/accident investigation, recurring costs are required for site adaptation, checkout, and demonstration. These costs are estimated at $3,000 per each unique Retrack program assembled and built. Unique Retrack programs are required for each site. When the operational software changes, the site data changes or the site's operational program is rebuilt, then Retrack must be readapted, reassembled, and rebuilt for each affected site.

3.3.7.3 Other Considerations.

EARTS-Mosaic is currently undergoing final APM acceptance testing. Field deployment of the system by Air Traffic should be in early 1988.

3.3.8 NAS En Route - Host/9020

3.3.8.1 Requirements.

Although a Retrack capability does not currently exist for the NAS En Route systems, one could be developed if the following requirements were satisfied.

a. Recording - The SAR tapes which can currently be generated in the field contain most of the data required to provide a retrack capability. A technique must be provided, however, to collect live radar data. These live data cannot be collected through SAR tapes on the 9020's because of the unacceptably high increase in computer processing utilization which would result. In addition, the existing reprocessing technique (using a software package called SIM) cannot, without modification, process live radar from SAR tapes.

   The increased processing power of the Host should make the collection of live radar data through SAR's more feasible; but more study must be performed before the feasibility can be determined.

   Live radar data can be collected by attaching data recorders and Coded Time Source (CTS) to the Data Receiver Groups (DRG's) in the Data Distribution System (DDS) of the NAS Systems. Recorders for each ARTCC are required which satisfy the following requirements. The input channel capacity should be large enough to be able to record every radar data line input to the ARTCC. Each radar uses a combination of either two or three lines to transmit data. With existing configurations, however, the ARTCC's are limited to 36 input data lines from a maximum of 13 radar facilities, forcing at least three sites to be using only two data channels. Hence, the recorders must have a minimum recording capability of 49 channels (36 data and 13 clock). The data input/output rate and power level must be the same as the receiving modems, i.e., 2400 baud and 6 volts. In addition, a continuous data recording duration of at least 24 hours before intervention is required for replacement of the storage medium.

   It should be noted that recording the live radar data and SAR data still does not allow the control console settings to be collected.

b. Reprocessing - The recorded SAR and radar data tapes from the field can be reprocessed by employing the SIM

software program. A simulation tape can be generated by running the SIM program against the SAR tape for non-radar data. The display data is dynamically recreated when the SIM tape is run against the NAS with the live radar data input through the DRG's into the Common Digitizer (CD) adapters in the Peripheral Adapt Modules (PAM's).

The recorded SAR and radar data tapes could be theoretically processed at either the FAA Technical Center or at the site. Substantive problems, however, exist for both options. In order to run the site operational program at the Technical Center, it would be necessary to modify the adaptation for the Technical Center's 12 sector hardware configuration. The current estimates for that activity range from 2 to 10 months per investigation, depending on the ARTCC, at an average cost of $50,000. An in-depth analysis of this adaptation method could substantially reduce this estimate. Processing at the ARTCC where the recording was made would have to be done during light traffic conditions when the complete NAS could be taken off-line to allow dynamic reprocessing and redisplay of the SIM and radar data tapes.

c. Redisplay. Once the SIM program had been employed against the non-radar data on the SAR tapes, the resultant SIM tape, together with the live radar tape, could then be reprocessed through the NAS En Route system and the reprocessed data redisplayed dynamically the same as during normal live operation. It should be noted that the output would not necessarily be the same as it was when the recordings were made since the settings of the controller's PVD's were not captured on the input data tapes.

3.3.8.2 Costs/Schedules.

In order for the aforementioned technique to be implemented, it would be necessary to purchase and install instrumentation recorders at each of the ARTCC's. Off-the-shelf recorders are available which provide up to a 50-channel capacity, 4800-baud rate, and a 48 hour recording time. The cost of these recorders is about $65,000 to $70,000 per copy with an annual on-call maintenance fee of approximately 10% of the original cost. Although these recorders are an off-the-shelf item, a lead time of about 3 months would be required to manufacture them in quantity.

Documentation would also have to be written to delineate the procedures required to perform the recording, reprocessing, and

redisplay. This would require about six man/months effort. The total cost for this approach would be $50,000 for documentation, plus $2.8 Million for the recorders. A competitive advertised procurement of this dollar value would require about 10 months to complete. Documentation of the procedure could be done in-house.

3.3.8.3 Other Considerations.

This technique will not provide an exact duplication of what a controller saw at his PVD. The settings of the PVD are not recorded and would not necessarily be redisplayed exactly as they occurred. Instrumentation recorders have previously been installed in the field. They were removed because of limited recording length, excessive maintenance problems, and sparce availability of parts. The problem of limited recording length has been reduced. Availability of parts should not be a major problem since the recorders being examined are state-of-the-art. The maintenance issue is uncertain since the recorders under consideration are of a new design. Maintenance, however, should be less than with the previous recorders although it must be noted that the recorders would be continuously operated.

3.4 PLOTTING CAPABILITIES

3.4.1 Overview

This section addresses automated plotting capabilities that could be employed for a paper display of the recorded aircraft information. The En Route NTAP program, described in section 3.2.9.5, provides a means to analyze radar and flight data collected on SAR tapes. This program generates on the printer, graphic plots of selected areas, tracks, and time intervals. Similiar capabilities could be possible for the other systems. Because of hardware and recording commonalities, ARTS III, ARTS IIIA (Type), ARTS IIIE and EARTS have a potential common solution. ARTS IIA may require a different solution and will be considered separately.

3.4.2 ARTS III, ARTS IIIA (Type), ARTS IIIE and EARTS Systems

3.4.2.1 Description.

Automated analysis tools have been developed and used successfully for various projects. One of these tools provided a track/target plotting capability. Specifically, the ARTS III

Conflict Alert project used a plotting capability extensively in the analysis of encounters during testing at the Technical Center. Previously recorded test data would be processed by an FAA developed program on an off-line ARTS III computer. This program generated a magnetic tape in a format that could be used as input to a CALCOMP drum plotter located at the Technical Center. The plotted data included: target, track, altitude and timing data. This plotter and necessary interface software are currently available at the Technical Center.

3.4.2.2 System Application.

Because of the hardware and recording commonalities of ARTS III, ARTS IIIA type, ARTS IIIE and EARTS Systems, the program described above, or a similar one, could be the basis for a common solution. Modifications may be required to provide compatibility with system data formats.

3.4.2.3 Cost/Schedules.

Contracting costs to provide a plotting capability for the above systems are estimated to be $130,000. This cost is distributed over the total development cycle and includes analysis, design, coding, documentation, testing and verification. The total development time, including 3 months for procurement, is estimated to require 11 months.

3.4.3 ARTS IIA System

3.4.3.1 Description.

A plotting capability, similar to the one described in sections 3.4.1 and 3.4.2 could be developed for the ARTS IIA system. This capability could be implemented by developing a computer program similar to the FAA program noted in section 3.4.2.1. The program would process the ARTS IIA data extraction tape as input on the General Purpose computer system producing an output tape which would contain the plotter application control commands and the plotter interface routines. This output tape would then be used to drive the CALCOMP drum plotter.

3.4.3.2 System Application.

Because of the differences in data extraction tape formats and densities between the ARTS IIA system and the systems addressed in section 3.4.2 the process described here would be applicable to ARTS IIA only.

3.4.3.3 Cost/Schedules.

Contracting costs to provide a plotting capability for ARTS IIA are estimated to be $130,000. This cost is distributed over the total development cycle and includes analysis, design, coding, documentation, testing, and verification. The total development time, including 3 months for procurement, is estimated to require 11 months.

3.4.3.4 Other Considerations.

An analysis should be performed to determine if the recording device to be used in ARTS IIA will handle continuous data recording.

4. NEW TECHNOLOGIES

4.1 OVERVIEW

This section discusses new technologies which could be employed to record, reprocess, and redisplay the aircraft information. These technologies include a digital display recording and playback system referred to as ERDIRS, a direct video recording technology, BRITE/DBRITE recording, and finally, the technology to be introduced by the Initial Sector Suite System (ISSS)/Advanced Automation System (AAS). For each system, a description of the technology is presented together with its requirements. The En Route or Terminal environment for which the technology would apply is then discussed. The cost of each is presented as is a schedule for its implementation. Finally, any constraints or limitations which should be considered are delineated.

4.2 EN ROUTE RADAR DISPLAY RECORDING SYSTEM (ERDIRS)

4.2.1 Description

During the period from 1975 to 1981, studies were made at the FAA Technical Center into various techniques for the recording and playback of the data displayed on controller displays. These studies culminated in the design, fabrication, and testing of a prototype system for the recording of the digital information provided to En Route controller displays. The results of this activity were documented in Technical Report DOT/FAA/CT-82/27 issued by the FAA Technical Center in February 1983.

This prototype system, the ERDIRS, extracted data for recording from the Display Generator Unit (DGU) which supplies the digital input to 6 PVD's. At this interface, the digital information for the display is presented at approximately 55 frames per second. The recording system captured and recorded the information sampling one complete frame per display on a periodic basis.

Recording was accomplished using a pair of high density digital recorders operating in a sequential mode such that a continuous recording was made with no gaps. This system was capable of recording the data from a maximum of 72 displays using a single pair of recorders.

On playback, each recorded frame was repeatedly displayed until a new frame was retrieved from the recording. Each sampled frame was recreated exactly as it was originally presented to the controller, with the exception of the effects of video intensity and focus control settings.

4.2.2 ERDIRS Characteristics

A draft specification for the ERDIRS was prepared and provided as a part of Technical Note DOT/FAA/CT-82/27. This draft specification provided for the following requirements:

a. Data would be recorded, on a sampling basis, for all on-line controller displays in the ARTCC.

b. Data for recording would be obtained from the existing DGU. This requires the modification of the DGU's to tap into the existing data signal path in order to provide line drivers for remoting these signals to a central recording station.

c. Data for the on-line controller displays would be recorded at the central recording station. Recording would be on a pair of high density digital recorders operated in a sequential mode such that a continuous recording could be made with no gaps. Each recorder would be capable of recording up to 72 displays for a minimum period of four hours.

d. The recorded data would include the recording of the output from the coded time source.

e. The system would be capable of displaying the previously recorded data from any two selected controller displays simultaneously. The operator would be able to select the starting time for the playback, and view the data at either normal or double speed. In addition, the operator would have the capability of freezing the display at any time. The capability would also exist to synchronize the playback display data with voice recordings.

f. During recording, the playback subsystem would allow the operator to monitor the recording currently being made for any selected display.

4.2.3 System Applications

This system was originally designed and built specifically for the En Route ARTCC. Since the point at which the recording signal is obtained is within the display subsystem, this system is applicable to all ARTCC's while the existing DGU's and PVD's are in use.

This system could also be adapted for EARTS facilities, as these use similar display drivers.

A brief review of the digital interfaces to the various displays used in Terminal facilities (ARTS subsystems) revealed that these are functionally equivalent to the En Route display interface. Therefore, it is felt that an equivalent design could be developed for use in the Terminal facilities. However, the signal recorded would only provide playback of the digital display data (Beacon targets), and would not provide for playback of the broadband radar data (primary targets).

If all playbacks were performed at the Technical Center or any single location, all the features contained within the ERDIRS may not be required in any proposed interim recording system. Such features that may be eliminated would be: playback capability at each site, double speed playback, data/voice playback synchronization, training capability, etc.

4.2.4 Cost/Schedule

It is currently estimated that the cost of currently implementing this system is as follows:

One Time Cost

Engineering (12 MY @ 125K/MY)	1,500 K
Documentation	350 K
Prototype Development	250 K
Total	2,100 K

Implementation Costs (Per Site)	EN ROUTE/ EARTS	TERM	COMMON PLAYBACK
Two Recorders	300 K	150 K	100 K
Record/Playback Interface Equipment	70 K	60 K	40 K
Installation	20 K	20 K	5 K
Spare Parts	65 K	65 K	20 K
Total (Per Site)	455 K	295 K	165 K

It is currently estimated that the schedule for implementing this system at the ARTCC, EARTS and ARTS sites would require a 5 to 6 year time frame, broken down as follows:

a. Revision of current draft specification, preparation of RFP package, release of Request for Proposals (RFP), receipt of proposals, proposal review, and contract award: minimum of 18 months from decision to proceed.

b. Contractor design, fabrication, and delivery of prototype: 18 months from contract award.

c. Evaluation of prototype and decision for implementation: 6 months.

d. Field implementation: 30 months. First site to be delivered 3 months after decision to proceed. Follow on deliveries to be made at 1 month intervals.

4.2.5 Other Considerations

To date, feasibility of this technique has only been demonstrated for the En Route display system. If this technique were to be expanded to include recording of the digital display data for the Terminal systems, it is suggested that a common recording and control system be developed for use in both the En Route and Terminal environments. The only difference between the two systems would be in the handling of the data from the digital interface. However, it is anticipated that this would add approximately 6 months to the time period for the development of the prototype. This would be due to the analysis of techniques for capturing the Terminal display data.

Cost estimates are based on the original design, developed over 7 years ago. This design was based on the use of high density digital recorders, as no other recording device available at the time was capable of handling the quantity of data required. As the major portion of the implementation costs for this system is due to the costs of these recorders, a study should be made to compare the capabilities and costs of currently available recording devices to determine if any cost savings can be realized.

Additional savings might be realized by using data compression techniques. A decrease in the quantity of data to be recorded, coupled with increased capacity of current technology devices, could again materially reduce cost of implementation. However, extensive studies into redesign of the system would increase the prototype development time.

The sampling technique used in the ERDIRS was not a requirement, but rather a means of making the system practical. Sampling is an exception to a requirement to record all the data (every frame) presented to a controller. This exception was accepted in order to reduce the capacity requirements of the recorders and, thus, the total system cost.

This system was specifically designed for use with current technology display systems. It does not appear to be compatible with the

AAS/ISSS displays which will replace the existing display system in the near future. Currently projected implementation time for the first site for this system is approximately 4 years after decision to proceed.

4.3 DIRECT VIDEO RECORDING

4.3.1 Description

The current operational systems in the field (ARTS II, ARTS III/IIIA, Tampa/Sarasota, New York TRACON, EARTS and EN ROUTE) use different situation displays for ATC.. Terminal towers currently use BRITE displays and will in the future have Digital BRITE displays currently under development by Burroughs Corporation. ARTS II and the impending ARTS IIA use Burroughs displays. ARTS III/IIIA and New York TRACON use Texas Instrument (TI) displays. Tampa/Sarasota used a combination of TI displays and Magnavox Full Digital ARTS Displays (Prototypes). Finally the EARTS and En Route systems use Raytheon Plan View Displays (PVDs). Except for BRITE and DBRITE, all of the aforementioned displays are stroke written displays. The BRITE's and DBRITE's are raster scan displays. A direct video recording of any of these displays would ensure that the data viewed on playback was, in fact, the data on the original display.

With this technique, a direct video recording could be made of the controller display in either the En Route or Terminal environment. This would ensure that the data viewed on playback was in fact the data on the original display.

4.3.2 System Requirements

The basic requirements for video recording are as follows:

a. All information within the PVD tube diameter shall be recorded.

b. Resolution of the recorded signal shall be sufficient to reproduce the information content of the original display on playback.

c. Playback shall be on a standard PVD to recreate the original viewing environment.

d. The recording device shall run for a minimum of 4 hours unattended.

4.3.3 Systems Applications

Tests of direct video recording were previously conducted at the FAA Technical Center, and are discussed in FAA Report FAA-RD-78-97. These tests were conducted using an En Route system PVD, and a high resolution 945-line TV camera.

The results of these tests showed that, in addition to a possible problem of the camera being partially obscured, the resolution of the reproduced display was insufficient to differentiate many of the alpha numerics included on the display.

It was also concluded that use of a higher resolution video system would increase the bandwidth of the signal to an extent which would cause recording difficulties. In addition, a higher resolution video signal would be incompatible and could not be reproduced on the PVD.

After a review of current state-of-the-art technology, it is still concluded that due to the number of displays to be monitored, the required amount of data to be recorded per display, and the resolution of the recreated display image on playback, that this technique is still not feasible for general use in recording display data. However, video recording may be of use in special situations, as further discussed in the next section on the Tower BRITE system.

4.3.4 Cost/Schedule

No cost or schedule information is provided.

4.4 RECORDING OF BRITE SCREEN DISPLAY

4.4.1 Description

BRITE displays are currently deployed in ATC Towers through the country. A contract was awarded to Burroughs Corporation on July 20, 1986, to produce a replacement for the BRITE display known as the Digital BRITE. The location of the current BRITE and the Digital BRITE to come is remote from the TRACON and receives data in various forms and combinations depending upon location. Data can be received solely via Television Microwave Link (TML) as is done at La Guardia Tower, or a combination of broadband (radar blips and beacon slashes) from a collocated radar and alphanumerics from Remote Display Buffer

Memory (RDBM) which in turn receives its data via telephone lines from a central processing point as is done at JFK Tower or from a radar as above and a refresh device at the TRACON.

The various forms and combinations of data used to drive the BRITE's/DBRITE's make it necessary to record the data at the remote locations of the display. This is so that any data loss resulting from the data transmission media during the event would be reflected in the recording. The remote location of the recording would require an independent recording capability at each Tower. A commercial, off-the-shelf high definition video recorder could be used to record the display of a BRITE or DBRITE system. This will allow a playback of the data as actually seen by the tower personnel.

4.4.2 Requirements

In order to be able to recreate as closely as possible the actual display the controller was able to see, a recording system is required which will be able to record the input to the BRITE display. This system should be low cost, off-the-shelf, readily available and easy to install and use.

4.4.3 System Application

This system could be used in any tower location which currently has a BRITE display, or in any future DBRITE system.

4.4.4 Cost/Schedule

There are a number of different systems which could be used for this application, of which only two have been looked into at this time. The first is a system built by Sony, the VO 5800H. This is a video cassette system, generally used for medical imaging systems such as CAT or ultrasound scans. The unit is on the GSA schedule for $6080.00. This recorder uses cassettes which will record for 1 hour, and several units can be attached in sequence such that when 1 cassette is full, the second recorder automatically starts recording. The price of each 60 minute cassette is $17.96, and is reusable when the information it contains is no longer required. The Sony system with 2 recorders and the appropriate cabling will cost about $14,000.00 per site. This is a true off-the-shelf item with a delivery time of several days for quantities of one or two, and delivery times of 30 to 60 days for quantities of 100 units. A 15 day supply of tape, assuming the system is in use 18 hours per day, will cost $4850.00.

The second system is a Hitachi reel-to-reel recorder, model HR 230 used by both the broadcast and medical industry. This unit will record 3 hours of video, and can also be used in tandem to allow a second recorder to be on-line while the tape is being changed in the first unit. The Hitachi system costs $41,000.00 each in units of one, and $29,000.00 each in units of 100. A dual recorder system with cabling will, therefore, cost about $60,000.00 per site. This recorder is available with a 60-day lead time. The price of the tape should be about $120.00 per reel, and, therefore, the cost of a 15 day supply will be about $10,800.00.

With either system, the only requirements are the recording units, standard cables, and tapes. The recorders will be hooked up in a manner similar to a standard home VCR, with the recorder attached at the input to the display of the BRITE at the tower. Playback of the information can be at the tower, using the standard display, or could be at any other site equipped with a recorder and a display. No modification will be required in any existing equipment.

Due to cost considerations, the Sony system appears to be more desirable, with the only limitation being that the tape will require changing every hour.

4.4.5 Other Considerations

This system will not show the information seen by controllers other than those in the tower. It will be able to reproduce the exact display as seen in the tower, including broadband video and alphanumerics. It will not be able to take into account the brightness setting of the tower display, and it is possible that a target will be recorded which was not visible on the display due to misadjustment of the display at the time of recording. It should be noted that the BRITE/DBRITE redisplay can be accomplished through the use of Retrack. This would be a representation of what the system saw and would not account for data loss through the transmission medium.

4.5 INITIAL SECTOR SUITE SYSTEM/ADVANCED AUTOMATION SYSTEM

4.5.1 Description

The ISSS will be the first segment of the AAS to be deployed and it will replace the PVD's currently in use in the NAS En Route centers. A sophisicated Display Recording and Playback System (DRPS) will be integrated into the controller workstations (commmon consoles) of the

ISSS. This system will transfer all track and target data, warning and status messages, and weather information that is received at each common console, as well as the state of the display controls (brightness, range and offset, and display category suppression settings) to an independent control and data storage system so that the information can be stored and redisplayed without affecting the Host System.

The Terminal Advanced Automation System (TAAS), using the same common consoles and DRPS as the ISSS, will be the second segment of the AAS to be deployed and will replace Terminal radar consoles. The TAAS's will be collocated with the ISSS where it is feasible to consolidate Terminal operations at the centers or they will be installed at existing ARTS facilities.

The Tower Control Computer Complex (TCCC) will be deployed concurrently with the TAAS and will replace the BRITE radar displays with Tower Position Consoles (TPC) and a DRPS with the same capabilities and similar in design to that used in the ISSS and TAAS.

The Area Control Computer Complex (ACCC) will be assembled from the ISSS and TAAS common consoles and no change to the DRPS is expected during this implementation phase.

The AAS Replan Team is currently reviewing all AAS requirements with a view to cost and schedule. The Team should be made aware of the requirements so that they don't inadvertently eliminate them from the AAS specification.

The specific capabilities of the DRPS that is to be provided by the ISSS are delineated in the following section.

4.5.2 ISSS/AAS Display Recording and Playback Requirements

The Display Recording and Playback Requirements of the ISSS and the fully configured AAS are identical. These are described in Sections 3.7.1.2.4, 3.7.2.2.4, and 20.3.7.1.2.5 of the AAS System Level Specification (FAA-ER-130-005F). A synopsis of these requirements is as follows:

a. All Common Console display, control, and message entry data shall be recorded. Except for the common console, the display recording and playback system shall be independent of the hardware and software which provides ATC operational functions.

b. Data playback and control shall be accomplished through common consoles configured for this purpose, and shall

provide a display reproduction with the same quality and characteristics as the original presentation.

c. The playback of common console data shall be time synchronized to the playback of voice recordings. A capability shall exist to vary the playback rate from 1/2X to 10X or to freeze the playback and produce a graphic hardcopy of the common console display.

4.5.3 System Application

The AAS DRPS will be implemented on all ATC radar displays (the ISSS segment for En Route positions, the TAAS for Terminal positions, and the TCCC for tower positions).

4.5.4 Schedule

The current schedule for implementation of the AAS is as follows:

Segment	Acceptance	Completion	Site 1 ORD
ISSS	6/90	11/91	2/93
TCCC	10/91	11/92	8/94
TAAS	7/92	9/93	8/94
ACCC	11/92	5/94	8/95

4.5.5 Other Considerations

The AAS Replan Team is currently reviewing all AAS requirements with a view to cost and schedule. The Team should be made aware of the requirements so that they don't inadvertently eliminate them from the AAS specification.

5. SUMMARY

5.1 ALTERNATIVES

The Display Recording and Playback System (DRPS) of the Initial Sector Suite System (ISSS) of the Advanced Automation System (AAS) saves all data, including display control settings required for a complete display recreation for the En Route and Terminal environment. It provides the only technique which can completely satisfy the requirement for a recording and display recreation capability in either the Terminal or En Route environment.

ISSS will be the first segment of the AAS to be deployed and it will replace the PVD's currently in use in the NAS En Route centers. Operational Readiness Demonstration (ORD) implementation is from February 1993 through November 1994. The Terminal Advanced Automation System (TAAS), using the same common consoles and DRPS as the ISSS, will be the second segment of the AAS to be deployed and will replace Terminal radar consoles. ORD implementation for TAAS starts in August of 1994.

Direct video recording of the video display was evaluated, but rejected as technically infeasible primarily due to bandwidth restrictions.

The Bright Radar Indicator Tower Equipment/Digital BRITE (BRITE/DBRITE) video recording has potential in the towers, but the additional storage requirement for about 100 video tapes, the need to change tapes every 3 hours, and the limited life span of the recording head assembly (1500) hours, detract from the attractiveness of this approach. In addition, the Retrack capability described below displays the digital data at the BRITE display as well as the Terminal Radar Approach Control (TRACON) displays.

A capability now exists in the Terminal area to record, reprocess and redisplay aircraft information. Automated Radar Tracking System (ARTS) III, ARTS IIIA, New York TRACON, En Route Automated Radar Tracking System (EARTS), and Tampa/Sarasota all have a Retrack capability. The Retrack approach is extremely attractive since the software exists for most of the systems and only the documentation needs to be strengthened. Retrack does not have to be deployed at any field site and does not require any additional hardware purchases. It is approximately a 1 week task to adapt the Retrack software to the site where an incident/accident occurs. A drawback is that the broadband video, i.e., radar blips and beacon slashes, that were present on the display at the time of the incident/accident are not available for playback nor are the switch settings of the displays. In addition, no capability currently exists for ARTS II, ARTS IIA, nor EARTS Mosaic.

One potential interim solution in the En Route area is to purchase instrumentation recorders to collect live radar data from the field. These data, together with SAR data, could be used to recreate the En Route displays. The difficulties of replaying these data at either an ARTCC or at the Technical Center reduces the attractiveness of this alternative. Controller display settings are also not available using this technique.

The En Route Radar Display Recording System (ERDIRS) was investigated for use in both the En Route and Terminal environments. This system extracts data for recording from the Display Generator Unit (DGU) which supplies the digital input to 6 Plan View Display (PVD's). At this interface, the digital information for the display is presented at approximately 55 frames per second. The recording system captures and records the information sampling one complete frame per display on a periodic basis. Two high density digital recorders operate in a sequential mode.

On playback, each recorded frame is repeatedly displayed until a new frame is retrieved from the recording. Each sampled frame is recreated exactly as it was originally presented to the controller.

It should be noted that currently the National Transportation Safety Board (NTSB) utilizes the National Track Analysis Program (NTAP) for accident/incident investigation in the En Route area. NTAP uses System Analysis Recording (SAR) tapes as input to prepare plots of combinations of selected areas, tracks, time intervals, geographical and weather data and untracked radar targets. A similar capability could be developed for the Terminal area using the data extraction tapes from the on-line systems as input to the plotter program. Unlike NTAP, the Terminal plotter routines would utilize the CALCOMP drum plotter rather than using the High Speed printer for graphic output. It is estimated that a plotting capability for ARTS IIA could be provided, under contract, for $130,000 in a period of 11 months.

5.2 TERMINAL TRANSITION TO TAAS

Although the only complete solution to the recording and display recreation issue in the Terminal environment is TAAS, it appears that Retrack offers an attractive interim alternative. A comparison of cost and schedule for the ERDIRS system versus the Retrack option is shown in Table 5-1. As seen in the table, ERDIRS would not be cost beneficial in the Terminal environment. ERDIRS does provide controller settings while Retrack does not, but neither system is able to provide broadband information

during display recreation. A comparison of the implementation schedules of TAAS and Retrack also shows that Retrack is a very attractive alternative. If cost is a major concern, the ARTS IIA plot capability combined with Retrack for the other Terminal areas and EARTS might be worth considering.

5.3 EN ROUTE TRANSITION TO ISSS

As in the case of the Terminal environment, the only complete solution to the recording and display recreation issue in the En Route environment is ISSS. Development of the ERDIRS system would also provide the required capability in the En Route environment. Table 5-2 presents a comparison of the schedules and cost required to implement both techniques. As shown, ERDIRS could not be implemented in the En Route environment more than 1 year prior to ISSS. However, if alternative technologies could be found, the development time could be greatly reduced. One such technology might employ personal computers using high density magnetic tape as the recording medium. In addition, it may be possible to considerably reduce the procurement cycle given in the table. If these assumptions are applied to the schedules, then ERDIRS might be a desirable alternative as an interim system to ISSS.

The use of instrumentation recorders to collect live radar data together with the SAR data also provides a viable alternative in the En Route area. As noted above, controller display settings are not available. The difficulties of replaying these data at either an ARTCC or at the Technical Center reduces this option's attractiveness. However, as seen in Table 5.2, the cost and implementation schedule for this option would suggest further study.

The alternative of using NTAP should not be overlooked for the En Route system. It is currently used by NTSB during accident investigations and is already in place.

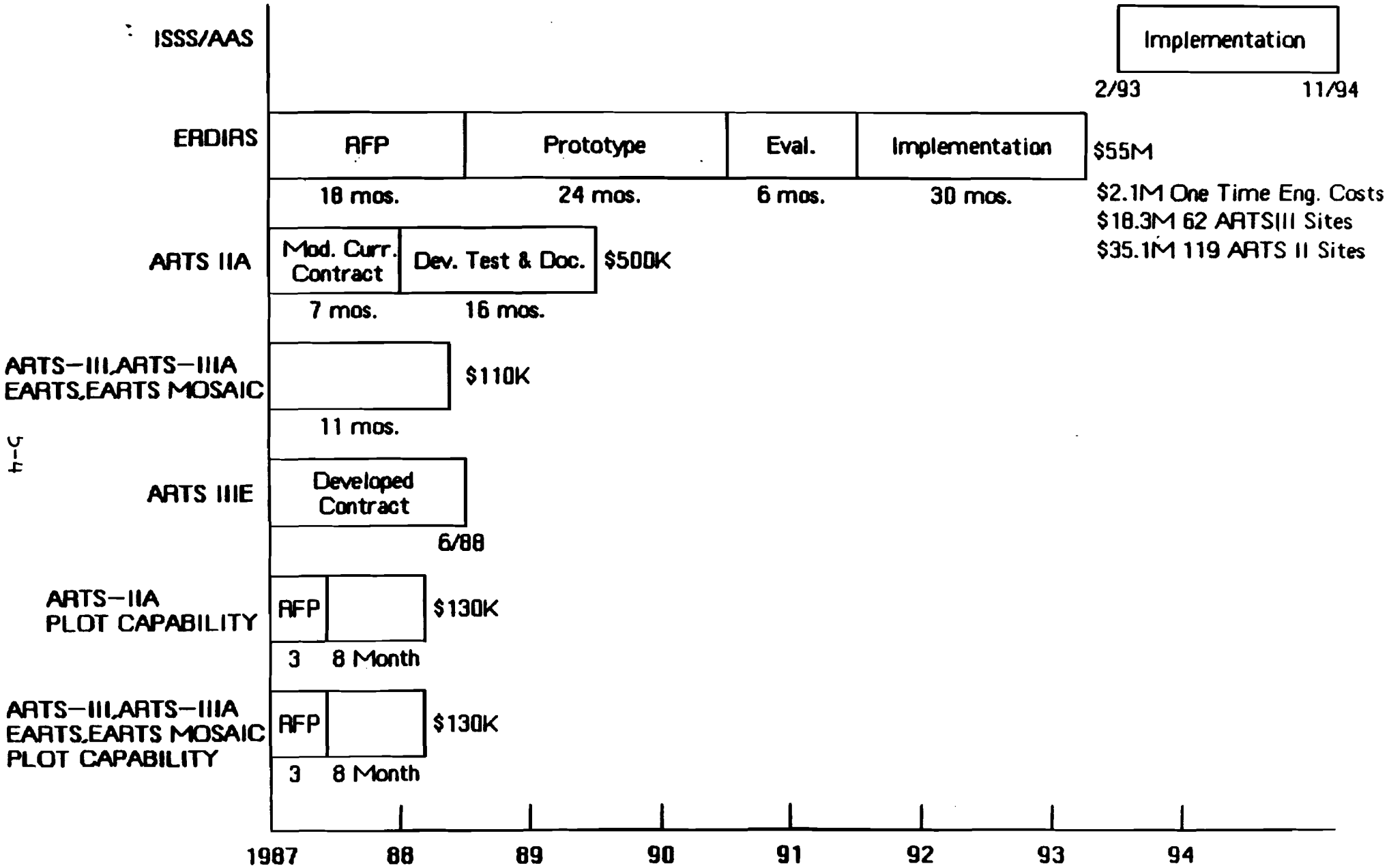

TABLE 5-1: ISSS VS. ERDIRS VS. RETRACK FOR TERMINAL AND EARTS COST AND SCHEDULE

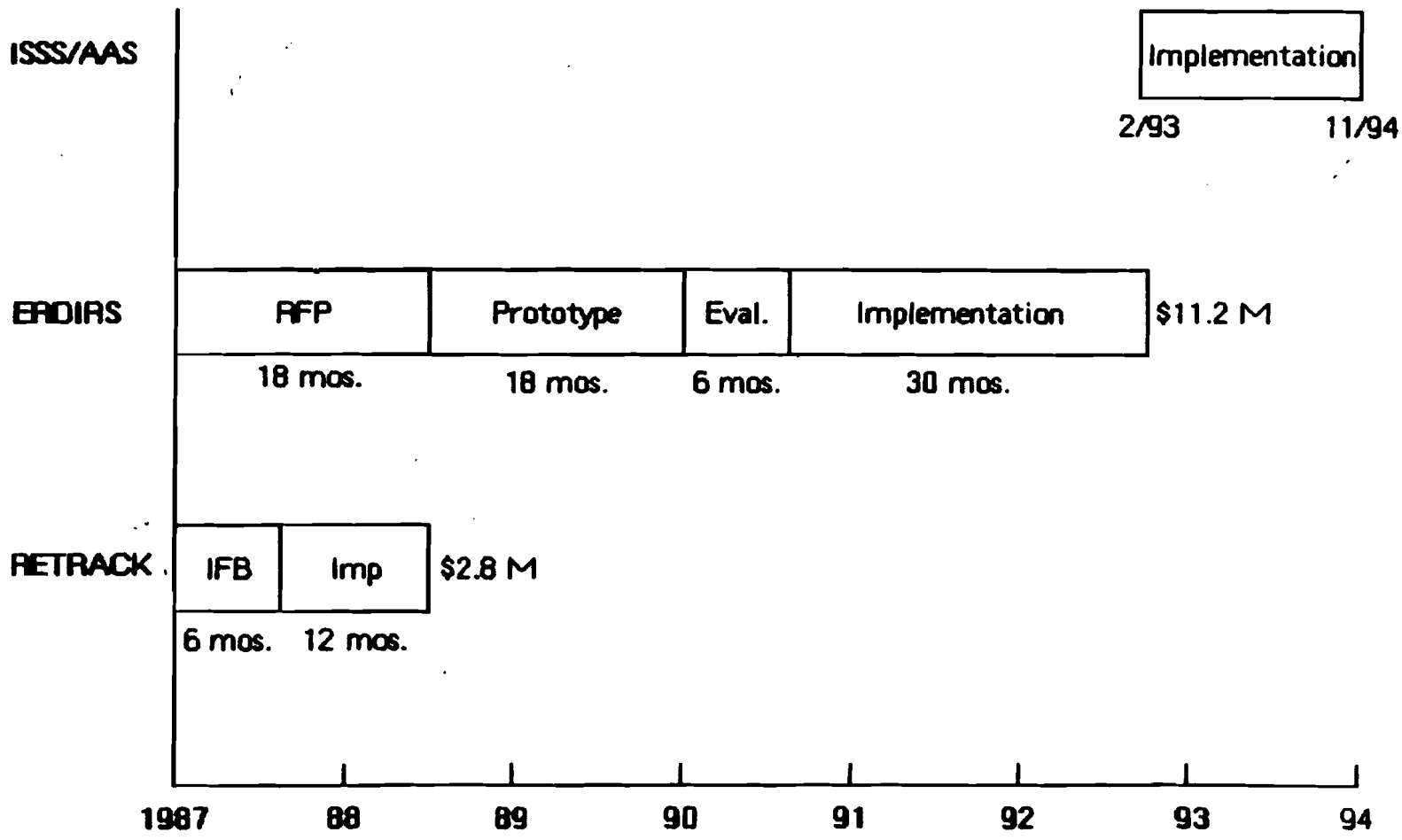

TABLE 5-2: ERDIRS VS. RETRACK ENROUTE ENVIRONMENT SCHEDULE COMPARISON

6. CONCLUSIONS

After review of the technologies discussed in this paper, it is obvious that the Initial Sector Suite System/Advanced Automation System (ISSS/AAS) technology will satisfy the display recreation requirement in the long term. The requirement is to bridge the gap with an interim solution between the present and the implementation of the ISSS/AAS displays which is scheduled for the 1993-1994 time frame.

6.1 TERMINAL TRANSITION TO TERMINAL ADVANCED AUTOMATION SYSTEM (TAAS)

The TAAS technology as specified in the requirement document will provide the required Terminal recording and display recreation in the long term. The Retrack technology is recommended for the transition period for the Terminal and En Route Automated Radar Tracking System (EARTS). Retrack is currently available for use for Automated Radar Tracking System (ARTS) III, ARTS IIIA, Tampa/Sarasota, New York TRACON and EARTS. The total cost of $610,000 and related schedule to upgrade the documentation for the existing Retrack software, upgrade Retrack for EARTS Mosaic,and develop Retrack for ARTS IIA and EARTS Mosaic are convincing arguments to utilize the Retrack technology in the Terminal area. It should also be noted that the National Transportation Safety Board (NTSB) has availed itself of Retrack to investigate previous incidents/accidents and NTSB has a current request to redisplay the Air Mexico midair crash. If a static representation of data would be acceptable for ARTS IIA, a combination of a plot capability for ARTS IIA and Retrack for all other Terminal Systems and EARTS might be the solution at a total cost of $240,000.

6.2 EN ROUTE TRANSITION TO INITIAL SECTOR SUITE SYSTEM (ISSS)

The ISSS technology as specified in the requirements document will provide the required En Route recording and display recreation capability in the long term. There are two technologies that are potential candidates to provide an interim solution for recording and display recreation. One technology is the installation of instrumentation recorders at the Air Route Traffic Control Center (ARTCC's) to collect radar data. The data could then be played back through the En Route system in conjunction with the corresponding System Analysis Recording (SAR) tapes to provide the display recreation. Further investigation of this technology is necessary to determine if

adaptation shortcuts can be achieved and if state-of-the-art instrumentation recorders are more easily maintained than previously experienced. Cost and schedule ($2,800,000 and 18 months) make this approach worth further study. The other approach is the En Route Radar Display Recording System (ERDIRS) technology which satisfies the requirement and is more attractive from a user point of view. The entire En Route system is not needed to recreate the incident/accident. Only the playback hardware of the ERDIRS and a display is necessary. If the procurement cycle for this technology could be significantly reduced and personal computer (PC) type technology could be applied to this approach to shorten the development time, ERDIRS would be the way to go. The benefits of this approach warrant further study of technology advances to determine whether the schedule in table 5-2 could be significantly reduced. The cost and schedule figures for ERDIRS are $11,200,000 and 72 months. If a static representation would be acceptable, the National Track Analysis Program (NTAP) program already in place would satisfy the requirement at no cost.

APPENDIX A

RETRACK PROGRAM DESCRIPTION

HISTORY

The concept of the Retrack program came in late 1975 during the later stages of development of the ARTS III Minimum Safe Altitude Warning (MSAW) and the early stages of the Conflict Alert program.

Retrack was developed to provide the capability of testing and analyzing new algorithms under more realistic environmental conditions than could be provided by the Enhanced Target Generator (ETG). Retrack was first developed to drive a research and development program which included Conflict Prediction and Resolution (CP/R). The CP/R program was the forerunner of the Conflict Alert program which has been implemented in the field. During initial implementation of the MSAW program, development and testing of the Conflict Alert program Retrack was used extensively for analysis of the new algorithms with much success. Its use allowed early detection and correction of both design and program deficiencies as well as use in parameter optimization. Since that time, it has been used continually for similar analysis applications, such as Conflict Alert Enhancements, New York TRACON tracker improvements, New York TRACON performance improvements, and capacity analysis. It has also been used to aid in analysis and debug of several field reported program deficiencies. In addition, it has been used to evaluate the performance and capacity of several ARTS IIIA version A3.Ø2 site programs prior to field implementation.

During the same time period, the National Transportation Safety Board (NTSB) has requested and has been provided with Retrack to aid in their investigation of several incidents and accidents utilizing the recorded data from various terminal facilities. It has apparently proved useful to the NTSB in their investigations because of their continued request for its use.

DESCRIPTION

The Retrack software system consists of hardware and software that provides the capability of driving an operational Automated Radar Tracking System (ARTS) III, ARTS IIIA (including New York TRACON and Tampa/Sarasota) or En Route Automated Radar Tracking System (EARTS) system during a totally non-operational time period. Retrack is an off-line capability which requires one dedicated Input/Output Processor (IOP) and one dedicated 16K word memory module for execution and storage of the Retrack software. The Retrack software requires access to all operational program memory. This access is necessary to provide the interfaces between Retrack and the operational programs being driven. Retrack interfaces with the input/output buffers and tables in the operational program data base. These are the same buffers and tables through which data are passed between the system processors and peripherals during normal live operation. The Retrack software is designed to simulate these peripherals by providing the data which is normally input by them. The data which were recorded during live and/or test operations is used to drive the operational system. Retrack retrieves the recorded data from disc or tape as appropriate. It processes the recorded data chronologically, message-by-message, searching for those message types which are to be replayed into the system. When a message is found that is to be replayed, Retrack reformats it from the recorded format to the normal peripheral input format. Retrack next inserts it at the appropriate time into the corresponding peripheral's input buffer or table in the operational program data base. All further processing of this data item is accomplished by the operational program the same as during normal live operation.

It should be noted that there are three separate and distinct Retrack software source programs. Although they all perform basically the same functions, each one is designed to interface with only one operational program type. The operational program types are:

ARTS III
: Refer to figure 1 for a block diagram of the ARTS III/Retrack system.

ARTS IIIA (Including New York TRACON and Tampa/Sarasota)
: Refer to figure 2 for a block diagram of the ARTS IIIA/Retrack system.

EARTS
: Refer to figure 3 for a block diagram of the EARTS/Retrack system.

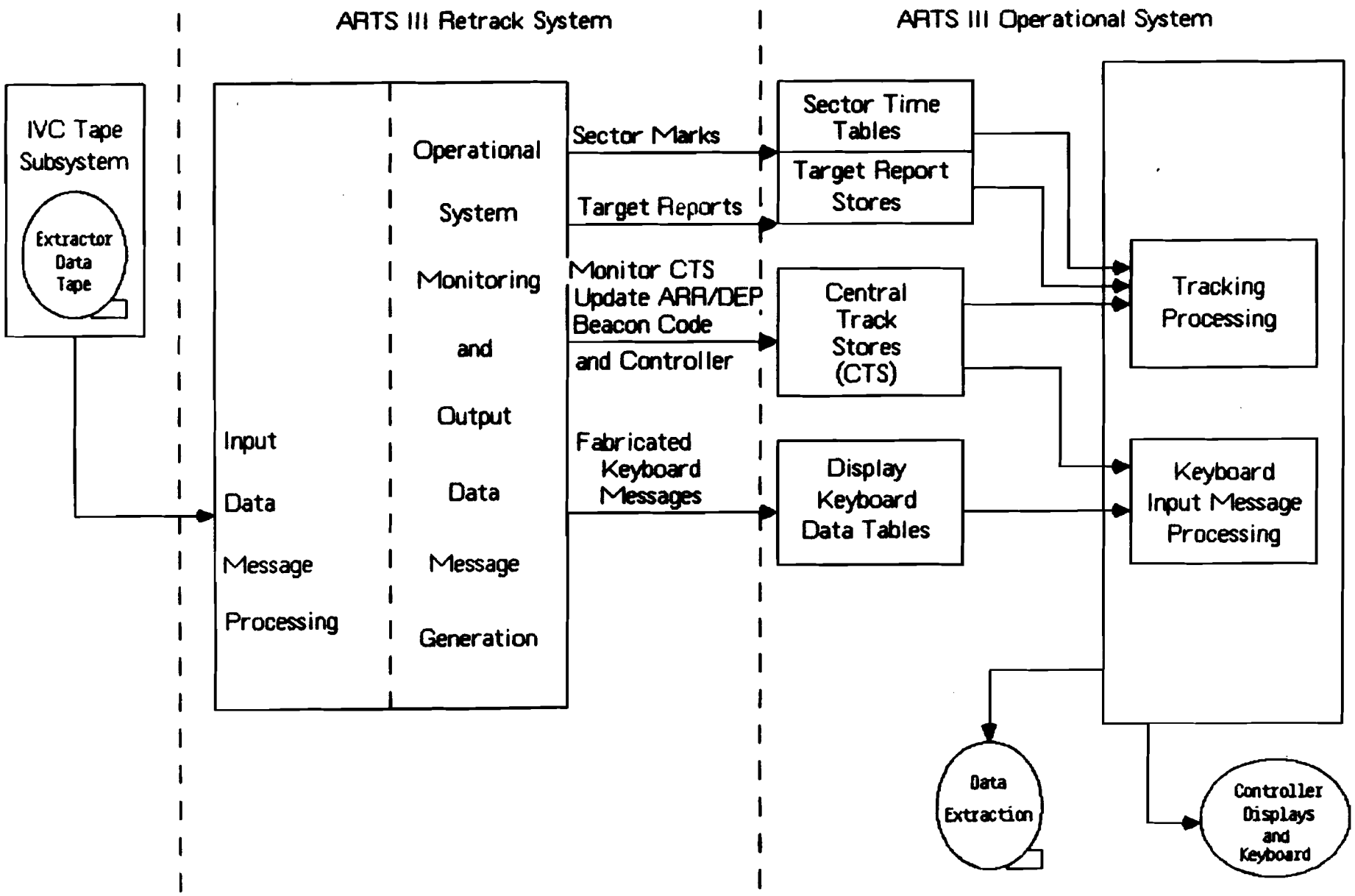

FIGURE A-1. ARTS III/RETRACK SYSTEM

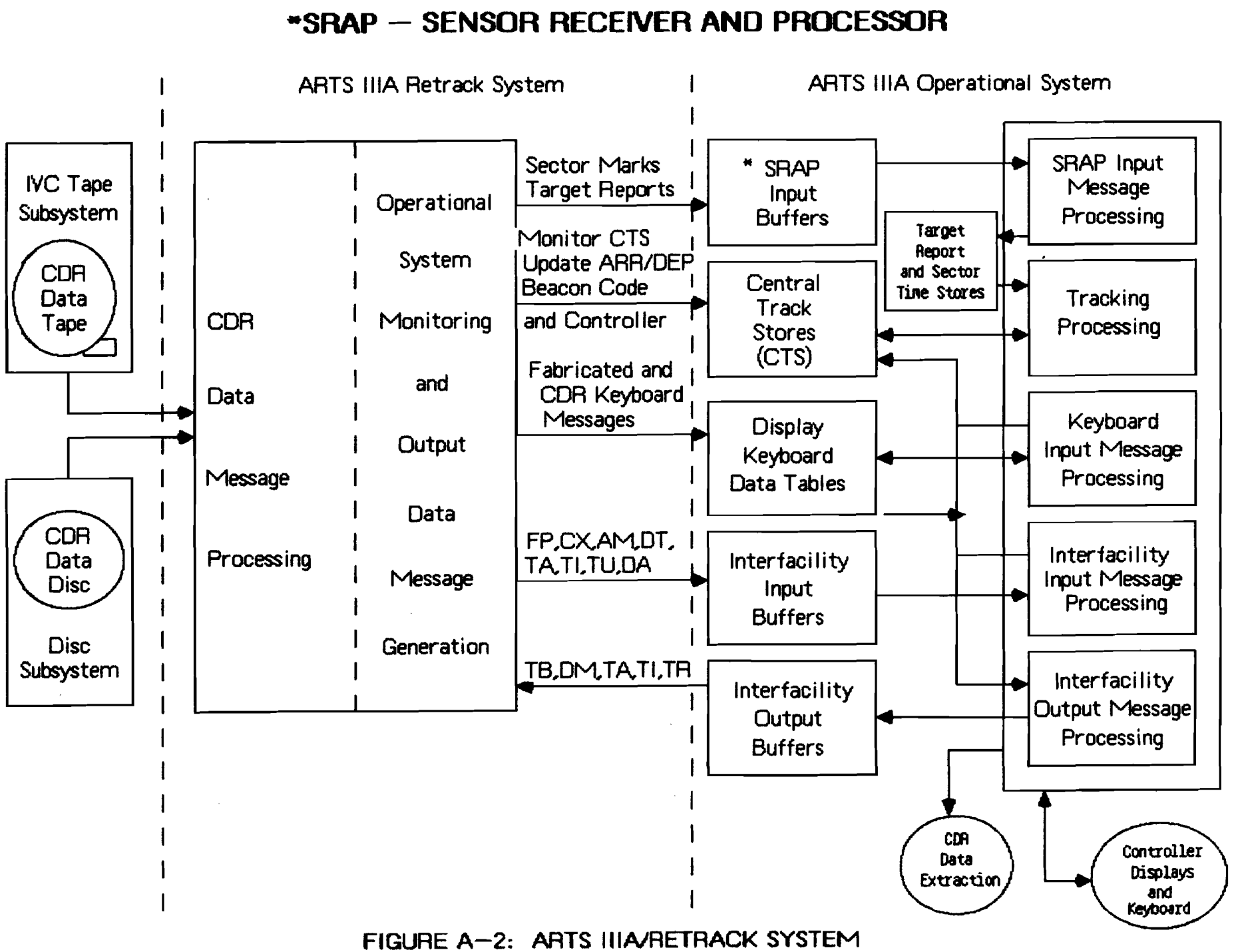

FIGURE A—2: ARTS IIIA/RETRACK SYSTEM

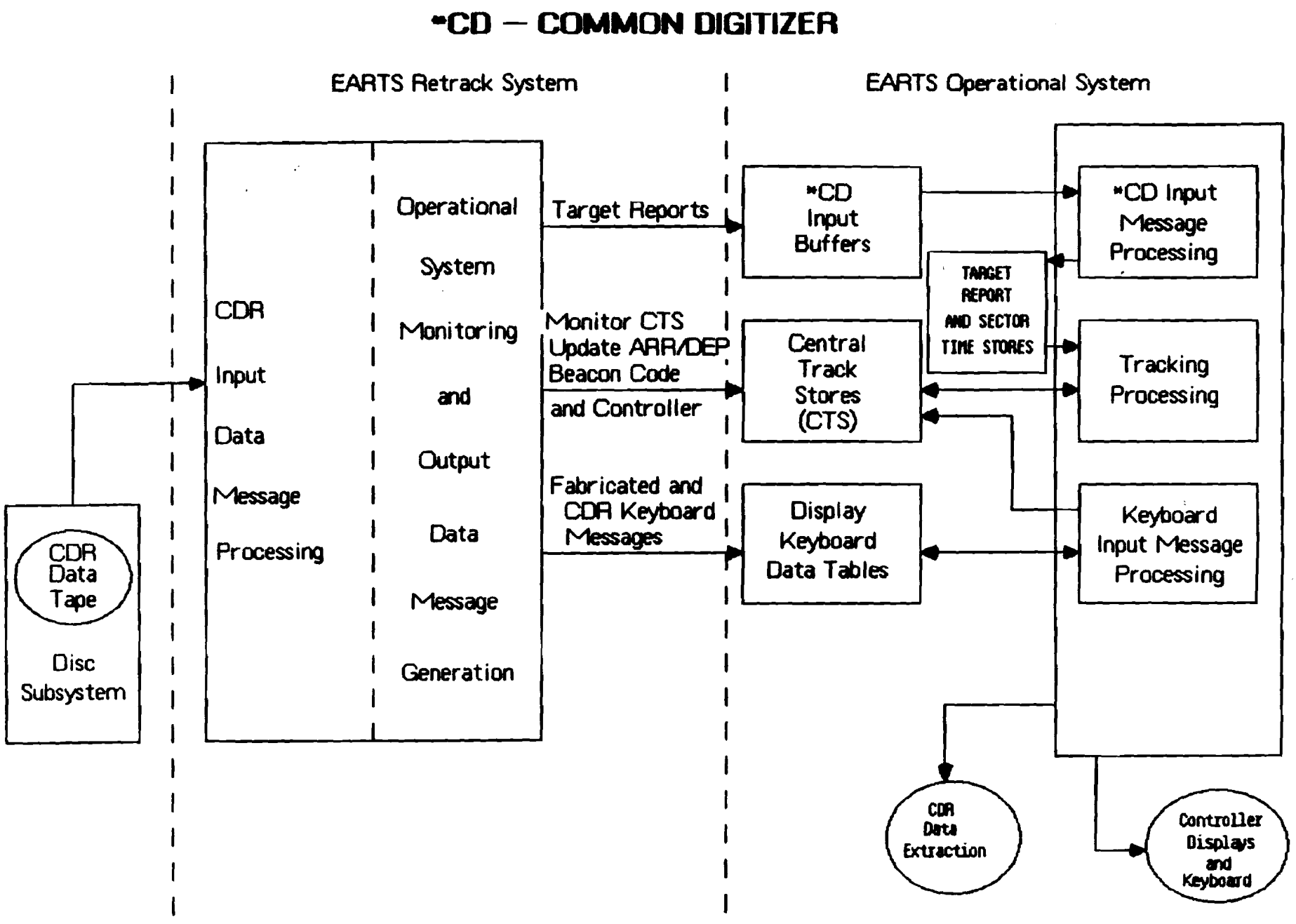

FIGURE A-3. EARTS/RETRACK SYSTEM

The corresponding Retrack software programs are appropriately referred to as:

ARTS III Retrack
ARTS IIIA Retrack
EARTS Retrack

These individual programs will be further addressed in Capabilities and Limitations of Retrack.

CAPABILITIES AND LIMITATIONS

In the Retrack description, it was stated that there are actually three separate and distinct Retrack software programs. The three programs were identified as the ARTS III Retrack, ARTS IIIA Retrack (including ARTS IIIA, Tampa/Sarasota and New York TRACON) and EARTS Retrack. All three have some capabilities and limitations which are common. Each of the three have some capabilities and limitations which are not found in the others. The capabilities and limitations are described below.

a. COMMON LIMITATIONS - Retrack must be adapted and assembled to make it compatible with each site program version to be driven. This is accomplished by review of the appropriate operational program instruction and data listings and memory map. These data must be included in the runstream for assembly of Retrack.

   Display control and switch settings are not and cannot be recorded or replayed by automatic means. Only manual recording and re-setup is available. These include quick-looks, range scale, decentering, intensities, character size, leader length, and data block field inhibits.

   Retrack cannot guarantee to display exactly what the controller saw, only what should have been displayed with the data that was available at the time.

   Retrack does not replay display or track data. Rather it provides target report and aircraft identification data to the operational system to allow it to process, track and display the data the same as during normal live operation.

   Historical system and configuration data are not automatically available to Retrack or the operational system at Retrack startup time. This means the system must default to the adapted data which was assembled with the operational system's data base. However, these data items may have been changed during the live system operation. These data include system configuration, altimeter settings, controller consolidations, sensor selection and altitude filters to name a few. These data are only recorded when it is changed by controller keyboard entry and keyboard entries can be replayed. However, the initial values at Retrack startup time are not available. All these data are available in the live operational data base and could be periodically recorded and subsequently replayed by Retrack.

Retrack cannot be executed during normal live operation.

b. ARTS III RETRACK LIMITATIONS - The ARTS III Retrack requires the Uniservo VI-C tape system for input of recorded data for replay. This tape system is quite old and is not very reliable. Disc input is not available in the ARTS III Retrack.

The recorded data must be preprocessed by an off-line JOVIAL program before using it for playback by Retrack. This step also requires use of the Uniservo VI-C tape system.

ARTS III Retrack does not replay recorded keyboard entries or interfacility data, but this is not a necessity for replay of aircraft identification and positional data.

c. ARTS IIIA RETRACK LIMITATIONS - Executes in real time only. Fast time/freeeze capabilities are not available.

d. EARTS RETRACK LIMITATIONS - Executes in real time only. Fast time/freeze capabilities are not available.

e. COMMON CAPABILITIES - Each of the Retrack programs has the capability of replaying all surveillance type data if included in the recorded data. This includes primary radar reports, beacon reports and radar reinforced beacon reports. They each provide sensor scan timing data to the operational system which is required for the system tracking functions.

It is important to note that during either live operation or when data are played back through Retrack, only the Tampa/Sarasota system tracks and displays all primary and beacon targets. ARTS III will display <u>all</u> beacon targets even though it only tracks beacon targets with associated flight plans. ARTS IIIA and New York TRACON track and display all beacon targets and only those primary targets with an associated flight plan. All the targets/tracks discussed above are displayed at the reported position.

Each Retrack program has the capability of fabricating a limited selection of controller keyboard entries and inserting them for processing by the operational system. These are necessary in order to associate aircraft identities to target data, e.g, track start and flight plan keyboard entries.

Each Retrack provides the capability to select the start/restart time of the data to be replayed. Upon detecting the request Retrack searches the disc or tape in the proper direction, forward or backward through the data until the requested time is found. When found, Retrack reinitializes the system and starts the replay from that point.

Each Retrack allows normal operational system display and console typewriter keyboard entries and data recording to be conducted concurrent with the replay.

f. ARTS III RETRACK CAPABILITIES - The ARTS III Retrack has the capability of driving the operational system in real time or fast time. It can also freeze the operational system when desired.

The ARTS III Retrack also has the capability of interfacing with the R&D ARTS III Metering and Spacing (M&S) and Enhanced Target Generator (ETG) programs. This allows live recorded data to be fed into the ARTS III system for testing of the M&S program.

The ARTS III Retrack has the capability of replaying data from one or two sensors.

g. ARTS IIIA RETRACK CAPABILITIES - The ARTS IIIA Retrack has the additional capabilities of replaying controller keyboard messages and interfacility messages back into the system.

The ARTS IIIA Retrack can also run concurrent with the Enhanced Target Generator (ETG). This provides the capability of mixing the live recorded data with ETG scenario data to build traffic loads for use in operational system performance and capacity testing.

The ARTS IIIA Retrack also has training applications. Recordings of training runs containing data which has been perturbed by controller actions can be replayed for controller/instructor observation.

The ARTS IIIA Retrack has the capability of replaying Continuous Data Recording (CDR) data directly from the CDR disc or tape without any preprocessing of the data as is required with the ARTS III Retrack.

The ARTS IIIA Retrack has the capability of replaying data from one to four sensors.