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FEASIBILITY STUDY - REPLACEMENT OF THE INOPERATIVE DECOMMUTATING BUFFER SUBSYSTEM FOR THE INSTRUMENTATION CHECKOUT COMPLEX IN THE QUALITY AND RELIABILITY ASSURANCE LABORATORY

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16. ABSTRACT

The intent of this document is to describe a general purpose computer system that is necessary for replacement of the present inoperative signal decommutator special purpose computer subsystem of the Instrumentation Checkout Complex in the Quality and Reliability Assurance Laboratory. The present decommutator subsystem has a very poor history of reliability and since April 1970, it has become inoperative because the core memory cannot be repaired.

Functions of the present signal decommutator subsystem are to receive, demultiplex, record in real-time, playback in real-time, and output to the SDS-930 control computer for analysis of the telemetry data.

Recommendations for replacement of the inoperative telemetry decommutator subsystem are for the purchase of a mini-computer that is described in this document.

A review of the General Service Administration Automatic Data Processing Equipment (ADPE) Availability List disclosed no general purpose or special purpose equipment that could meet telemetry decommutator requirements.

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LIST OF ABBREVIATIONS

Abbreviation	Definition
A/D	Analog/Digital
ADPE	Automatic Data Processing Equipment
ASAP	Automatic Storage and Playback
ATMGS	Automatic Telemetry Ground Station
BPI	Bits Per Inch
CPU	Central Processor Unit
DDAS	Digital Data Acquisition System
DECOM	Decommutator Buffer System
EOM	Entergize Output Mode
FM	Frequency Modulation
GETS	Ground Equipment Test System
GFE	Government Furnished Equipment
GSA	General Service Administration
ICC	Instrumentation Checkout Complex
IDTS	Instrumentation Data Test Station
I/O	Input/Output
IPS	Inches Per Second
PAM	Pulse Amplitude Modulation
PCM	Pulse Code Modulation

LIST OF ABBREVIATIONS (Concluded)

Abbreviation	Definition
RACS	Remote Automatic Calibration System
RF	Radio Frequency
RSIU	Remote Selector Indicator Unit
SKS	Skip on Signal
SS	Single Sideband
TDS	Telemetry Data System
TM	Telemetry
VIS	Vehicle Instrumentation Simulator

TECHNICAL MEMORANDUM X-64676

FEASIBILITY STUDY – REPLACEMENT OF THE INOPERATIVE DECOMMUTATING BUFFER SUBSYSTEM FOR THE INSTRUMENTATION CHECKOUT COMPLEX IN THE QUALITY AND RELIABILITY ASSURANCE LABORATORY

INTRODUCTION

The purpose of this report is to: (1) show necessity for replacement of the inoperative signal decommutator special purpose computer subsystem of the Instrumentation Checkout Complex in the Quality and Reliability Assurance Laboratory; (2) give the economic and technical feasibility for replacement of existing decommutator hardware; and (3) show that all other alternatives for signal decommutation utilizing existing instrumentation checkout equipment would cause loss of continuous real-time recording capabilities, increase software development, endanger the Instrumentation Checkout Complex capabilities, and as a result, compromise Quality and Reliability Assurance Laboratory's mission requirements.

SUBSYSTEMS AND FUNCTIONS OF THE INSTRUMENTATION CHECKOUT COMPLEX (ICC)

ICC Subsystems

In order to show the necessity for replacement of new hardware and show that other alternatives for existing equipment are insufficient, it is necessary to see the ICC as a total complex. Figure 1 is a functional diagram of the ICC. This complex was designed to provide instrumentation checkout support of Saturn and follow-on programs. It is presently being used for postmanufacturing checkout and experiment data printout of the Apollo Telescope Mount (ATM) in real/near-real time.

The following are subsystems of the ICC:

1. Instrumentation Data Test Station (IDTS).

2. Decommutator Buffer System (DECOM).

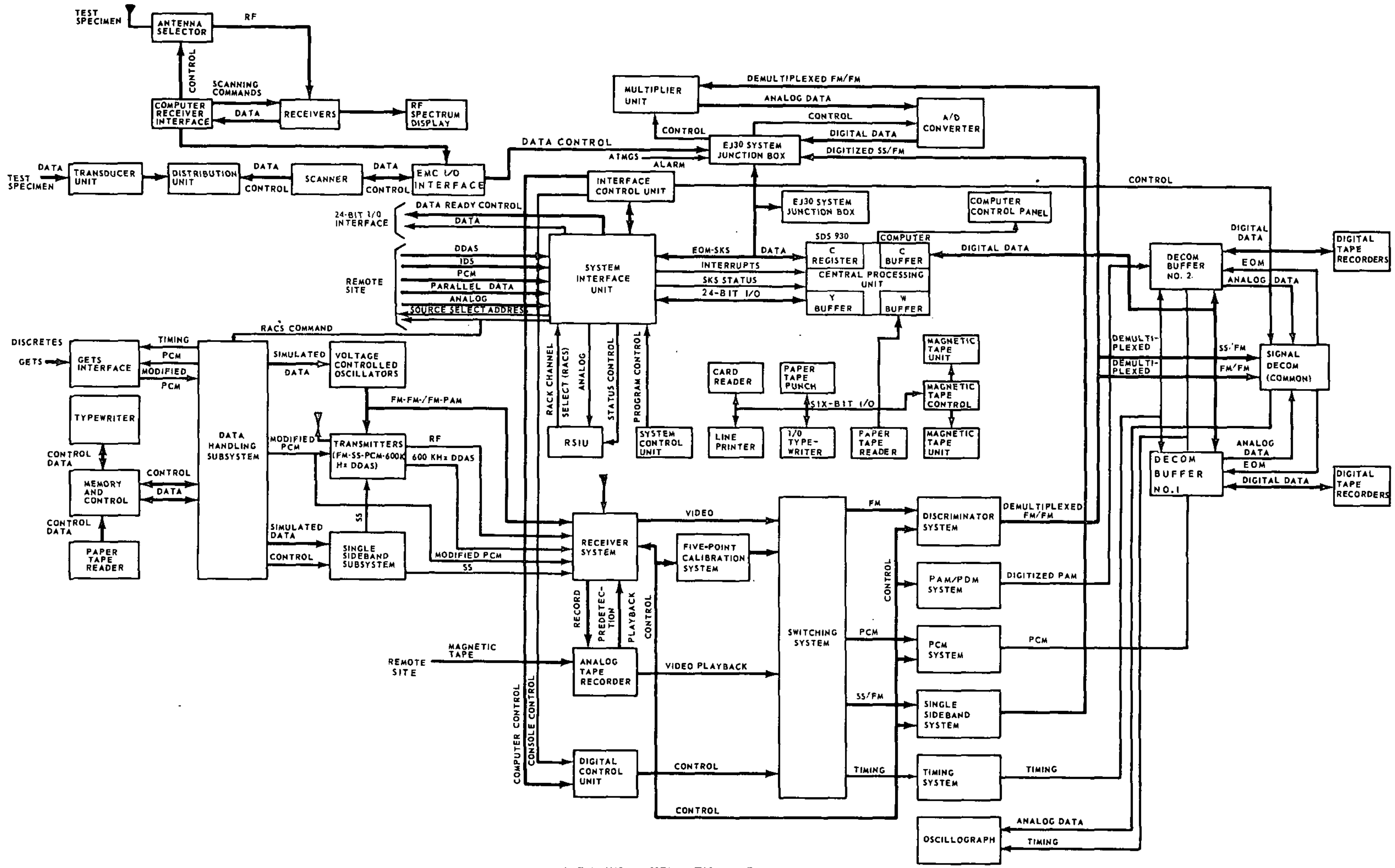

FIGURE 1 INSTRUMENTATION CHECKOUT COMPLEX

Figure 1. Instrumentation Checkout Complex (ICC).

3. Automatic Telemetry Ground Station (ATMGS).

4. Vehicle Instrumentation Simulator (VIS).

ICC Subsystem Functions

The primary function of the IDTS SDS-930 computer is to automatically control the entire complex. Other functions of IDTS are performing calibration checks, computing and outputting results of calibration, and communicating with other subsystems (Fig. 2).

The DECOM (Fig. 3) was designed to receive telemetry (TM) data, demultiplex, record continuously in real-time, output to the strip chart recorders for display, and output to the control computer for processing. These functions are accomplished by executing a program stored in the DECOM memory. The DECOM subsystem is dynamically controlled by IDTS.

Functions of ATMGS are receiving and conditioning TM data that is routed to the DECOM. This system has six subsystems (Fig. 4). Functions of each subsystem can be found in referenced documents.

Figure 5 is a functional diagram of the VIS. This subsystem was developed so that a systematic training and verification program could be provided for electrical support equipment without utilizing valuable flight hardware.

DESCRIPTION OF DECOM SYSTEM

Figure 3 describes the DECOM subsystem as being two separate decommutating buffers; each with digital tape input/output (I/O) and one common signal unit. Simply, this is a special purpose computer with two memory banks, digital tape I/O, plus ATMGS and IDTS interfacing.

This DECOM hardware is completely dependent upon the IDTS computer for input of application programs. There are only 13 executable software instructions which are limited to digital tape I/O, ATMGS I/O, indirect addressing, and interrupts.

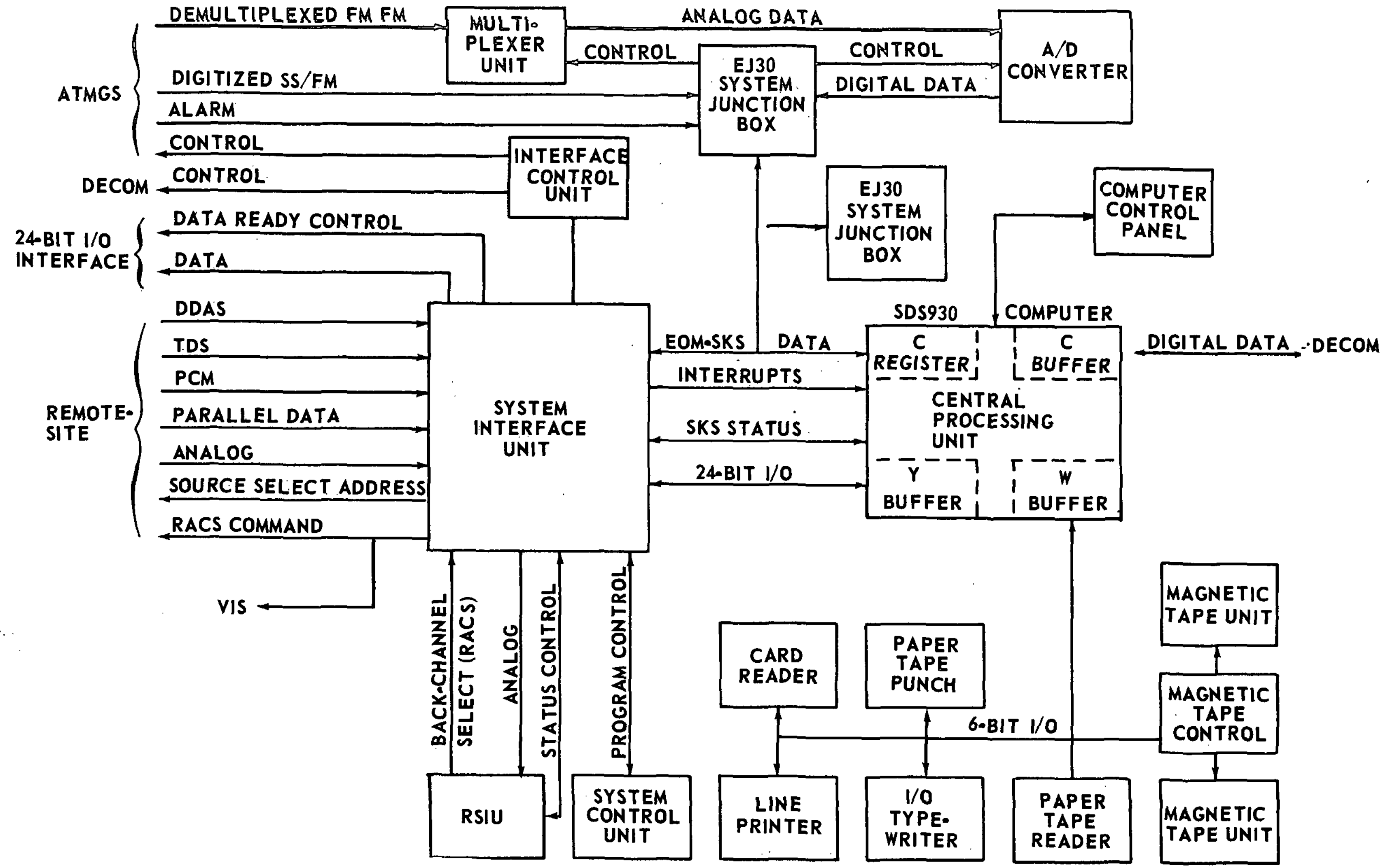

Figure 2. Instrumentation Data Test Station (IDTS).

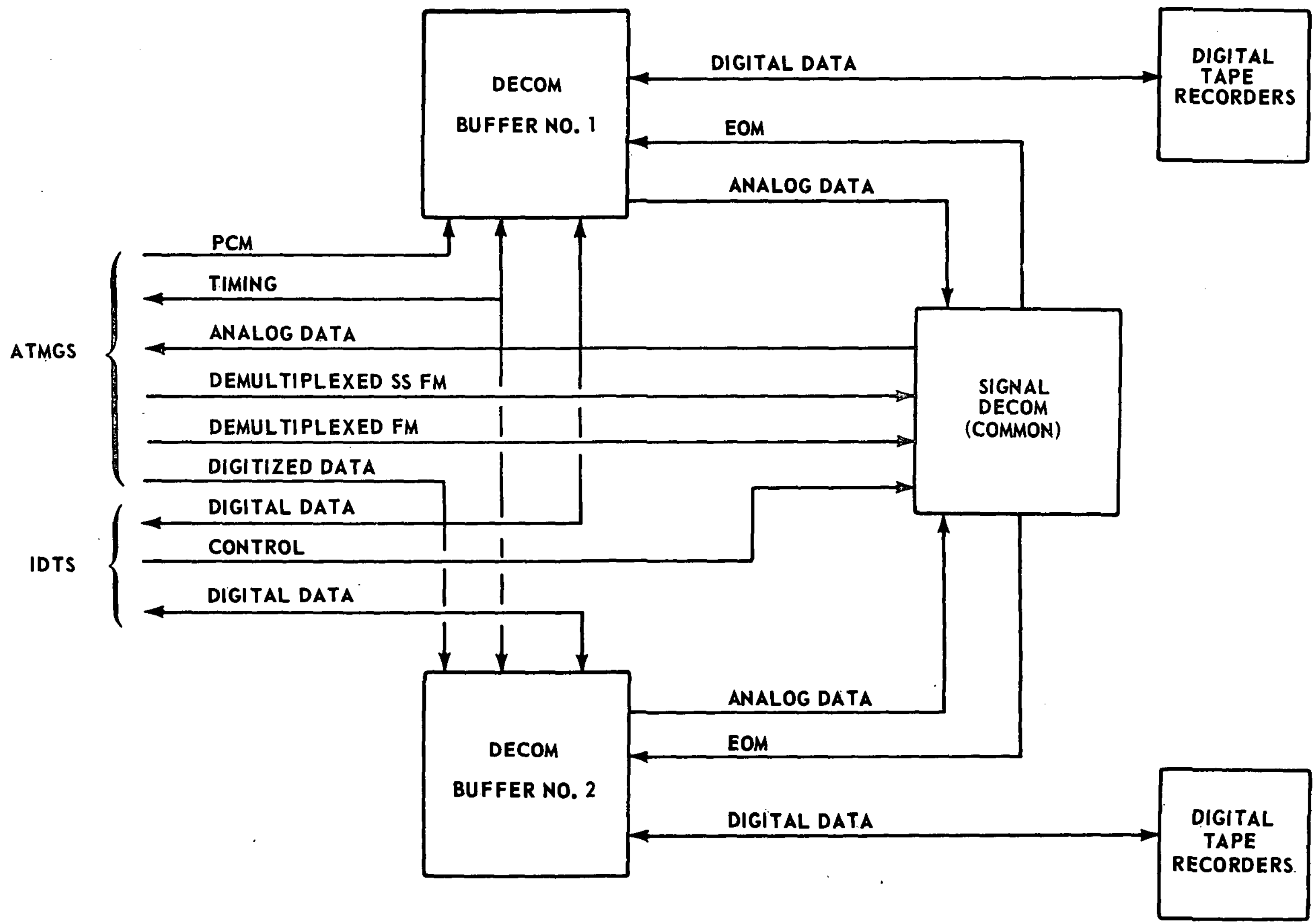

Figure 3. DECOM Buffer System.

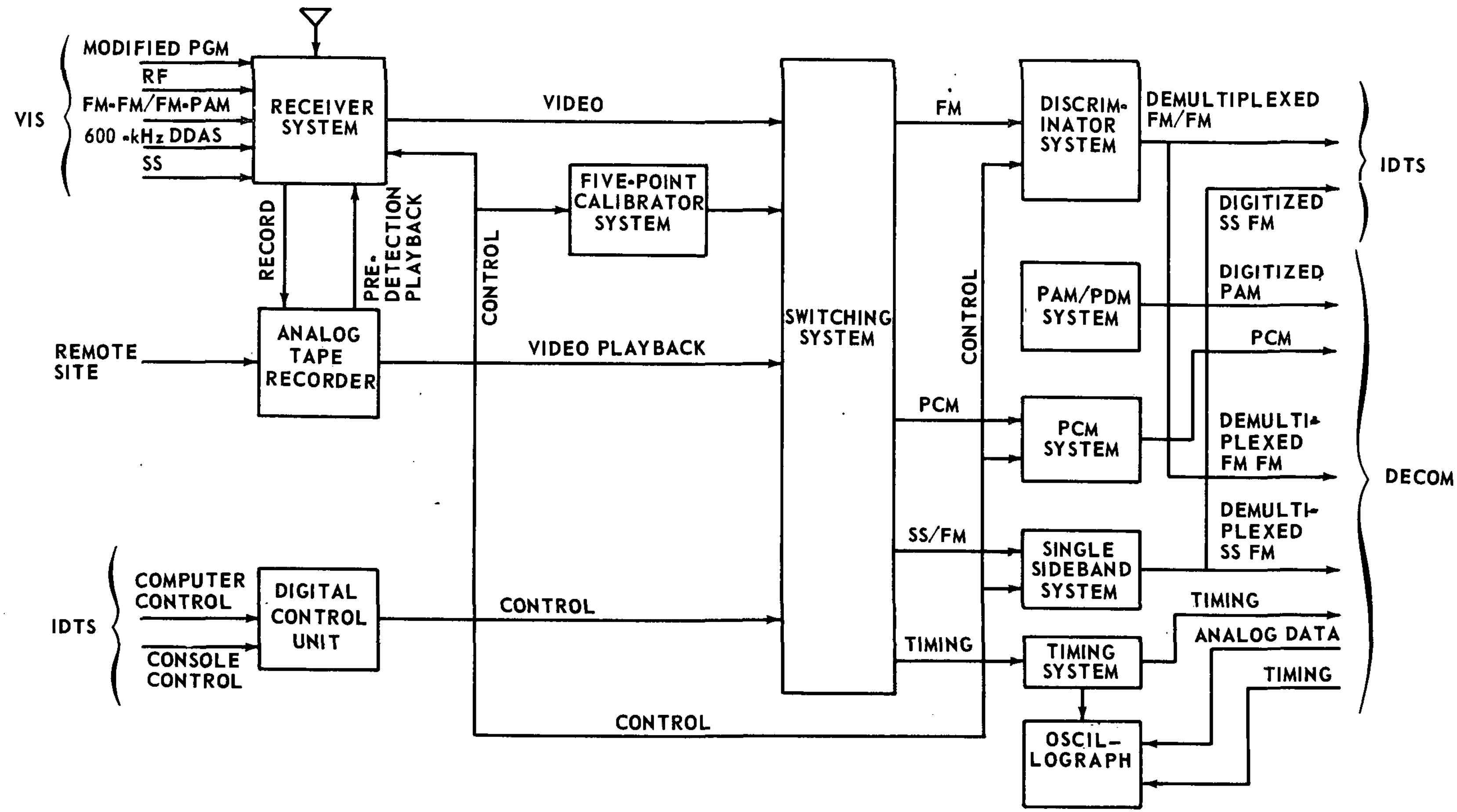

Figure 4. Automatic Telemetry Ground Station (ATMGS).

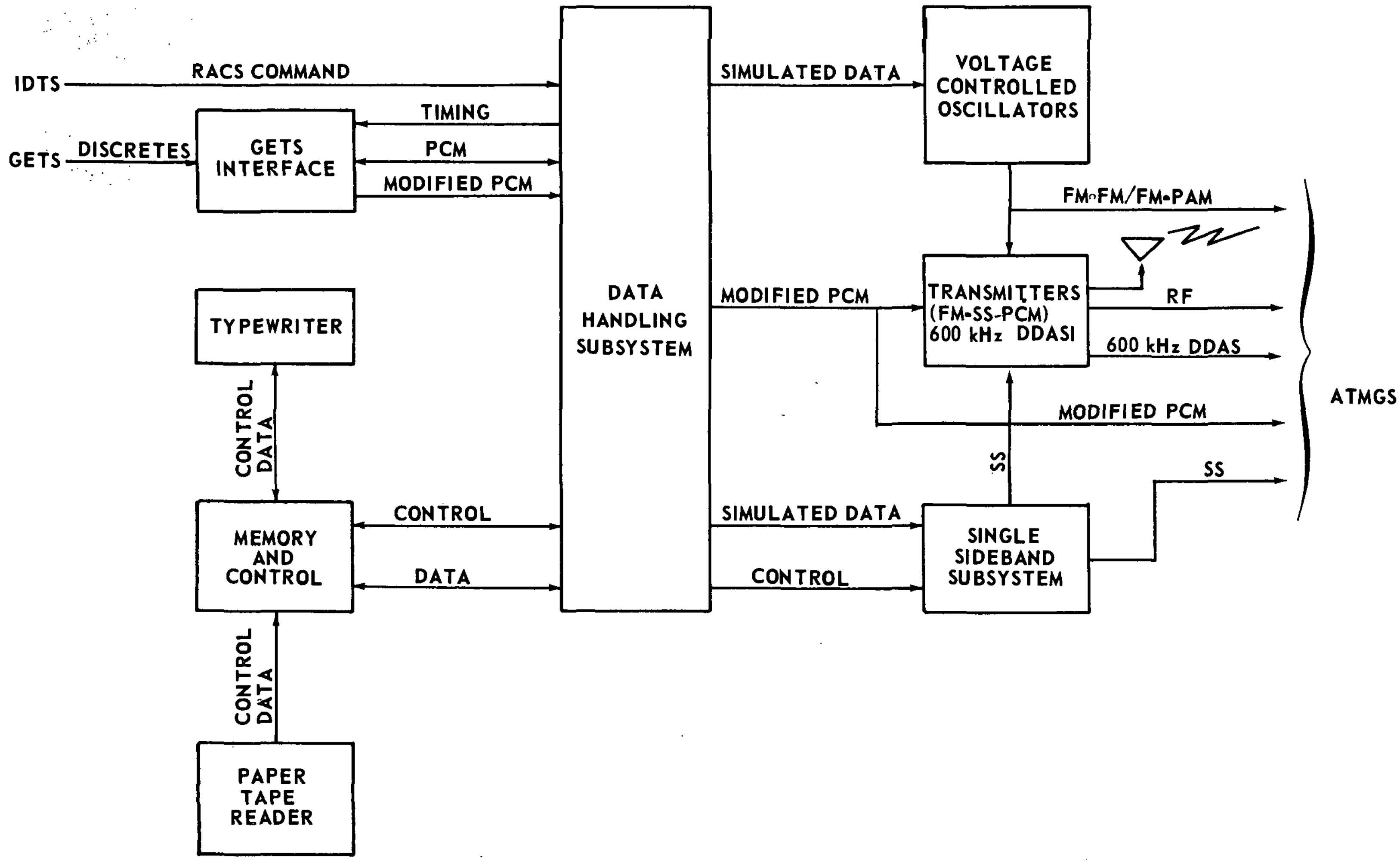

Figure 5. Vehicle Instrumentation Simulator (VIS).

Application programs are designed for recording and playback modes of operation by the DECOM. During the recording mode, TM data is received in serial form (one bit per time increment) and stored on digital tape in 10-bit word form formated according to TM specifications. During playback mode, the TM data is buffered into the DECOM memory from digital tape, and the IDTS computer retrieves the TM data for processing and output.

Characteristics of the DECOM subsystem are as follows:

1. Central Processor Unit (CPU).

   a. Two memory banks.

   b. Each bank contains 4000 words.

   c. Twenty-four bits per word.

   d. Cycle time — 2 μsec.

   e. Thirteen executable instructions.

   f. Indirect addressing.

   g. Four interrupts.

2. Tape drives.

   a. Four AMPEX TM-11's [Government Furnished Equipment (GFE)].

   b. Speed — 120 inches per second (IPS).

   c. Density — 800 bits per inch (BPI).

3. Interfaces.

   a. Twelve bit interfaces to ATMGS with speed of 72 000 bits per second.

   b. Twenty-four bit parallel (24 bits per time increment) direct memory access to the SDS-930 computer with speed equal to 500 000 words per second.

c. Zero to four V positive I/O chassie logic levels for the SDS-930 computer.

For more details of the DECOM subsystem see Reference 1.

A careful study of Figures 1 through 4 will reveal that when the DECOM buffers are inoperative, the Pulse Code Modulation (PCM) data cannot be recorded in real-time at 72 000 bits per second. Under this condition, the Quality and Reliability Assurance Laboratory is forced to compromise the ICC capabilities. Following are impacts experienced by ICC during system checkout when the DECOM is inoperative:

1. Slower recording rate of TM data on the IDTS tapes.

2. No continuous recording capability.

3. Real-time recording and playback cannot be simultaneous.

4. Strip-chart recording and display cannot be performed.

5. Larger CPU time is required of the SDS-930 during checkout.

HISTORY OF DECOM UNRELIABILITY

History of the present DECOM has been compiled from files of three repair requests, the ICC log, letters, phone calls, and people associated with the system [2].

Figure 6 is a pictorial representation of the present DECOM hardware as installed in the ICC. DECOM buffer 1 was installed at the Marshall Space Flight Center (MSFC) during August 1967, and DECOM buffer 2 was installed during January 1968. Two GFE tape drives were installed with each DECOM buffer subsystem.

The contract, NAS8-11763, for purchase and installation of the DECOM subsystem was awarded to Dynatronics, Electronics Division of the General Dynamics Corporation. Lack of funds caused MSFC to terminate the contract before DECOM buffer 2 was completely installed and accepted. Quality and Reliability Assurance Laboratory engineers completed the installment during August 1968. The complete subsystem gave reliable

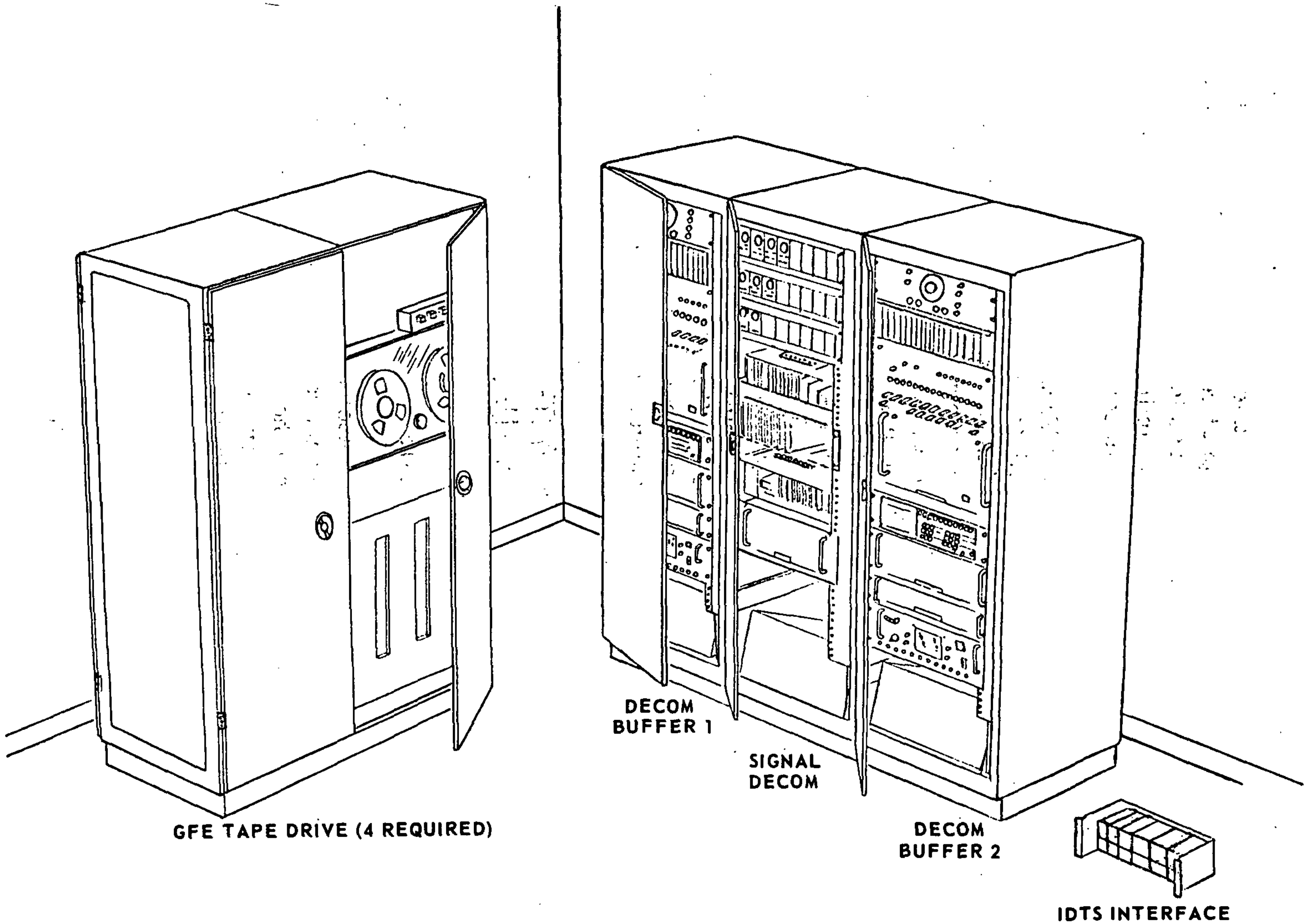

Figure 6. DECOM Buffer Equipment.

performance for 11 months. During July 1969, core memory malfunctions were encountered with DECOM buffer 2. That same month, Quality and Reliability Assurance Laboratory personnel tried for the first time to have the memory bank repaired. In this attempt at repair, Fabri-Tek Incorporated split the core stack through the x and y planes to repair bad wires. Fabri-Tek indicated that to split the core stack, a possibility of permanent damage would exist, and they could not guarantee its performance.

Varian Data Machines purchased the Versastore Core Memory Division, fabricators of the DECOM memories. With the second attempt to restore the DECOM memory, Quality and Reliability Assurance Laboratory personnel tried to purchase a new Versastore core memory stack from Varian Data Machines. The equipment was not available, however, Varian's personnel indicated that they could fabricate a new core stack for the DECOM buffer 2. During the process of gathering all the MSFC requirements for the core stack, Varian Data Machines personnel realized that new fabrication was not feasible.

A survey of the ICC log has revealed that an increasing number of intermitting problems that are difficult to resolve are occurring in the DECOM buffer 1. These problems with the DECOM buffers 1 and 2 have caused the Quality and Reliability Assurance Laboratory personnel to realize that restoration of the existing DECOM subsystem is not feasible.

FUNCTIONS AND CHARACTERISTICS OF PROPOSED DECOM SUBSYSTEM

Functions

Since recommendations are for replacement of the ICC Decommutating subsystem, functions of the proposed system are required to be at least the same as the present inoperative system; however, when installed and properly interfaced, the proposed DECOM subsystem will have more capabilities (Fig. 7). The following are additional capabilities the proposed system will have:

1. Random access of TM data.

2. Data compression for compatibility between other hardware and software systems.

3. Measurement stripout for quick-look analysis.

4. Additional SDS-930 CPU capability for system control of real-time I/O devices.

5. Wider expansion capabilities.

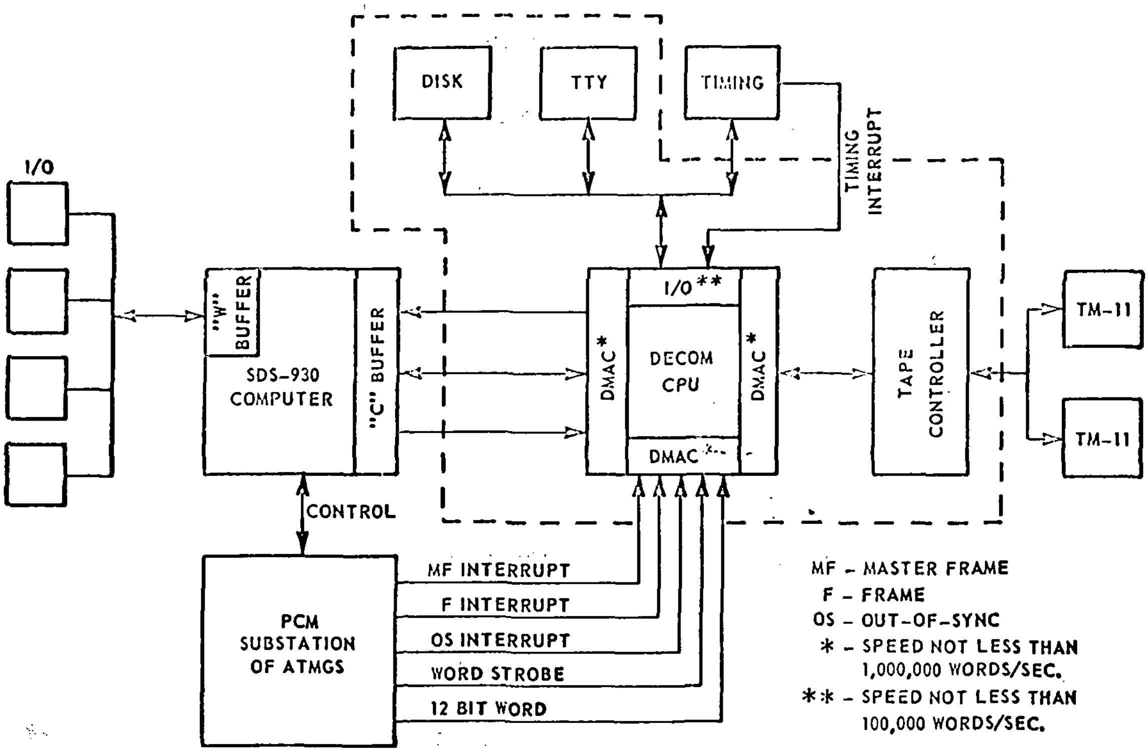

Figure 7. SDS-930 and Proposed Decommutator System.

Characteristics

The proposed replacement system is a general purpose mini-computer. It will replace the two existing DECOM buffers and two existing AMPEX TM-11 tape drives. The following are components and characteristics of the proposed DECOM subsystem:

1. Central Processor Unit (CPU).

   a. Control console.

   b. Eight thousand words of memory.

   c. Sixteen bits per word or greater.

   d. Maximum cycle time of 1.0 μsec.

   e. Modular memory expansion capabilities.

2. Tape drives.

   Two existing TM-11's.

3. Teletype input/output (I/O).

   ASR-33 or better.

4. Disc system.

   a. Storage of 1 million 2 hundred thousand 16-bit words or 1 000 000 24-bit words.

   b. At least one removable disc pack.

   c. Eighty msec access time or less.

   d. Controller and power supply.

   e. Associated software.

5. Interfaces.

   a. Twenty-four bit direct memory access to the SDS-930 computer with channel speeds of 1 million words per second or better.

   b. Twelve or twenty-four bit interface to the ATMGS with speeds greater than 72 000 bits per second.

   c. Seven data track interface with two TM-11's (more details of this interface can be found in referenced documents and Section 5 of preliminary specifications, NASA form 55).

It can readily be seen that the existing DECOM subsystem has four AMPEX TM-11 tape drives, and the proposed system has two AMPEX TM-11's and one disc system. Tables 1 and 2 reveal that interfacing four TM-11's is estimated $ 4000 less than to utilize the disc system. A disc system, in a similar manner to tape drives, is a mass storage device, and can replace at least one tape system. The primary reasons for proposing a disc system with the replacement DECOM are as follows:

1. Time and manpower savings in software development.

2. Random access of mass stored data.

3. Quick-look analysis during real-time data storage.

4. Removable disc pack capability for system software and application subroutines.

TABLE 1. ESTIMATED COST OF COMPUTER SYSTEM

Equipment	Cost in $
CPU with 8K of memory	14 500
Teletype-ASR-33 or better	2500
Disc system	12 000
Total	29 000

TABLE 2. ESTIMATED COST OF INTERFACES

Equipment	Cost in $
SDS-930 interface	6000
TM-11 interface (2)	8000
ATMGS interface	1000
Total	15 000
Total (computer system)	29 000
Total (DECOM subsystem)	44 000

SURVEY OF EXISTING EQUIPMENT

A review of the General Service Administration (GSA) Automatic Data Processing Equipment (ADPE) Availability List disclosed no general purpose or special purpose hardware that could meet the ICC decommutating requirements. The inoperative DECOM system will be salvaged by the Quality and Reliability Assurance Laboratory for functional subcomponents and spare parts. The two TM-11's that will not be interfaced to the proposed DECOM will be interfaced to the SDS-930 computer for additional I/O that is needed for software development.

SURVEY OF SOFTWARE

Existing Systems

The software package being used by the ICC is a magnetic tape library consisting of 65 assembly language systems. Forty software systems are SDS-930 programs used primarily for:

1. Setup and control of the ICC.
2. Edit and update of application programs.
3. Posttest data checkout programs.
4. System software.

Nineteen of the ICC software systems are integrated SDS-930 and DECOM computer programs used primarily for:

1. Real-time data evaluation.
2. Real-time posttest data evaluation.
3. Real-time executive systems.

Six of the ICC software systems are DECOM computer programs used primarily for:

1. Real-time data record.

2. Real-time data playback.

3. DECOM system software.

Proposed Systems

The six existing DECOM programs will be of no use to the new DECOM hardware, hence, new software development is required for the new system. Until the model and word size of the new hardware is known, it is not possible to determine the impact on the other 59 software systems.

System software will be supplied with the proposed DECOM which includes the Fortran compiler, assembler, loader, and monitor. The application software will include three separate systems:

1. Real-time data record.

2. Real-time data playback.

3. Data evaluation during real-time recording.

Software systems are developed in three phases:

1. Requirements and specifications.

2. Design, implementation, and test.

3. Documentation.

There will be a study conducted to determine which ICC checkout programs will be placed on the disc library, which programs will remain on tape library, which programs must be modified, and which programs will be for new development. This study will also determine all software requirements and specifications for the proposed DECOM subsystem.

Disc library programs, modified programs, and new development requirements must be designed with modular concepts so that they can be used as subprograms in any TM checkout languages developed for the ICC.

COST

There are no costs of facility preparation for the proposed system, and very little difference between the existing and proposed systems for operation and maintenance expenses (Table 3).

TABLE 3. OPERATION AND MAINTENANCE COSTS FOR EXISTING AND PROPOSED HARDWARE

Items	Cost	
	Existing: $/month	Proposed $/month
Electrical Power	5.52	6.00
Air Condition Expense	4.75	0.00
Maintenance	415.00	325.00
Totals	425.27	331.00

The major difference in cost between the existing hardware and proposed system is the special purpose design versus the general purpose concept. The present DECOM buffers were purchased under special purpose design. Total cost was approximately $250 000. Another special purpose purchase for the ICC DECOM system would cost approximately $200 000 for engineering, hardware, and system software. The possibility of a special purpose system becoming inoperative and incapable of repair is too high compared to the general purpose equipment whose fabricators maintain all the spare parts necessary for repair.

The total estimated cost for installing the proposed mini-computer system into the ICC is discussed in Tables 1 and 2.

Since the general purpose equipment, itemized in this report, can meet the ICC TM decommutating requirements, it is the best technical and most economical way of replacing the existing inoperative DECOM subsystem.

RECOMMENDATIONS

Based on the necessity to maintain functions and capabilities of the ICC and since there are no available computers capable and cost effective for ICC decommutation requirements, it is recommended that procurement be initiated to purchase the system described in the "Functions and Characteristics of Proposed DECOM System" section.

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APPROVAL

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The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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