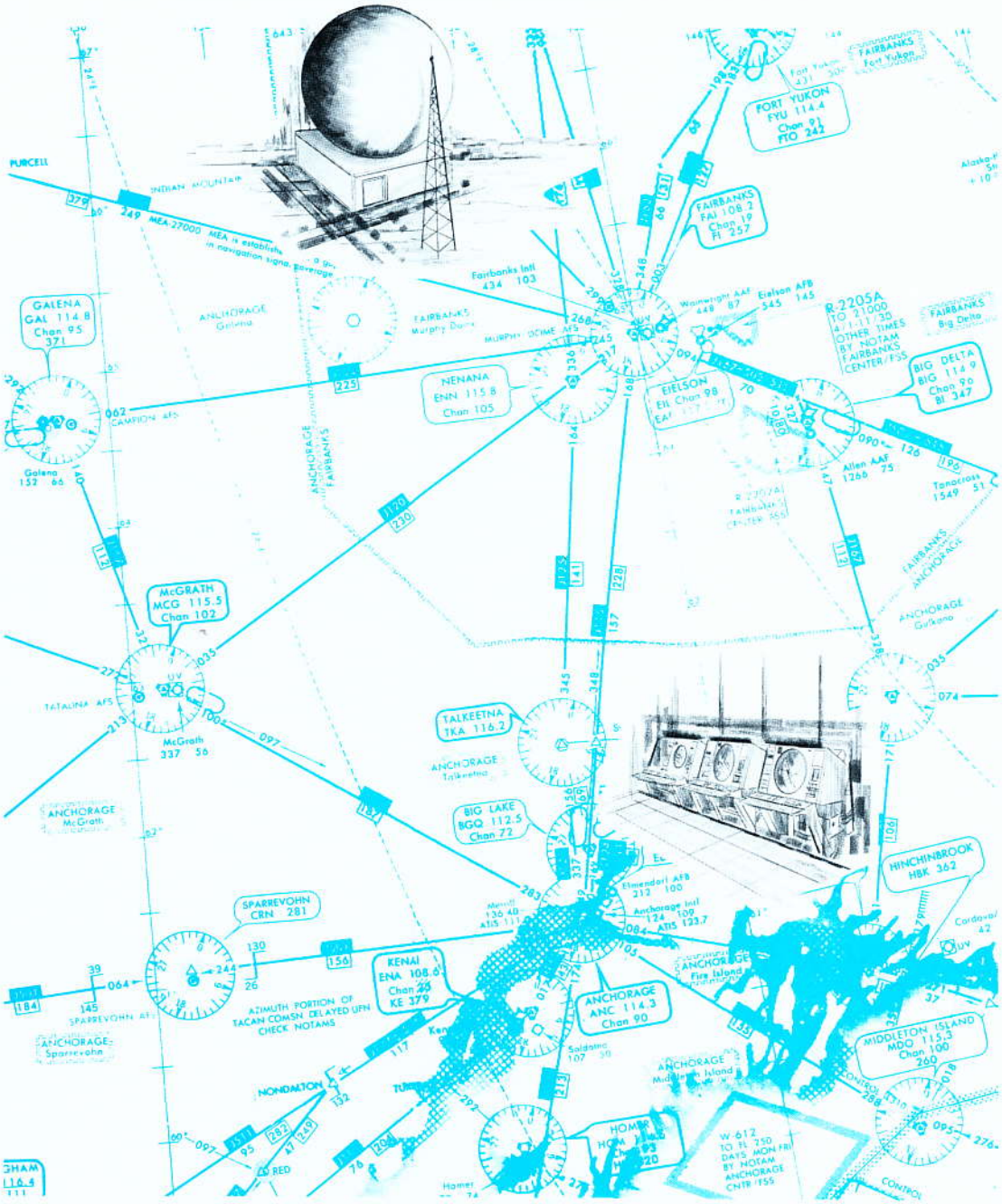
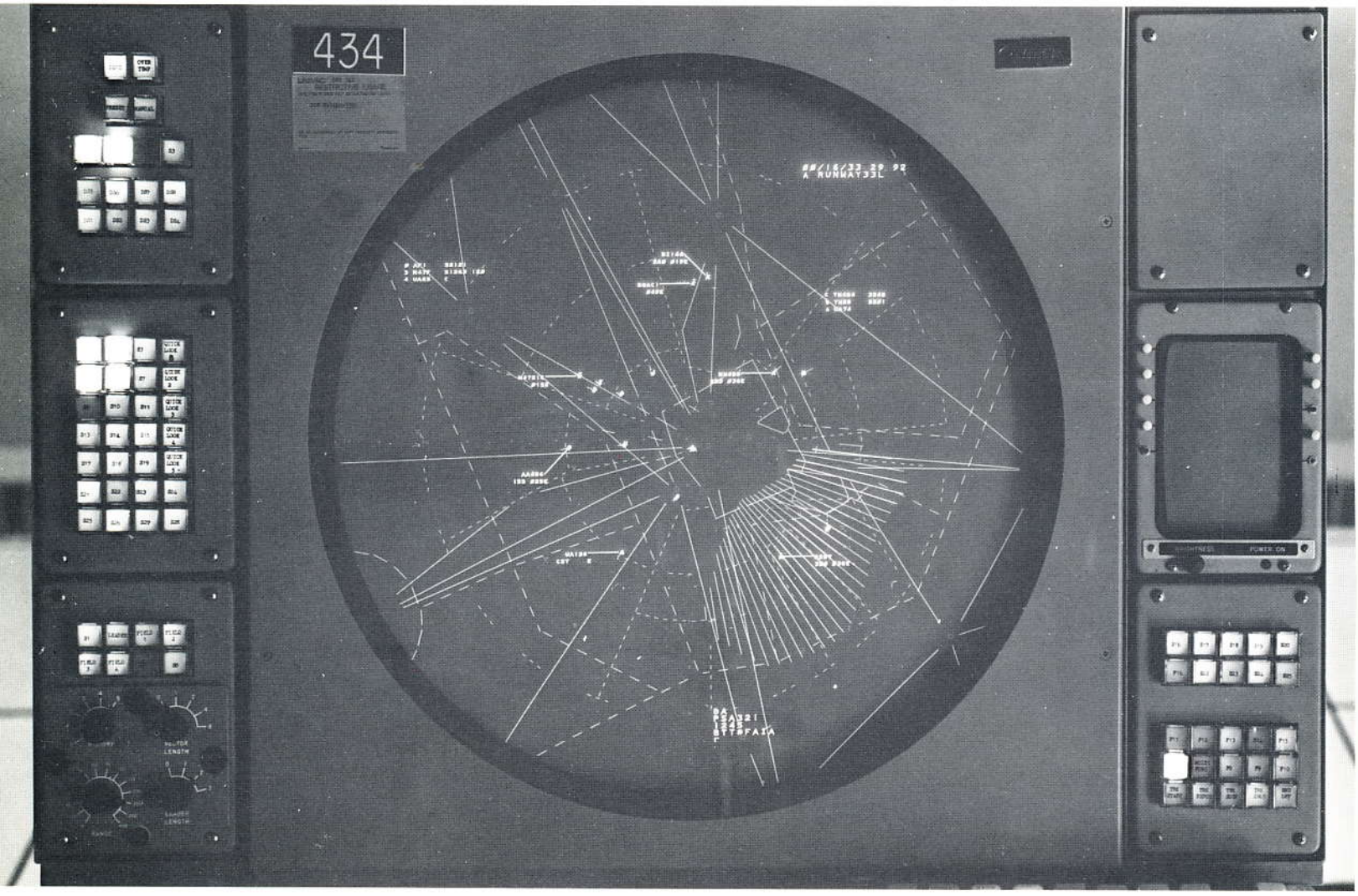
MURPHY DOME AUTOMATED RADAR TRACKING SYSTEM



SPERRY UNIVAC
DEFENSE SYSTEMS

INTRODUCTION

In October, 1974, nine months after contract award, a low-cost radar/beacon tracking and display system was delivered to the Air Route Traffic Control Center in Anchorage, Alaska. The system will fulfill the Federal Aviation Administration (FAA) requirement to relocate the radar information in an area remote from the Murphy Dome Radar Site near Fairbanks, Alaska. After installation of this system, the high and low altitude en-route sectors at Fairbanks will be handled by air traffic controllers in the Anchorage Center using synthetic radar presentations on plan view displays.



A TYPICAL SYNTHETIC RADAR PRESENTATION

FAA REQUIREMENT

The Federal Aviation Administration (FAA) will be required to close the En-route ARTCC Center located at a military base in Fairbanks, Alaska, by December, 1974. It has been determined that the most cost-effective replacement method would be to relocate and combine the center with the one at Anchorage. The air traffic information provided by the en-route radar and beacon antennae at Murphy Dome will now be sent to Anchorage.

PROBLEMS

Various alternatives were examined in light of the limited budget and extremely tight time schedule. Transmission of broadband radar data using microwave links from Fairbanks to Anchorage would have been very expensive, requiring as many as 10 separate legs. Digitizing the radar data at the antenna site, then sending it over phone lines was considered to be the most cost-effective transmission technique.

A second major problem arose in the utilization of the digital information at Anchorage. In en-route systems of the continental United States, digitized radar and beacon data is processed by NAS computers located at each one of 22 en-route centers and presented as synthetically generated target data on plan view displays. The relatively low traffic in the Fairbank's region did not warrant a large NAS computer system to process the data on a cost versus benefit basis.

SOLUTION

The solution to providing a digital synthetic display system in a cost-effective and timely manner was to use existing technology from the en-route and terminal automation programs within the Federal Aviation Administration. The production common digitizer is capable of digitizing the radar and beacon data from a 200-mile ARSR radar and transmitting it over telephone lines. The controllers are using synthetic radar presentations on the plan view displays at many of the en-route centers in the continental U.S.

The terminal ASR radars, which have a 60-mile range, are used in the TRACONS to control approaching and departing aircraft. The ARTS III system is used operationally in 62 of the medium and high density TRACONS to process aircraft beacon data in a time shared radar and alpha-numeric display presentation. The ARTS III system has a data processing subsystem that consists of a medium size computer called the IOP (input/output processor) that has modular expansion in terms of memory size and processing power.

On-going research and development activities have been conducted in the terminal automation program. In addition to the current operational beacon tracking program, the Systems Research and Development Service of the FAA is working with Sperry Univac on the enhancement of the ARTS III system. New hardware and software modules have been developed to fit the basic ARTS modular framework for future terminal automation with the ultimate being an all-digital system. Many of these modules were used to build the Murphy Dome system.

ADAPTED TECHNOLOGY

Some of the on-going terminal enhancement efforts that were useful in designing the Murphy Dome system are listed below:

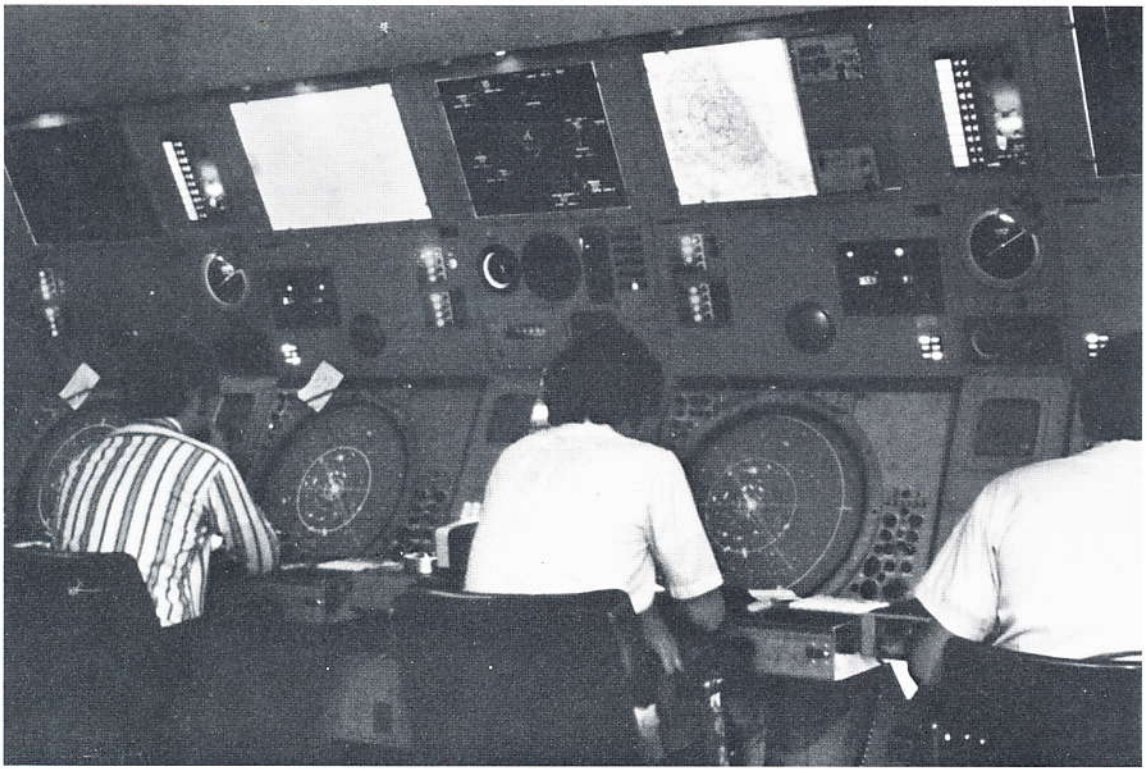
1. Improved Radar Beacon Tracking Program
2. Terminal Weather Digitizing
3. All Digital Terminal Display
4. Multiprocessing Executive Program
5. Failure Recovery Software
6. Multi-sensor Tracking Software.

Two modified enhancement hardware modules were especially useful in completing the system hardware interface.

1. A communications multiplexer was developed to interface the ARTS system with en-route ARSR radars. This data would backup the terminal ASR radar coverage in the terminal multi-sensor tracking program. Minor modifications were made to use this as a digital radar communications multiplexer (DRCM) used in the Murphy Dome ARTS system.

2. A buffer memory was developed to refresh the terminal displays. The buffer memory provides refresh during system reconfiguration, serves as a multiplexer between two computers driving a display, and relieves the processor load in driving the all-digital display. Concepts borrowed from this hardware module were used to design the interface buffer adapter (IBA), used in the Murphy Dome ARTS system.

By using technology from these development efforts, Sperry Univac and the FAA were able to establish a cost effective approach to a system that could be implemented in a timely manner.



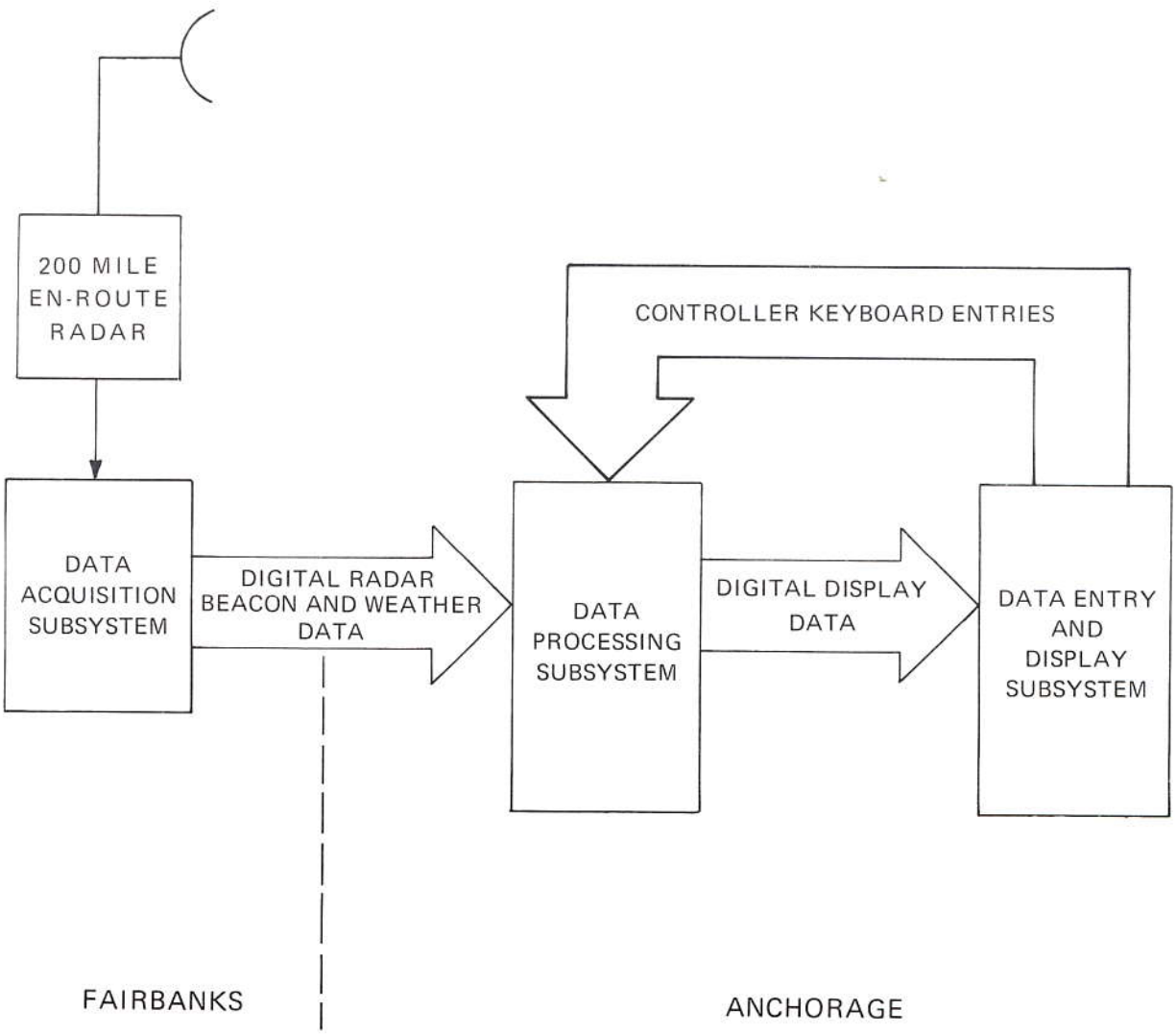
CONTROLLERS CONTROLLING AIR TRAFFIC USING THE ARTS III SYSTEM

THE SYSTEM

With many of the building blocks available, the FAA contracted with Sperry Univac Defense Systems to act as the systems integrator. The Murphy Dome system is comprised of a data acquisition, a data processing, and a data entry and display subsystem.

Both of the government-furnished subsystems were provided from existing hardware inventories.

The FAA provided the production common digitizer and the weather fixed map unit for the data acquisition subsystem at Murphy Dome and the phone-lines to Anchorage. The FAA also furnished the data entry and display subsystem, which consisted of a display generation unit and three plan view displays. Sperry Univac Defense Systems provided the data processing subsystem, the operational and support software, and the systems engineering to interface the three major subsystems.



SYSTEM BLOCK DIAGRAM

SYSTEM FUNCTIONS

For years, air traffic controllers have kept track of aircraft by watching them move as blips across a radar display. Using a basic radar and beacon system, the controller must maintain continuous mental association of radar blips with aircraft information through repetitive communications with the pilots.

In the Murphy Dome ARTS system, synthetic radar blips are electronically "tagged" with luminous letters, numbers, and symbols called alphanumerics. Use of alpha characters eliminates the need to translate from coded aircraft identity to actual identity, or vice versa. This considerably lessens the controller's work load, while providing him with continuous, positive identification of the aircraft under his control.

The Murphy Dome ARTS system provides the air traffic controller with the following functions:

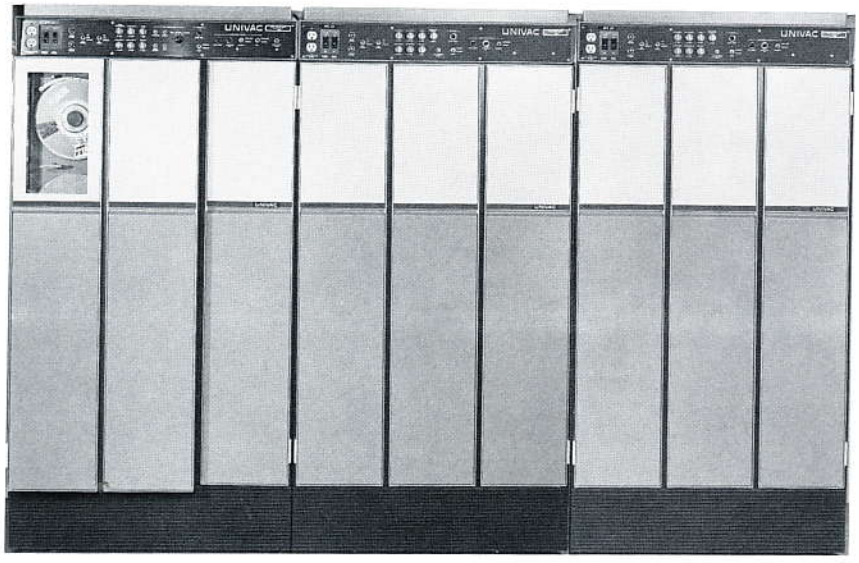
1. Tracking of all primary radar and beacon targets received from the digitizer at Murphy Dome
2. Alphanumeric display of the tracked targets on the plan view displays
3. Data block information on controlled targets consisting of aircraft identity, ground speed, and altitude (if aircraft is mode C equipped) and controller assigned to the aircraft
4. Automatic display of identification (ID), radio failure (RF), emergency (EM), and hi jack (HJ) messages received from aircraft equipped with beacon transponders
5. Synthetically generated geographical map showing routes, fixes, and control boundaries
6. Digital display of weather data received from the weather fixed map unit at Murphy Dome
7. Track history for the last five antenna scans to show the trail of the aircraft
8. Tabular data preview areas on the display for beacon code assignments, expected flight arrivals, and other system information.

DATA PROCESSING SUBSYSTEM

The Sperry Univac Defense Systems data processing subsystem consists of off-the-shelf modules used in the ARTS III and the modified modules developed in the ARTS Enhancement program. The cabinets, memories, and the peripheral adapter module are the same as those used in the ARTS terminals today. The I/O processor is an enhanced multi-processing version of the basic ARTS III IOP.

The peripheral switch panel and the memory reconfiguration panel allow system configuration flexibility.

The DRCM, IBA, and the switch panels were designed to occupy the same cabinets as the IOP and memories. The IBA was designed to interface the 30-bit IOP with the 64-bit DGU with no modification to the existing FAA equipment.



OUTSIDE VIEW OF THE CABINETS CONTAINING THE DATA PROCESSING SUBSYSTEM

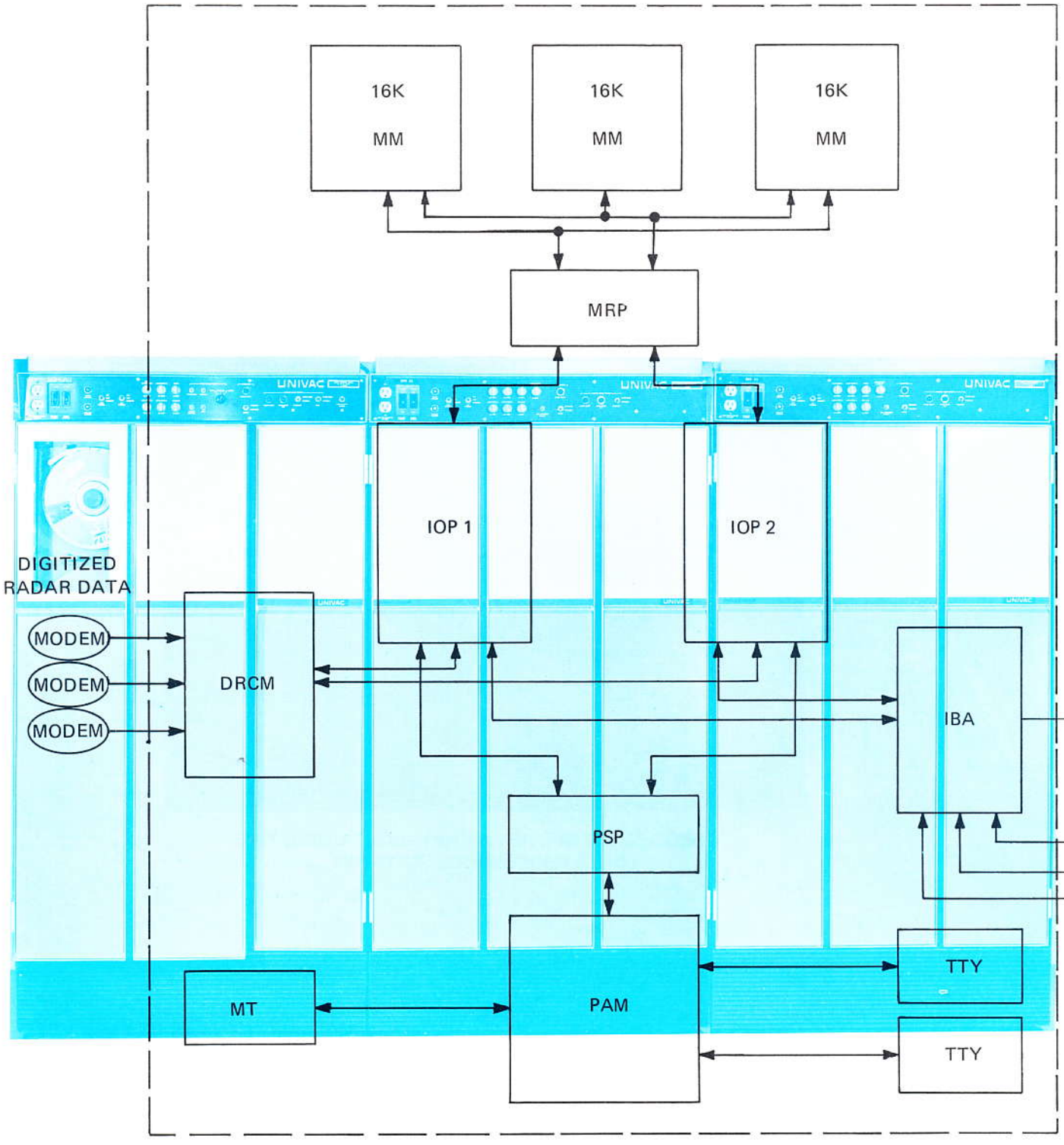
REAR

TERMINAL DAS (SPACE UNUSED IN MURPHY DOME SYSTEM)		16K MEMORY	16K MEMORY	16K MEMORY	DRCM
TAPE DRIVE	PAM	IOP 1	(PERIPHERAL AND MEMORY) SWITCH PANELS	IOP 2	IBA
PERIPHERAL CABINET		PROCESSOR CAB 1		PROCESSOR CAB 2	

FRONT

EQUIPMENT LAYOUT FOR MURPHY DOME DPS

DATA PROCESSING SUBSYSTEM

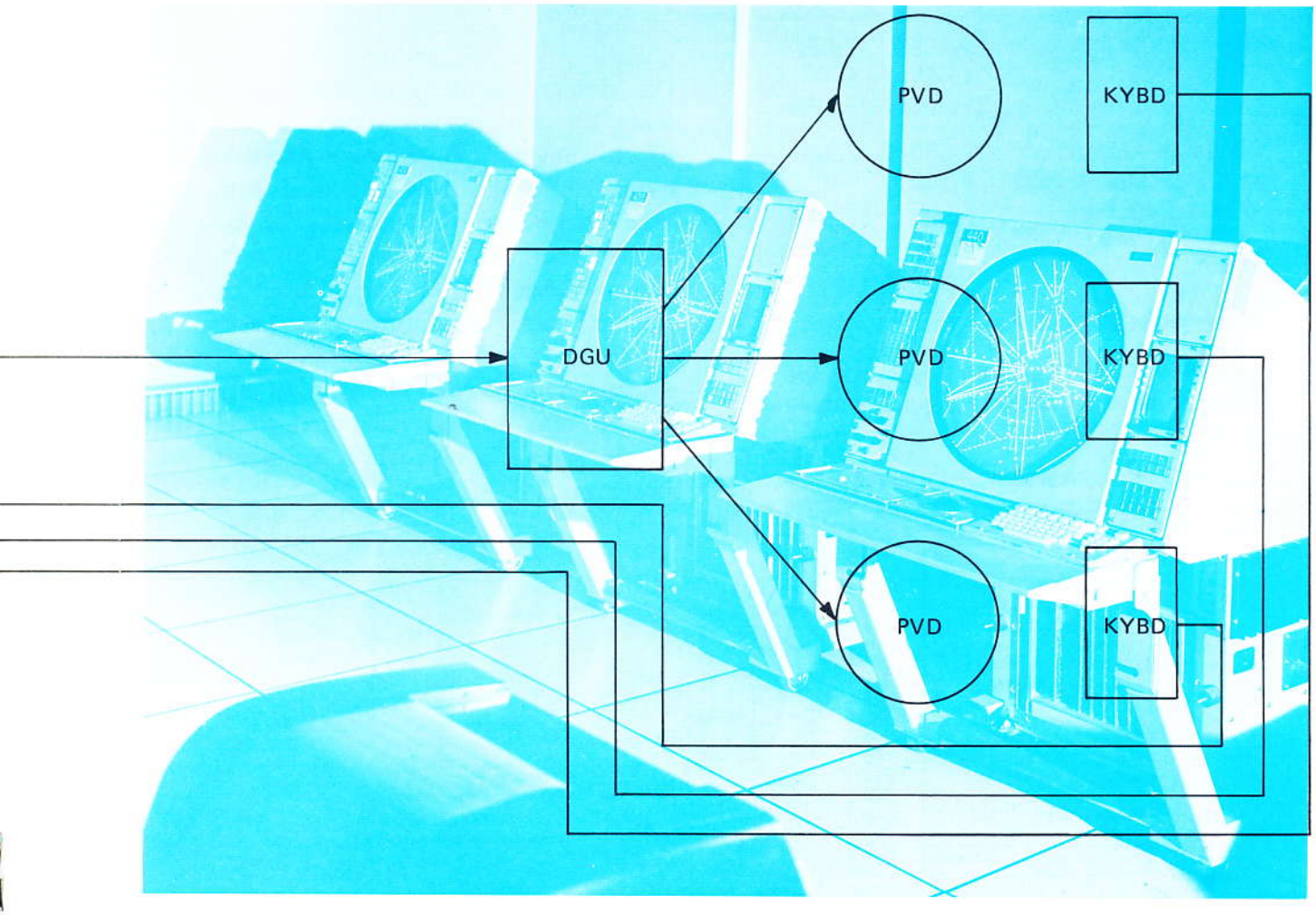


BLOCK DIAGRAM, DATA PROCESSING A

LEGEND

- DPS — DATA PROCESSING SUBSYSTEM
- MM — MEMORY MODULE
- MRP — MEMORY RECONFIGURATION PANEL
- IOP — INPUT/OUTPUT PROCESSOR
- PSP — PERIPHERAL SWITCH PANEL
- PAM — PERIPHERAL ADAPTER MODULE
- IBA — INTERFACE BUFFER ADAPTER
- DRCM — DIGITAL RADAR COMMUNICATION MULTIPLEXER
- DGU — DISPLAY GENERATOR UNIT
- PVD — PLAN VIEW DISPLAY
- KYBD — CONTROLLER KEYBOARD
- TTY — TELETYPEWRITER
- MT — MAGNETIC TAPE DRIVE

DATA ENTRY AND DISPLAY SUBSYSTEM



D DATA ENTRY AND DISPLAY SUBSYSTEMS

SYSTEM CAPACITY

The initial system is sized to handle the following data:

1000 target reports
400 tracks
100 full data blocks
100 limited data blocks
200 single symbols
500 tabular characters
200 map and weather lines.
200 Map and weather lines

A back-up operational program will track 200 targets and run in one IOP and two memory banks. The following table shows the approximate core usage in the two versions of the operational program.

	Program Version (400 Tracks)	(200 Tracks)
Program Algorithms	22,650	22,350
Critical Data Storage	4,100	-0-
Track Data Base	18,000	10,000
Total Core Used	44,750	32,350
IOP Modules	2	1
Memory Modules	3	2

A breakdown of the operational program algorithms and their core requirements is as follows:

PROGRAM MEMORY USAGE

SUBROUTINE	CORE
EXECUTIVE	5,100
DISPLAY OUTPUT PROCESSING	1,400
WEATHER AND MAP PROCESSING	800
PCD INPUT PROCESSING	2,100
KEYBOARD, TRACKBALL, QUICK LOOKS	4,200
TRACKING	5,100
RADAR HISTORY	400
TIMEOUT PROCESSING	300
AUTOMATIC FORMAT OFFSET	250
MAGNETIC TAPE FLIGHT PLANS	300
COMMON SUBROUTINES	2,400
CRITICAL DATA RECORD	300
TOTAL PROGRAM MEMORY	22,650

RELIABILITY

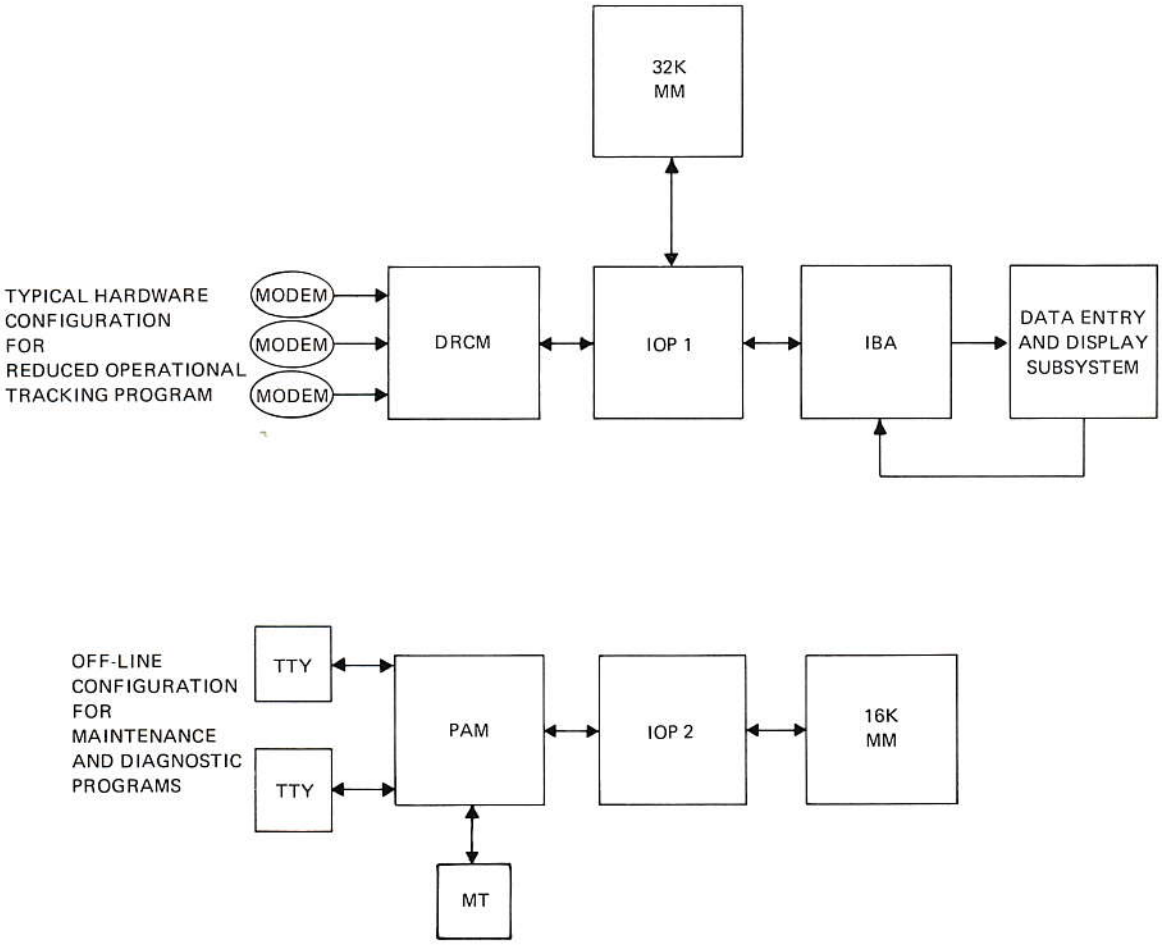
Reliability was an important consideration in configuring the data processing subsystem for two main reasons. There is no broadband radar or beacon backup from Murphy Dome as in the continental centers. Any failure of the processing system causes a loss of critical radar and beacon data for the controller. Secondly, because of the remote location of Anchorage from the continental U.S., the logistics of sending parts and people to repair failed equipment would be time-consuming and costly.

The system was designed with redundancy for continual operation in a cost-effective manner. As shown in the subsystem diagram, there is a dual path from the processors to the memories, the DRCM, and the IBA. The system software is designed with several levels of programs such that a processor or memory failure would result in a lower level program running with reduced capability but providing the basic radar picture and beacon targets to maintain safe aircraft separation.

MAINTAINABILITY

Maintainability of the system was also an important consideration in the system design. The memory reconfiguration and peripheral switch panels were provided to allow flexibility in system reconfiguration for maintenance and training. Sperry Univac provided diagnostic programs for each of the hardware modules in the data processing subsystem. In addition, interface tests programs were provided to verify proper operation of the GFE subsystems.

In the event of a failure in one of the DPS modules, the system can be reconfigured into an operational system that runs on one processor. The other processor can then be used off-line to run diagnostic programs to isolate the failure with no impact on controller activities.



SYSTEM PARTITIONING TO ALLOW FOR SYSTEM MAINTENANCE

MODULAR EXPANSION

The Murphy Dome ARTS is the first step in providing automation of low density en-route centers. The system is adaptable to other en-route centers, terminals, and combined terminal and en-route centers. There is flexibility for expanding the three major subsystems, data acquisition, data processing, and data entry and display, by adding additional hardware modules.

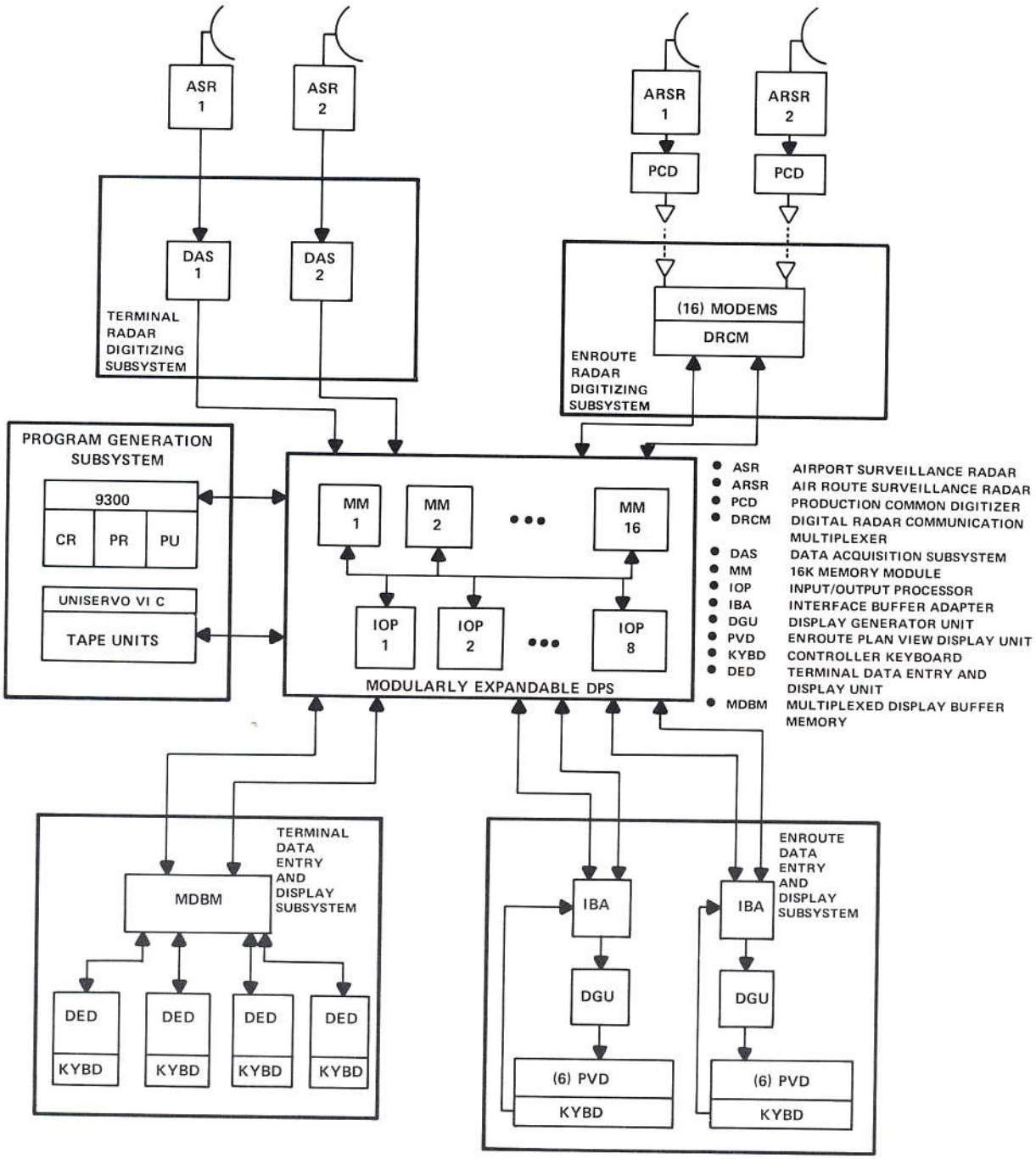
The software is also modularly expandable. The multiprocessing executive allows the addition of new program functions without changing existing software.

Adding additional I/O processors and memory modules will increase the processing and storage capability of the system. The maximum expansion is eight IOP's and eight memory banks of 16 thousand words. Each IOP has 16 input/output channels for communicating with peripheral devices. Four of the channels are special purpose to interface with the terminal beacon data acquisition subsytem and the PAM. The other 12 channels are for 30-bit parallel data transfers to external devices like the IBA, DRCM, terminal display, or 9300 subsystem.

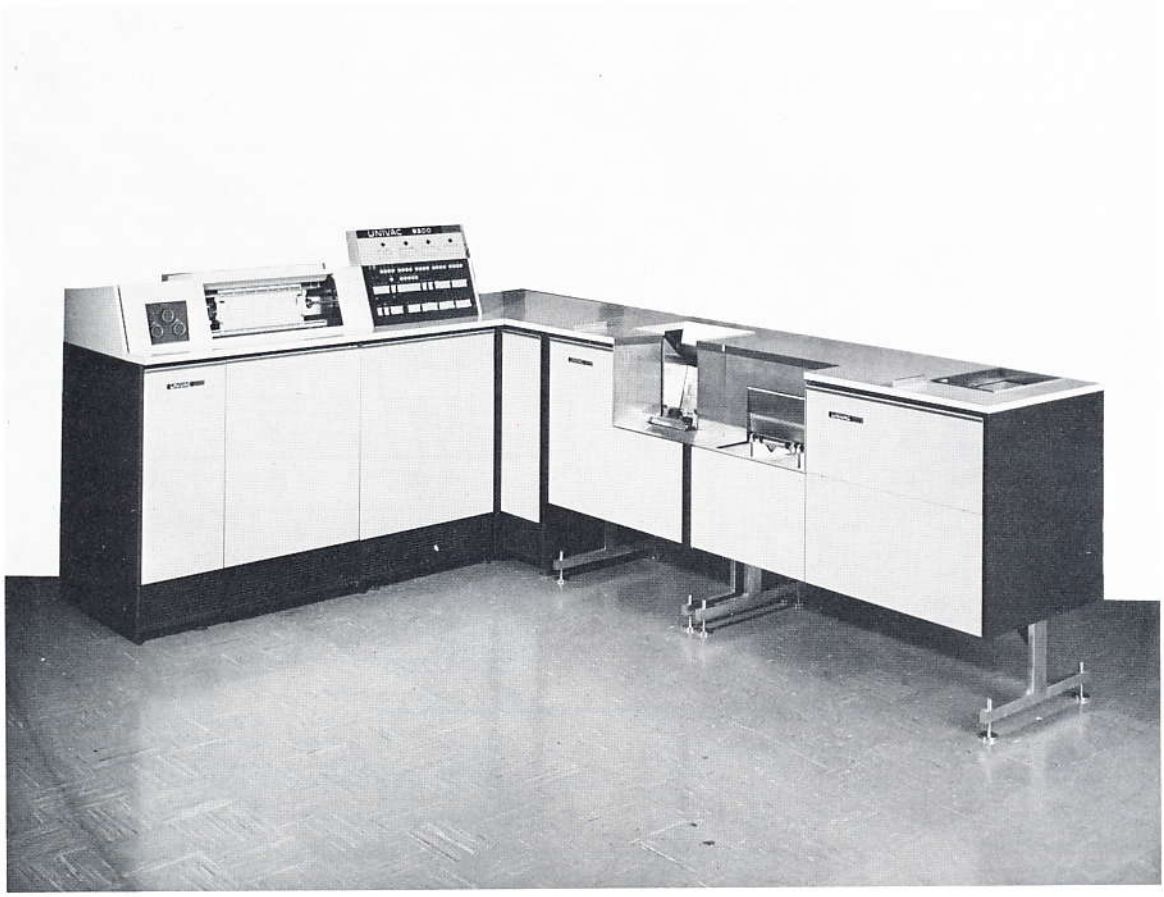
The DRCM is a serial-to-parallel multiplexer that can interface up to 16 send and receive modems. The DRCM takes the inputs from any 2400 baud RS 232 serial interface and re-formats the data into a 30-bit parallel transfer to the IOP using the externally specified index (ESI) mode of the IOP. The production common digitizer (PCD) uses three serial data lines to send data to the DRCM. More PCD's can be added to the system by adding receiver cards to the existing DRCM. Additional DRCM's can also be added to the DPS.

The IBA receives 30-bit data transfers from the IOP and re-formats the words into 64-bit data transfers to the DGU. The IBA can be expanded through the addition of logic cards to handle up to six displays on a DGU. More displays can be driven by adding other IBA's and DGU's to the data entry and display subsystem.

Additional system expansion capabilities include the addition of the terminal digitizer and the terminal displays, which are driven directly by the IOP with no additional interface. A program generation capability is provided by adding a 9300 card reader, printer and punch unit, and a set of UNISERVO® VIC tape drives. Software for operating the additional modules already exists from the ARTS III programs.



ARTS SYSTEM EXPANSION CAPABILITIES



SPERRY UNIVAC™ 9300 CARD READER, PRINTER AND PUNCH UNIT

UNISERVO® VI C MAGNETIC TAPE DRIVES

SUMMARY

Murphy Dome ARTS is an outstanding example of the problem solving capability of Sperry Univac Defense Systems in the area of air traffic control. As systems contractor, Sperry Univac is providing overall systems management, system hardware, operational and support software, factory system testing, site installation and checkout, initial maintenance and training service, and system documentation.

Sperry Univac is familiar with this type of systems involvement and has developed successful programs for other air traffic control systems. These programs date from the earliest automation systems at Indianapolis using the UNIVAC® File Computer through the 62 ARTS III sites and the ARTS Enhancement program.

Sperry Univac is prepared to ensure successful Air Traffic Control programs by offering a combination of experienced management and technical personnel; reliable equipment that is fully tested and field proven; and a support organization of world-wide scope.

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