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DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150594

PRELIMINARY DESIGN REVIEW PACKAGE FOR THE SOLAR HEATING AND COOLING CENTRAL DATA PROCESSING SYSTEM

Prepared by

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Under Contract NAS8-32036

National Aeronautics and Space Administration
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For the U. S. Department of Energy



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16. ABSTRACT This preliminary design review package, consisting of the Software Performance Specification, Hardware Performance Specification, and the Verification Plan for the Central Data Processing System (CDPS), was prepared by the IBM Corporation under NASA/MSFC Contract NAS8-32036. The Central Data Processing System, located at IBM's FSD facility in Huntsville, Alabama, provides the resources required to assess the performance of solar heating and cooling systems at remote sites. These sites include residential, commercial, government, and educational types of buildings, and the solar heating and cooling systems can be hot water, space heating, cooling, and combinations of these. The instrumentation data associated with these systems will vary according to the application and must be collected, processed, and presented in a form which supports continuity of performance evaluation across all applications. The MSFC review and critique of this design review package are not included.			
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Prepared for the
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SECTION A

CENTRAL DATA PROCESSING SYSTEM SOFTWARE PERFORMANCE SPECIFICATION

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1. INTRODUCTION

The Central Data Processing System (CDPS) is the Central Integration Facility which transforms the raw data collected at remote sites into performance evaluation information for assessing the performance of solar heating and cooling systems.

This CDPS Software Performance Specification (CSPS) provides the medium for baselining the overall software system requirements. After baselining, the software requirements will be placed under change configuration control and can be changed only through formal change procedures established by the Marshall Space Flight Center (MSFC). Through this procedure, the document will remain current with the requirements/capabilities of the CDPS software throughout the contractual period.

The objective of this document is to establish the requirements which must be satisfied by the CDPS software. All descriptions of and references to the CDPS hardware configuration are only to facilitate explanation of the software requirements and not to control the configuration of the hardware. The CDPS hardware is controlled by IBM and is used for support of multiple contract programs. To support this varying utilization environment, IBM must maintain the flexibility to modify the configuration as required. Because of this flexibility requirement, the CDPS hardware configuration may vary during the performance of the SIMS contract, but the capability to satisfy all SIMS processing requirements contained within the CDPS Hardware Performance Specification will be maintained. This document will not be updated to reflect changes in the detailed CDPS hardware configuration which do not affect CDPS software requirements.

The programming standards to be used in development, documentation and maintenance of the software are discussed in Appendix A. In addition, the CDPS operations approach in support of daily data collection and processing is discussed in Appendix B.

1.1 CDPS ROLE IN SOLAR HEATING AND COOLING PROGRAM

The CDPS, located at IBM's FSD facility in Huntsville, Alabama, provides the resources required to assess the performance of solar heating and cooling systems installed at 60 remote sites. These remote sites consist of residential, commercial, government, and educational types of buildings, and the solar heating and cooling systems can be hot-water, space heating, cooling, and combinations thereof. The instrumentation data associated with these systems vary according to the application and must be collected, processed and presented in a form which supports continuity of performance evaluation across all applications. In addition, data must be maintained for historical purposes and for detailed analysis.

In supporting the overall program objectives, the CDPS satisfies the following functional requirements:

Data Collection - The CDPS daily collects instrumentation data from all remote sites via standard voice-grade 1200 Baud telephone lines. In addition, non-instrumentation data available from MSFC, ERDA, HUD, etc., which is needed in performing overall system evaluation, is collected via manual means.

Data Processing - The CDPS accepts raw data, as collected by the data collection function, and performs the data processing functions required to transform the raw data into processed information for use in system evaluation/analysis activities. The CDPS also provides the resources to maintain a performance evaluation data base, containing both raw data and processed information, for use in support of performance analysts.

Data Archiving - To provide capability for detailed analyses of system performance and to maintain data for historical purposes, the CDPS provides the capabilities to archive data collected and processed during the program. Both raw data and processed data is retained on magnetic tape, and formal reports are archived in a library.

Data Distribution - In addition to collection, processing, and archiving of data, the CDPS provides the essential function of distributing the data to the appropriate organizations. Distribution is in the form of printed reports, data plots, and magnetic tapes.

Systems Analysis Simulation - An essential capability in assessing the performance of solar heating and cooling systems is the ability to predict performance for correlation with operational performance. The CDPS provides the resources needed in support of this simulation activity and provides capabilities for automated correlation of predicted and actual performance.

As shown in Figure 1, the CDPS consists of three major elements - communication interface computer, central data processing computer, and performance evaluation data base. These three elements provide the capabilities required to satisfy the functions mentioned above.

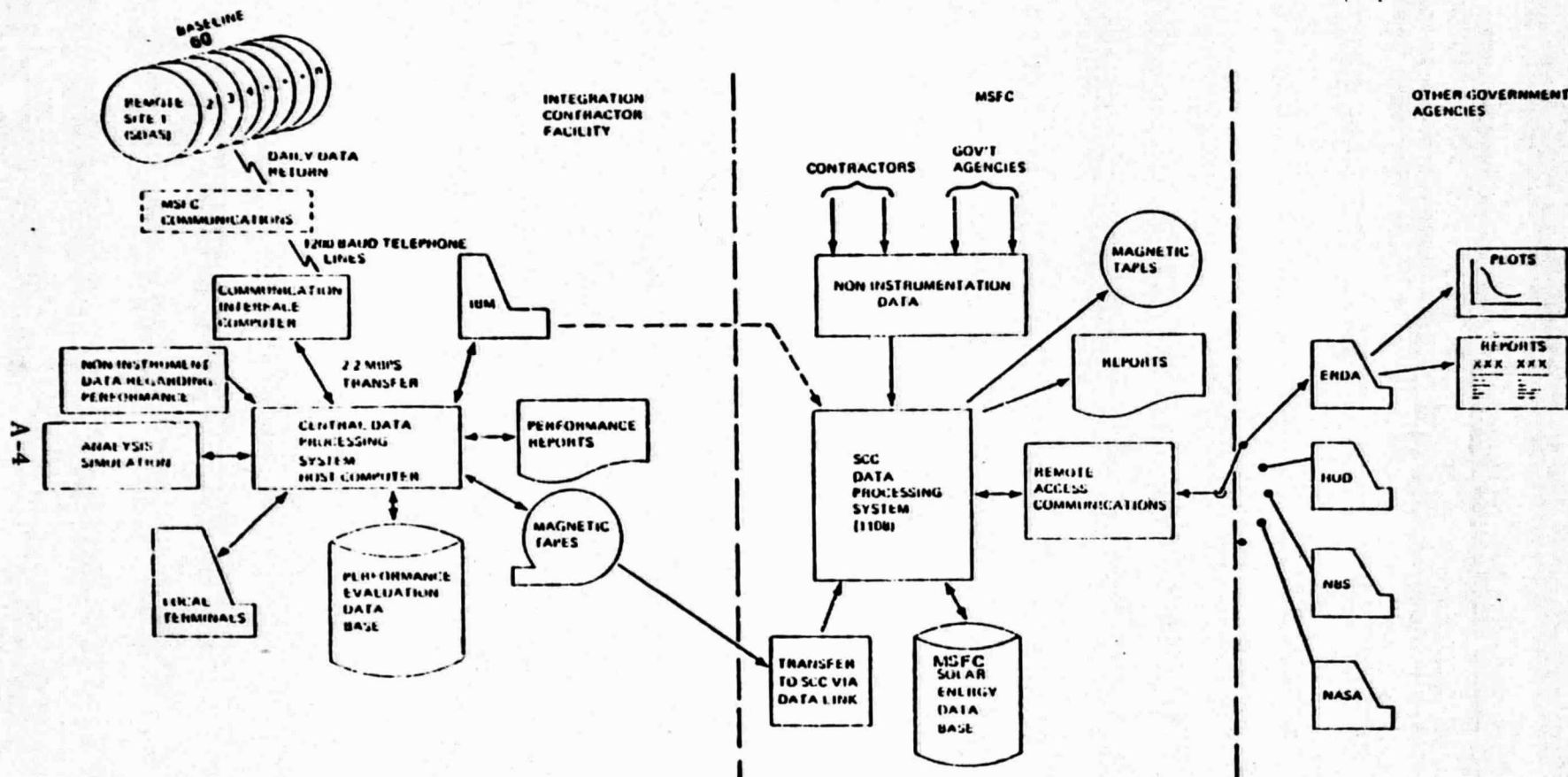


Figure 1. Role of Central Data Processing System

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1.2 CDPS FUNCTIONAL REQUIREMENTS

In performing its role within the solar heating and cooling demonstration program, the CDPS, through its hardware/software, shall satisfy overall system requirements. A summary of these system requirements is given in the following paragraphs:

Growth Potential - Because of the distinct possibility of growth in the data collection and processing requirements as additional sites are added to the program, the CDPS shall be designed to allow growth in capability with a minimum of cost.

Data Collection - To support timely processing/presentation of data in support of the performance evaluation activities, daily collection of data shall be provided from all remote sites.

Timely Processing of Data - The processing data flow within the CDPS shall minimize the delay between receipt of data at the CDPS and availability of processed information. An operations goal will be to provide processed information and reports at the start of first shift each day.

Operations Personnel - The design goal of the system shall be to minimize operations personnel utilization during data collection and processing. Software shall provide built-in error detection/recovery techniques to allow maximum of automatic control.

SDAS/CDPS Communication - Because of the availability of software/proven concepts on other programs which use telephone lines for automatic data collection, maximum benefit of this prior experience shall be utilized to reduce program risk.

System Recovery - The overall data collection concept shall provide the flexibility to ensure that site data is not lost through failure of the communication interface or host computer. Backup shall be provided to restore entire contents of performance evaluation data base in the event of computer malfunction.

Data Archiving - Within any demonstration program, availability of historical data must be provided in order to support the performance evaluation activities. The CDPS shall support this archiving of data and provide the means of identifying the location for timely retrieval.

User Support - Because of the requirements generated through a diverse user community, the CDPS shall provide a flexible user support capability which can be easily structured to satisfy needs.

Flexibility - Because variations in instrumentation at remote sites, the CDPS shall support the processing of variable input formats.

1.3 CDPS HARDWARE DESCRIPTION

As shown in Figure 1, the CDPS hardware consists of a communication interface computer configuration and a host computer configuration. The following paragraphs briefly describe the components of each of these configurations.

1.3.1 Communication Interface Configuration

The communications interface configuration provides the capability to collect data from remote sites via 1200 baud voice-grade telephone lines. WATS lines will be used for this communication and will be supplied by the Government. In addition, the communications facility at MSFC will provide the necessary communications hardware to support the data collection functions. Automatic dial-up and command interface with the remote sites will be provided by the communications interface computer.

The communication interface configuration operates in a standalone mode of operation and consists of:

- (1) An IBM System/7 computer with input/output peripherals to support operator interface, report generation, and data storage.
- (2) Communication interface hardware for communications with remote sites via telephone lines.
- (3) Hardware to support collection of data via manual means.
- (4) Communication hardware for transfer of data to the host computer configuration (IBM S/370-145).

The overall hardware elements are shown in Figure 2 and are discussed in the following paragraphs.

1.3.1.1 System/7 Computer

As can be seen in Figure 2, the System/7 computer configuration consists of the following hardware:

- (1) Central Processing Unit (CPU)
- (2) Memory
- (3) Teletype Keyboard/Printer (5028)
- (4) Disk Storage (5022)
- (5) Printer (7431)

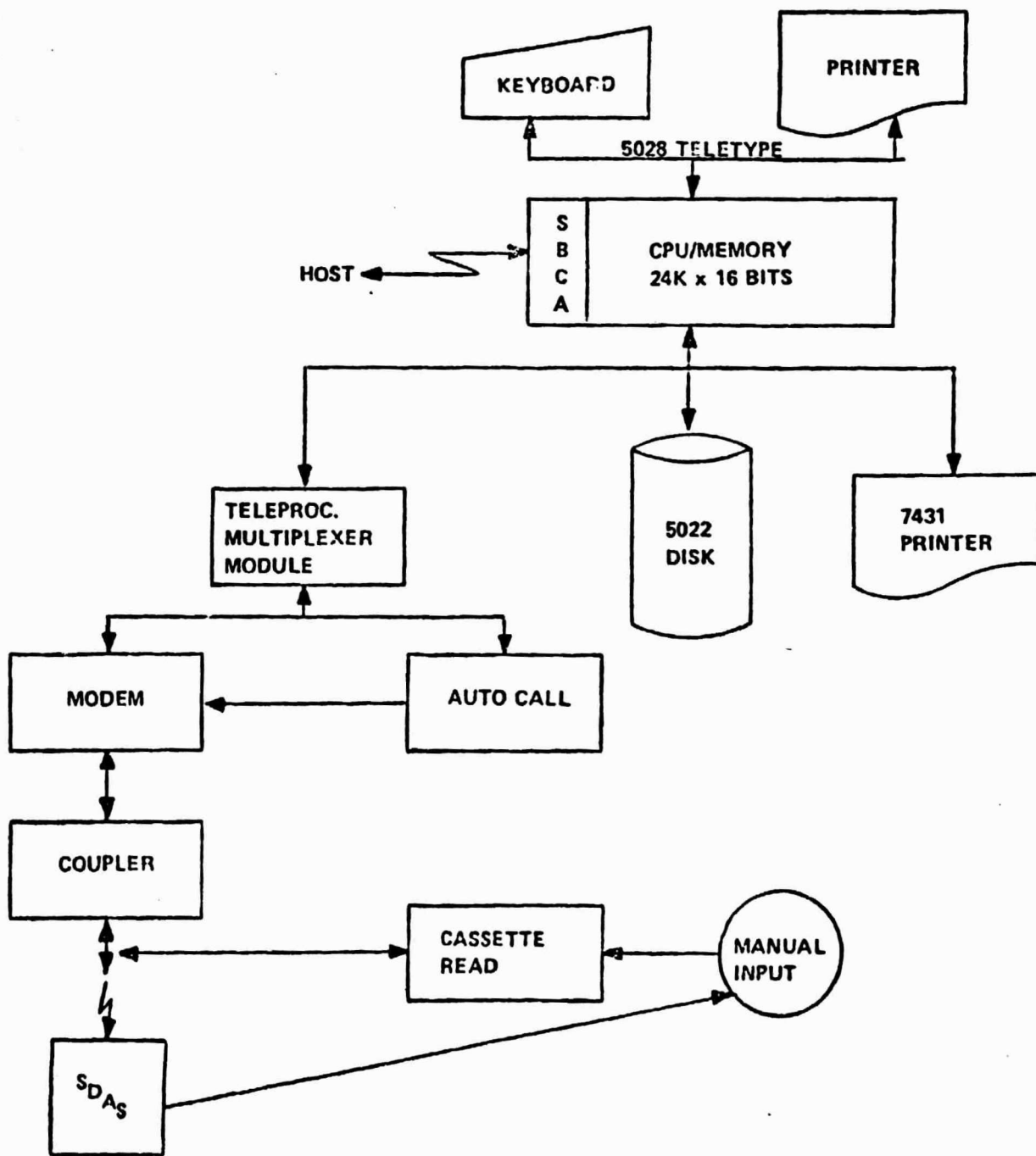


Figure 2. Communication Interface Configuration

These hardware, with capabilities relative to CDPS objectives, are discussed below:

Central Processing Unit (CPU) - The Central Processing Unit supports an interrupt-driven, multi-program environment through a priority interrupt system. A total of 4 interrupt levels with 16 sublevels are provided. Seven index registers, an accumulator register, and an instruction address register are supported for each interrupt level. The CPU also provides 2 interval timers for timekeeping and program control. Addressing capability for up to 64K - 16 bit words is supported.

Memory - 24K Words of 16 Bits Each - Main storage provides the communication processor with fast access, adequate storage to provide the control, interface and application programs necessary for control of the communications interface. The main storage can be expanded to 64K words through field modification.

Teletype Keyboard/Printer - The Teletype Keyboard/Printer provides the operator interface required during program load, initiation of data collection and SDAS troubleshooting. In addition, the printer provides hard copy reports in support of communication logging, memory dumps for software debug, and maintains status of software operation.

Disk Storage - The baseline configuration contains one disk unit which provides storage for a maximum of 2.457 million 16-bit words. The unit supports mountable disk files to allow storage of data in excess of 2.457 million words.

Printer - The printer provides the capability for generation of communication and error reports during data collection. The printer has the capability to print 115 characters per second.

1.3.1.2 Communication Interface Hardware

The communication interface hardware provides the interface capabilities which allow the System/7 computer, under software control, to automatically collect data from remote sites via telephone lines. This hardware, shown in Figure 2, consists of:

- (1) Teleprocessing Multiplexer Module (TPMM)
- (2) Auto-Call Unit
- (3) Modem
- (4) Coupler

The following paragraphs briefly describe these hardware elements:

Teleprocessing Multiplexer Module (TPMM) - The TPMM provides the communication interface logic for controlling up to eight asynchronous communication lines simultaneously. The TPMM also provides the interface to the System/7 for control of the communications with remote sites.

Auto-Call Unit - The Autocall Unit consists of a Western Electric 801 Autocall Unit and provides the interface with the TPMM for dial-up information and status. The Autocall Unit is an output-only device and performs automatic dialing of the remote sites as commanded by the System/7 via the TPMM.

Modem - The modem is a Western Electric 202C device which is compatible with the modem in the SDAS unit at the remote sites. The modem performs modulation/demodulation of signals being transmitted to/from the remote site.

Coupler - The coupler is a standard Western Electric device which provides voltage transient protection for the telephone lines.

1.3.1.3 Manual Data Collection (Cassette Read)

To support collection of data via manual means from remote sites, the communication interface configuration contains a prototype Site Data Acquisition Subsystem (SDAS). Cassette tapes manually retrieved from sites will be inserted into the prototype unit and transmitted to the System/7 via local telephone lines.

1.3.1.4 System/7 - Host Computer Communication (SBCA)

The Sensor Based Communication Adapter (SBCA) provides the capability for high-speed data transfer between the System/7 and the host computer. The SBCA will transfer data at a rate of 2.2 megabits per second.

1.3.2 Host Computer Configuration

The host computer configuration receives raw data collected from all remote sites, on a daily basis, via the communication hardware from the communication interface configuration. This data is then processed and stored into the performance evaluation data bank for use in evaluation activities. The host computer configuration consists of an IBM System/370-145 which is shared with other users. The configuration is shown in Figure 3, and significant elements are discussed in the following paragraphs. Detailed descriptions are available in existing IBM equipment reference manuals.

1.3.2.1 Sensor Based Control Unit (SBCU)

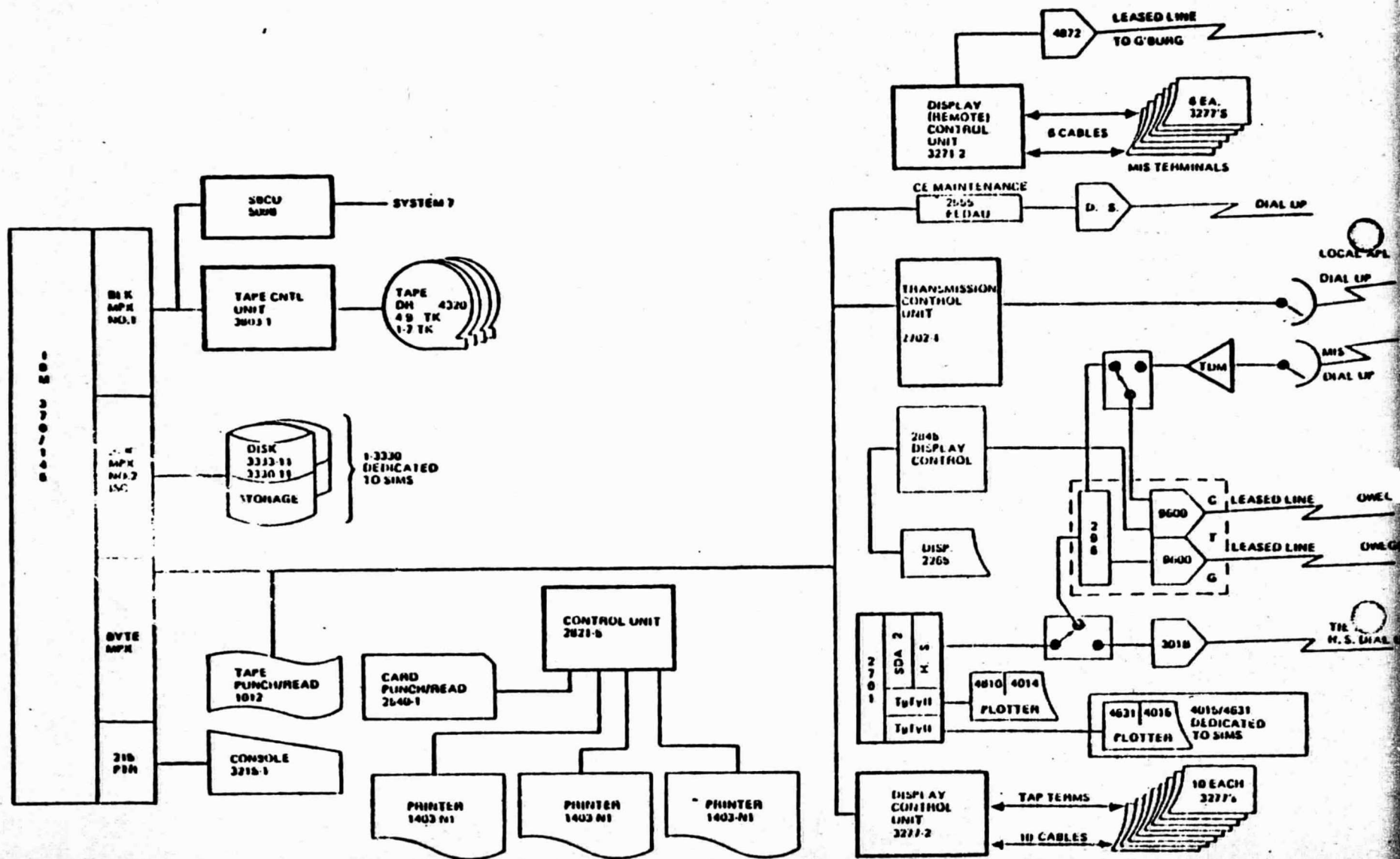


Figure 3. System/370 Model 145 Configuration

The SBCU provides the communications medium for receipt of data from the communication interface configuration for processing. Data transfer rate is 2.2 megabits per second.

1.3.2.2 Terminal Support

IBM 3277 terminal units are provided for access/update of the performance evaluation data base. Two terminals will be dedicated to the solar energy applications to ensure availability. Tabular output can be displayed on these terminals.

A Tektronix 4015/4631 display hard copy unit provides the capability to generate either text or graphical data representative. This unit is dedicated to support of the analytical/reporting requirements of the program.

1.3.2.3 Magnetic Tape Units

The configuration provides both 9-track and 7-track magnetic tape handling capabilities. Density for 9-track tapes is 1600 BPI or 800 BPI; whereas, 7-track tapes are 800 BPI. The magnetic tape units will be used to generate deliverable tapes to MSFC for use in updating the MSFC solar energy data base and to other data users as required. In addition, archival data will be placed on magnetic tape for storage.

1.3.2.4 Disk Storage Units

The configuration provides IBM 3333/3330 disk units for use in supporting the performance evaluation data base. The present configuration contains storage capacity of 400 megabytes; however, the system supports expansion without hardware modification to 2 billion bytes of storage. One disk unit, which provides storage for 200 megabytes, will be dedicated to CDPS functions.

SIMS

1.3.2.5 High-Speed Printers

Three high-speed Printers (1100 lines per minute) are provided for support of report generation/distribution requirements. In addition, reports created during processing of data will be printed for analysis.

1.3.2.6 Console

The operation console provides the operator with visibility into and control of operations within the computer. It will be used to allow the operator to initiate daily processing of data from remote sites. Status during processing and operator actions required will be presented on the console.

1.3.2.7 Mainframe

The Mainframe of the host computer consists of a memory capacity of 1 million bytes, input/output channels, and the Central Processing Unit (CPU). Memory utilization of approximately 256K bytes is anticipated in support of data processing functions; thus, significant margin (excess capacity) exists. The CPU provides the instruction set, memory addressing logic, registers, and input/output control functions required in support of software execution.

1.3.2.8 Operating System

The System/370 operating system (OS/MVT) is utilized to control the execution of data processing functions within the software. In addition, the operating system provides the language processors (compiler/linkage editors/etc.) used in generation of both the S/370 and System/7 software.

A processing priority system is utilized by the operating system to maximize computer utilization. To ensure that solar energy data is processed within specific time constraints, a high priority level will be assigned.

1.4 CDPS OVERALL SOFTWARE DESCRIPTION

Within the CDPS, the major software tasks to be performed are:

- o Communication Interface - for data collection
- o Input Processing - for conversion of raw data into information
- o File Maintenance - for updating/maintaining performance evaluation data base
- o User Support - for generation of outputs to satisfy the needs of the data user community.

As can be seen in Figure 4, the major software tasks have been allocated to CDPS hardware configurations. This allocation is based on the philosophy of the System/7 computer configuration's performing the data collection function and the host computer configuration's performing detailed data editing, data conversion, file maintenance, and user support functions.

Also shown in Figure 4 is the performance evaluation data base. This data base will contain all data required to support the performance analyst and will reside on disk storage and magnetic tapes within the host computer configuration.

Subsequent sections of this document define the detailed requirements which must be satisfied within the software elements and the data base.

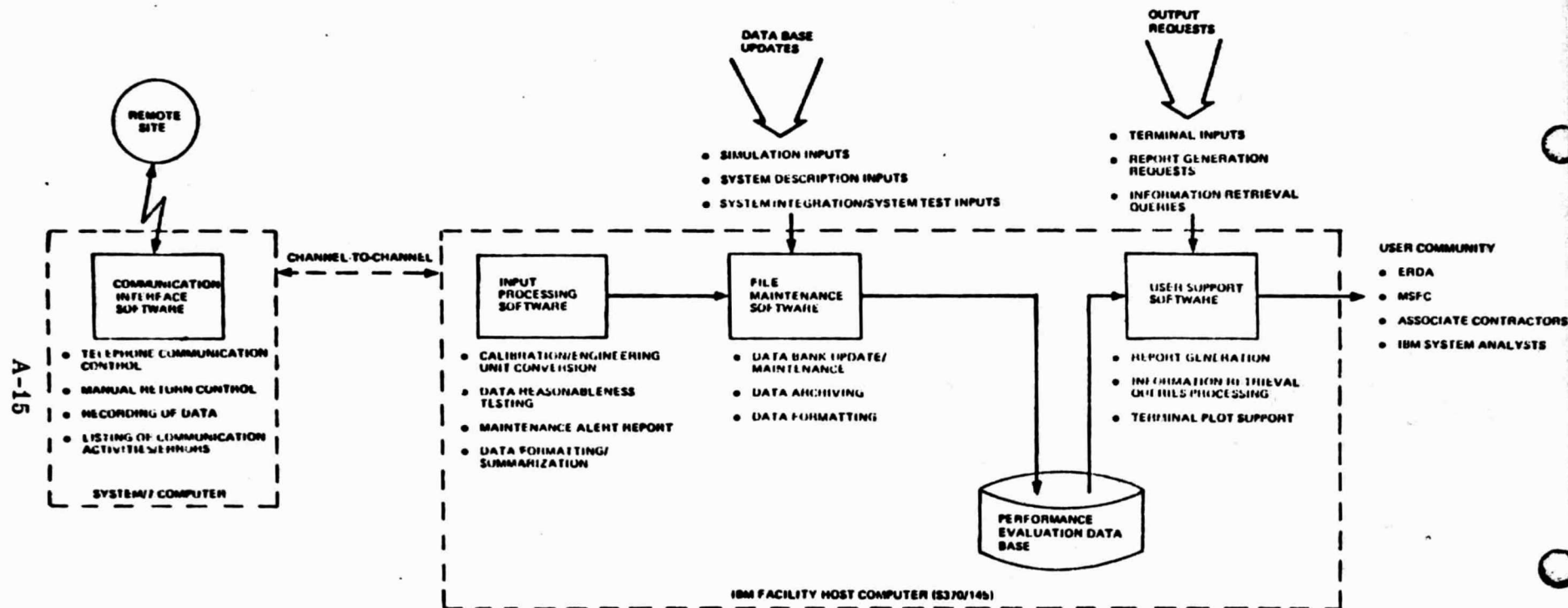


Figure 4. Major Software Tasks

2.0 COMMUNICATIONS INTERFACE SOFTWARE REQUIREMENTS

The communications interface software will reside in a System/7 computer and provide the communications interface functions for the central data processing system.

The System/7 communications interface software will sequentially dial sites over switched asynchronous telephone lines and collect sensor data. A site directory on disk will be used to control the proper sequencing of site data collection. After data collection is complete the System/7 - host computer link will be used to transmit the data to the host for subsequent detailed processing and data base update.

2.1 FUNCTIONAL SOFTWARE REQUIREMENTS

The communications interface software must provide communications with each SDAS, control the collection of SDAS sensor data, and send the data to the host computer. In order to meet these requirements, the following functional capabilities will be provided.

- o Access to Remote Sites via automatic telephone calling sequences contained within a site directory.
- o Control of communications signals to support a switched telephone interface to each SDAS.
- o Control of each SDAS over telephone lines for data collection.
- o Temporary buffering and disk storage of the data from each SDAS.
- o Transmission of SDAS data to the host computer.
- o Manual control of SDAS commands for troubleshooting.

The detailed software requirements associated with each of the above functions are presented in the following paragraphs:

2.2 SITE DIRECTORY REQUIREMENTS

A site directory containing information on each site shall be provided for the communications interface software to control the data collection process. This information shall be maintained on the System/7 disk to insure data integrity during power off conditions.

2.2.1 Site Directory Information

Information in the site directory is required for each site. The information shall be organized on disk by site records and fields of data. Each site shall have a record of information that contains fixed data fields. Each field of SDAS information required will be described in the following paragraphs:

2.2.1.1 SDAS Station Address

This field shall contain the unique station address associated with each site. This field will be used to obtain the station address for SDAS command messages described in Section 2.4.1.

2.2.1.2 SDAS Status

This field shall provide the operational status of each SDAS. It shall be modified by the communications interface software as each site is called, commands sent to the SDAS, and data collected. The status field will allow proper sequencing during a restart of the data collection process.

2.2.1.3 SDAS Dial Digits

This field shall contain the autocall dial digits required to automatically call a site over switched lines. These digits shall be entered by an operator when the remote site becomes operational and shall remain fixed thereafter.

2.2.1.4 SDAS Process Requirements

This field shall specify how often data will be collected from a site. It will contain the number of days desired between data collections. A "1" in this field for instance would indicate daily collection. This field shall initially be input by an operator when the site becomes operational and shall be changed only if collection requirements change.

2.2.1.5 SDAS Data Collection Time

This field shall be required by the communication interface software to determine when data is to be collected from a site. It shall contain the time (year, day, hour, min, sec) that data was last

collected. By subtracting this field from the current time and comparing the result with the SDAS process requirements field, the software shall automatically determine when to collect data from a site.

2.2.1.6 SDAS Error Information

This field shall contain error information received from a site during data collection. Error information is contained in the reply message from a site and is described in Section 2.4.2.2.

2.2.1.7 Number of Site Disk Extents

Data collected from each remote site shall be temporarily stored on disk until forwarded to the host computer for processing. To provide the flexibility to continue the collection from sites when either the data transfer link (SBCA) or the host computer is not functioning, the software shall allow provisions for up to five daily collections before data transfer to the host must be accomplished. This field of the site directory shall indicate the number of times data has been collected since last transfer to the host computer. Upon completion of data transfer, this field shall be reset to indicate that no data is being retained on the disk.

2.2.1.8 Site Record Index

This field shall indicate where the data collected from a site is stored on disk. This field shall have the capability to contain five entries due to the collection requirement specified in 2.2.1.7.

2.2.1.9 Site Byte Count

This field shall indicate how many bytes of data were collected and, when used with the field specified in 2.2.1.8, will indicate where data was stored on disk and how much data was stored. This field will hold up to five entries (one for each possible data collection).

2.2.1.10 Initial Real Time Clock Reading

This field is required in order to determine the actual (LOCAL TIME) (CST) time of sensor readings in the collected data. It shall contain the time (year, day, hour, min, sec) in CST that the Real Time Clock in each SDAS read zero. This field shall hold five entries (one for each possible data collection).

2.2.1.11 BCH Errors

This field shall indicate the number of BCH errors detected during each data collection (five entries shall be provided). BCH error processing is discussed in Section 3.2 of this document.

2.2.2 Site Directory Update Requirements

The ability to manually update the site directory from the System/7 teletype shall be provided. The fields which shall be updated are:

- o SDAS Dial Digits
- o SDAS Process Requirements

All other fields shall be updated under program control during data collection and subsequent transmission to the host.

2.2.3 Site Directory Print Requirements

All the site directory fields described in section 2.2.1 shall be printed, either upon request or when the site directory is initially generated. This function will not be done on-line during data collection but shall be initiated as an off line program.

2.3 COMMUNICATIONS HARDWARE INTERFACE REQUIREMENTS

In order to automatically collect data from remote sites, software shall be provided to communicate with each SDAS via the communications hardware. Figure 5 shows the communications hardware with which the software shall interface. The software shall initiate commands to the Teleprocessing Multiplexer Module (TPMM) to establish proper communications to the autocal unit and modem for both transmission to and receipt of data from the SDAS. In addition, the software shall perform status checking after every input/output operation to ensure correct operation. The following paragraphs define the detailed requirements to be satisfied in interfacing with the communication hardware.

2.3.1 Interface Command Requirements

Interface commands and required software action to initiate communication operations are shown in Table 2-1.

Table 2-1. Interface Commands/Software Required Actions

COMMAND	SOFTWARE ACTION
OPEN A LINE	Initialize a communications line for asynchronous send/receive operations or a dial operation
CLOSE A LINE	Place a communications line in the inactive state.
DIAL A REMOTE SITE	Automatically issue dial digits to the Bell 801 autocal unit and complete a connection to a site over a switched telephone line.
ISSUE SDAS COMMAND	Transmit data (SDAS commands) over an asynchronous communications line and then receive data (SDAS reply) over the same asynchronous communications line.

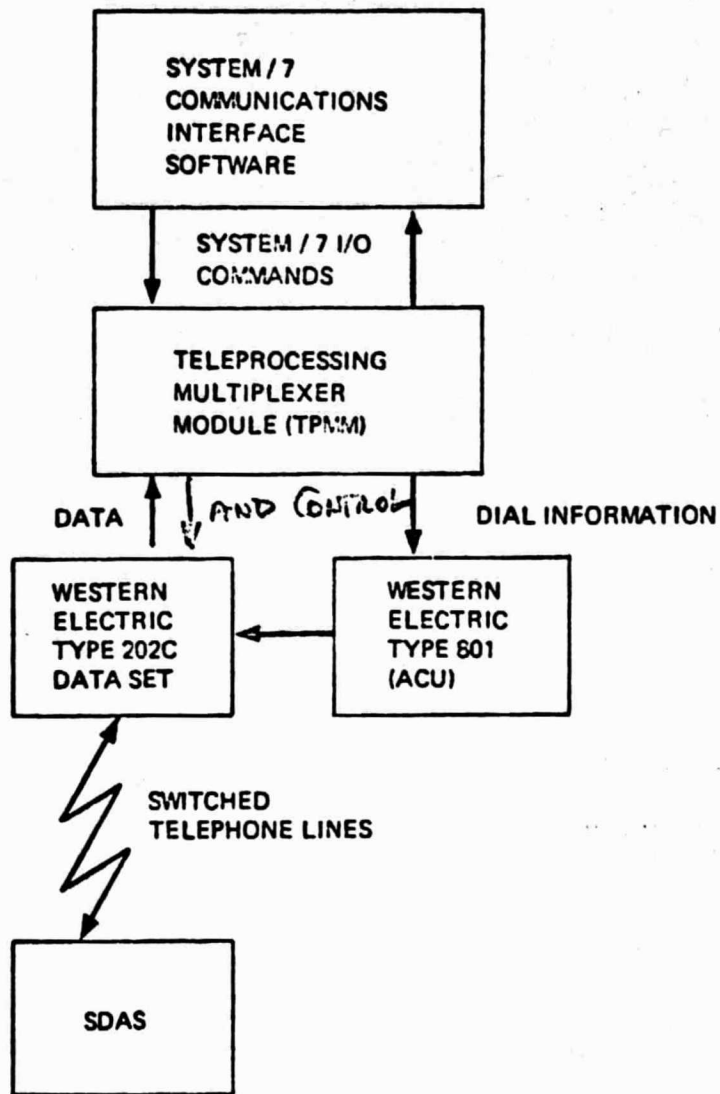


Figure 5. Communication Interface Hardware

2.3.2 Data Integrity Requirements

A validity check shall be required on all data sent or received over the communication system. This validity check will be sent/received every eight bytes as part of the data and will provide a data integrity check down to eight bytes.

The method of validity checking shall be a cyclic redundancy code method called Base-Chaudhuri-Hocquenghem (BCH). A BCH shall be calculated and sent with all data transmitted to a SDAS. The SDAS will calculate a BCH for the data received and verify the BCH sent is the same value. If the value is not the same, an error reply message (as defined in Section 2.4.2) shall be sent to the System/7. A similar verification shall take place in the communications interface software in the System/7 for all data received from the SDAS. Action taken by the System/7 software for error conditions is discussed in Section 2.4.2. place in the communications interface software in the System/7 for all data received from the SDAS.

2.3.3 Communications Hardware Status Requirements

During each interface command specified in Section 2.3.1, status checking shall be performed and status information made available after the operation. The types of errors required to be detected and required software actions are defined in Table 2-2.

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Table 2-2. Communication Error Detection/Software Action

ERROR STATUS	SOFTWARE ACTION
Data Set Check - o Loss of Data Set Ready during a read - o Loss of Carrier Detect during a read - o Loss of Clear to Send during a write - o ACU not ready during a dial	Make three attempts to reestablish communications and retry the command. If unsuccessful, continue to next site*
Data Overrun o Character interrupt occurred before previous character serviced	Retry command three times, then continue to next site*
System/7 XIO Error	Retry command three times, then continue to next site*
Time Out Between Characters	Make three attempts to reestablish communications and retry the command. If unsuccessful, continue to next site*
Time Out - No SDAS Reply	Make three attempts to reestablish communications and retry the command. If unsuccessful, continue to next site*
BCH Error in Received Data 1 error for all commands other than "Read Tape." 10 errors for "Read Tape."	Retry command three times then reestablish communications and retry three times then continue to next site*
Software Error	Stop**
*If retries are unsuccessfully attempted on two consecutive sites, the error will be considered a hard failure and processing will stop. Operator will notify communications personnel for trouble shooting.	
**System recovery shall be under operator control (reload of system and restart/contact System/7 programmer)	

2.4 SYSTEM/7 - SDAS COMMUNICATIONS REQUIREMENTS

The System/7 communications software shall initiate all communications with a site. Each site communications shall be initiated with a command message from the System/7 and be followed by a reply message from the site. Figure 6 illustrates the communications command/reply sequences necessary to collect sensor data from a site. The following paragraphs describe the System/7 - SDAS communications requirements.

2.4.1 Command Message Processing

Upon establishing communications with a remote SDAS via the communications hardware (described in paragraph 2.3), the communications software shall transmit a command message to the SDAS. Each command message shall contain:

1. A unique command code for the SDAS function to be performed.
2. SDAS identification information
3. BCH code for data validity checking

The format of the command message is discussed in paragraph 2.4.4. After transmission of the command, the software shall delay for 21 seconds awaiting a reply message from the SDAS. If no reply is received within the time limit, the communications software shall disconnect from the telephone line, print a message indicating failure to respond, and attempt to reestablish the command interface. The software shall attempt to establish communications three times. If not successful, a message shall be printed indicating unsuccessful communications, and the software must proceed to the next remote site.

2.4.2 Reply Messages Processing

A reply message shall be sent to the System/7 from the SDAS after each successfully received command message. Reply messages will vary in length depending on the command which was transmitted to the SDAS; however, each reply message will contain the following information:

1. Command Code (as received by SDAS)
2. Site Identification (as received by SDAS)
3. Status of the SDAS
4. BCH Code generated by SDAS for data validity checking.

Format of the Reply Message is discussed in Paragraph 2.4.5.

Two types of Reply Messages shall be received from the SDAS:

Normal Reply Message - Bit 0 of the SDAS status code contains a "0".

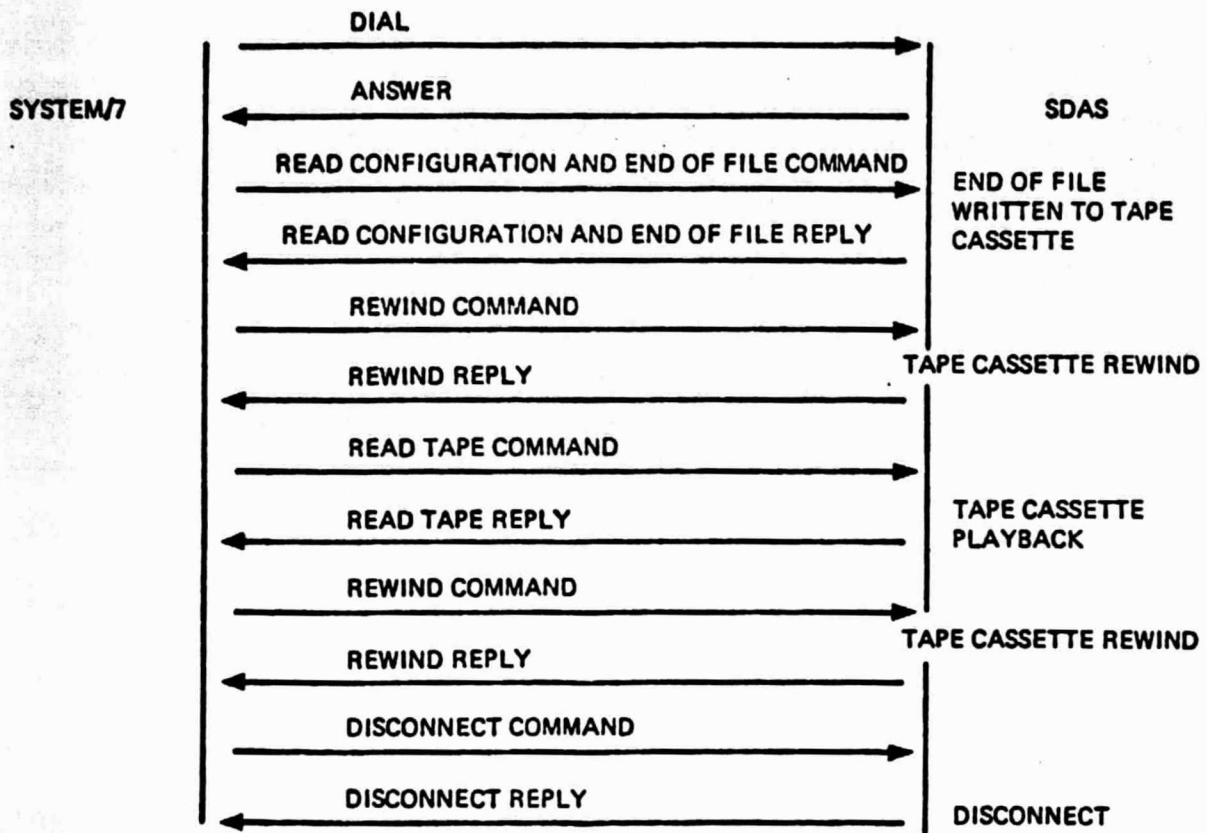


Figure 6. Command/Reply Sequence

Error Reply Message - Bit 0 of the SDAS status code contains a "1".

Upon receipt of a Reply Message, the software shall determine the type of reply and perform the processing functions required for the type. These processing requirements are discussed in the following paragraphs.

2.4.2.1 Normal Reply Processing

The software shall examine the status and BCH codes returned with the reply message. If the BCH returned with the data does not agree with the BCH calculated for the data, the software shall repeat the command sequence up to three times. If the reply data is incorrect for three consecutive attempts, a message shall be printed, communications shall be reestablished and three more attempts made. If still unsuccessful, the software shall proceed to the next site for continuation of data collection.

If the status returned indicates an SDAS error, the message reply is considered an error reply message and the actions specified in section 2.4.2.2 shall be performed.

For normal reply messages which pass BCH and status tests, the software shall proceed to the next command in the site data collection sequence.

2.4.2.2. Error Reply Message Processing

The error reply message shall contain status codes indicating the error which exists within the SDAS. These errors, with the corresponding required software action, are shown in Table 2-3.

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Table 2-3. SDAS Error Conditions and Software Action

Error Condition	Software Action
1. BCH Error in Previous Command	Reissues command to SDAS (3 times, if required) then continues to next site
2. Invalid Command Received	Reissues command to SDAS (3 times, if required) then continues to next site
3. Invalid Station Address Received	Reissues command to SDAS (3 times, if required) then continues to next site.
4. SDAS Devices Failures - o MPX 1 - o MPX 2 - o MPX 3 - o AI Basic - o Interface Timer 0 - o Tape Control - o Realtime Clock - o Interval Timer 1	A message containing the status received is printed and the software proceeds to the next site. The SDAS error information is placed in the site directory field specified in Section 2.2.1.6

2.4.3 Command Definitions

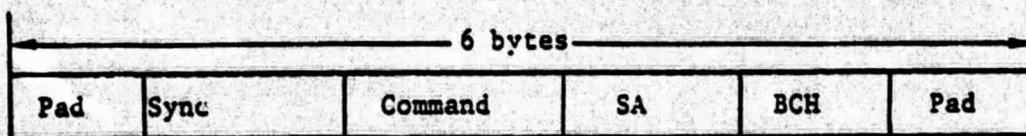
The communications software shall support the commands to the SDAS as shown in Table 2-4. The actions taken by both the SDAS and the communications software in accomplishing the command function are also shown.

Table 2-4. System/7-SDAS Commands/Software Action

COMMAND	SDAS ACTION	REPLY ACTION
Read Configuration & End-of-File	End of file written to tape cassette and reply message with current Realtime Clock (RTC) reading sent to System/7	System/7 computes when SDAS RTC was initially "0" and proceeds to next command
Rewind	Tape cassette is re-wound and reply sent to System/7	Reply message verified and next command issued
Read Tape	Tape cassette is placed in play mode and data on cassette sent as reply message	Tape cassette data is read, BCH checked, & stored on disk
Disconnect	Reply message sent to System/7 and SDAS disconnected from communications	Reply message verified-any new command must dial to reestablish communications with SDAS
Disconnect & Rewind	Reply message sent to System/7, SDAS disconnected from communications, and tape cassette rewound	Reply message verified-any new command must dial to reestablish communications with SDAS
Read Configuration*	Reply message sent to System/7 with current SDAS RTC reading	Reply message verified
Reinitialize**	Reply message sent to System/7 and a master reset of SDAS hardware and software executed	Reply message verified
*This command useful for verifying status of SDAS **Not used during operational data collection.		

2.4.4 Command Message Format

All command messages shall have the following format:

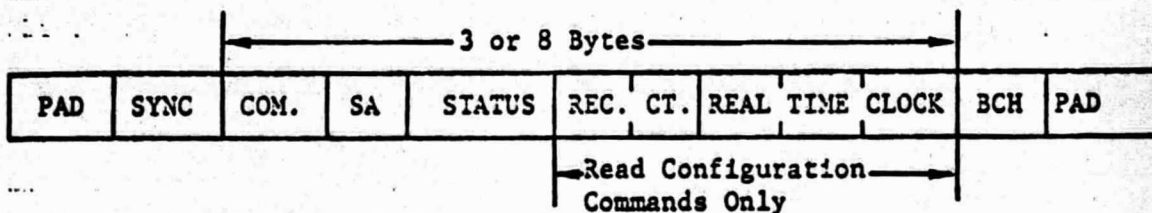


Pad - FF Circuit Activation Bits - 1 byte
 Sync - 6C Synchronization byte
 Command - HH* Unique command code
 SA - HH Station Address - SDAS Identification Code
 BCH - HH Block Check Code for previous two bytes

*H - Hexadecimal digit - 4 bits

2.4.5 Reply Message Format

All reply messages with the exception of the Read Tape reply shall have the following format.



Pad - FF Circuit Activation Byte - 1 byte
 Sync - 6D Synchronization Byte
 Command - HH* Command Received
 SA - HH SDAS Station Address
 Status - HH SDAS Status
 Record Ct. - HHHH Unused
 Real Time Clock - HHHHHH 24 Bit SDAS Real Time Clock Reading

BCH - HH

Block check clock for previous 3 or 8
bytes depending on reply

*H - Hexadecimal digit - 4 bits each

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2.4.6 Read Tape Reply

The Read Tape reply contains data transmitted from the cassette tape in the SDAS. This reply message shall vary in length depending on the amount of sensor data on the tape. The format of the Read Storage Table reply is shown in Figure 7.

2.4.7 Communication Report Requirements

During the System/7 - SDAS communications required for data collection an operational log or report shall be generated. This report shall maintain a history of each site command/reply activity and shall contain the following:

- o Time information with each message
- o Commands sent to SDAS
- o Status information associated with each command
- o Action taken after errors

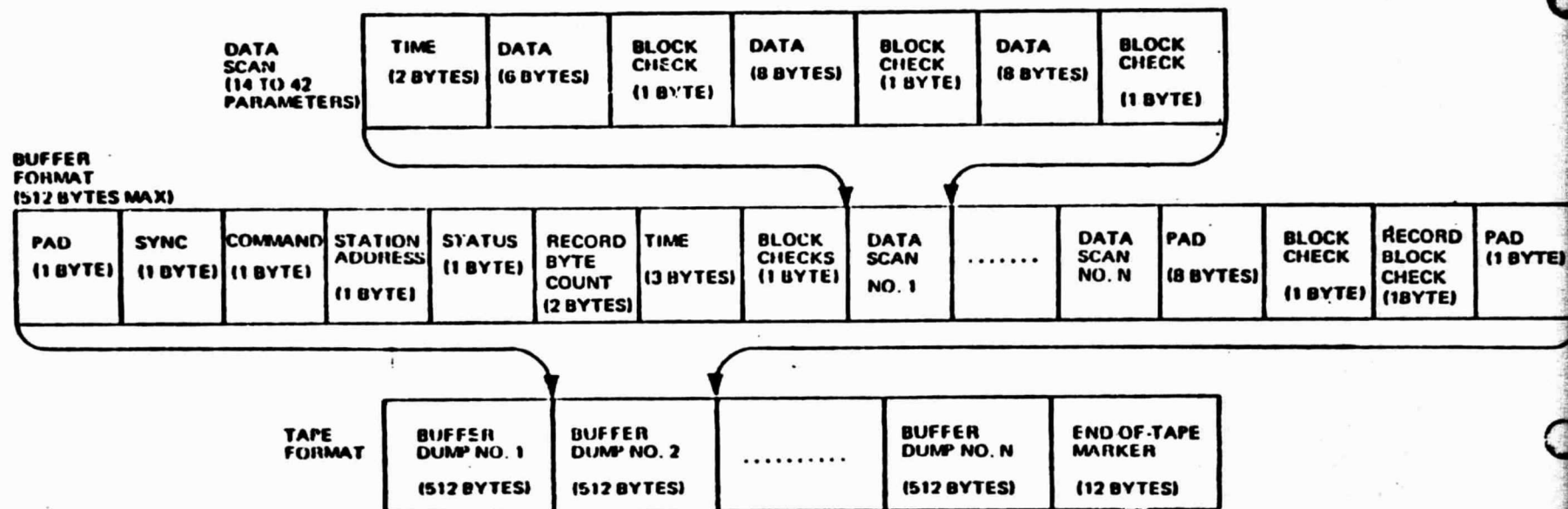


Figure 7. Read Tape Command Reply Format

2.5 DATA STORE REQUIREMENTS

The communications interface software shall accept and store on disk all incoming SDAS sensor data. This data will be received as the reply to a Read Tape Command and will be in the format described in Section 2.4.6. The data store software shall provide the following:

- o Buffers in System/7 memory to accept the data transmitted from the SDAS. Two separate, chained buffers will be required to allow one buffer to accept data while data is being written to the disk from the other.
- o Provide storage (non-volatile) of the data on System/7 disk
- o Maintain the Site Directory fields that provide an index to the data on disk.
- o Maintain the time (CST) that the data was collected

2.6 TRANSMIT DATA TO HOST COMPUTER

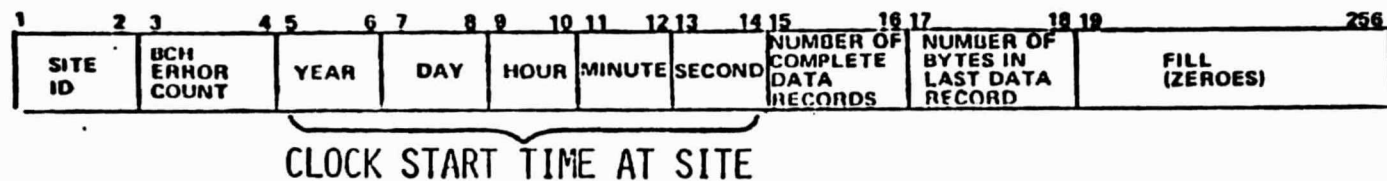
The communications interface software shall provide a host forward store capability. This software shall perform the following:

- o Automatically retrieve the sensor data for each site from the System/7 disk.
- o Build an identification/header record to be sent to the host with the data from each site.
- o Update the Site Directory fields on System/7 disk.
- o Transmit the header records and data from site to a data set on the S370-145 host computer.
- o Provide error recovery during System/7 - HOST data transfer.

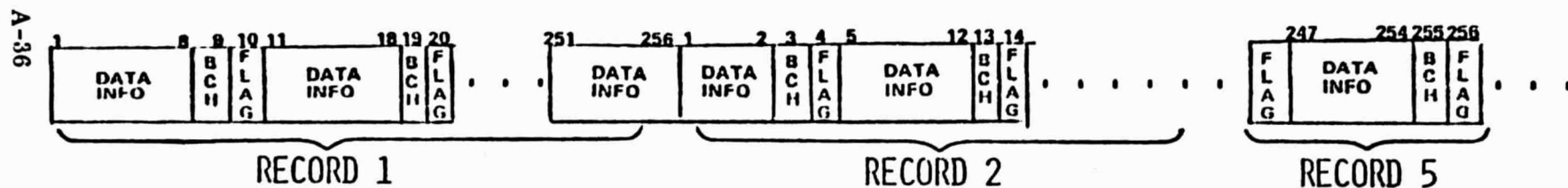
The required format of the header records and data to be sent to the host are shown in Figure 8.

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ID RECORD



DATA RECORDS



BCH - BLOCK CHECK CHARACTER

FLAG - INDICATES WHETHER THERE WERE ERRORS IN THE PRECEDING 8 BYTES OF DATA

DATA INFO



(BLOCKS ARE ALIGNED TO BEGIN ON A BYTE AFTER A FLAG BYTE)

Figure 8. System/7 Output Format.

END OF SITE

1	2	3	4	8
COMMAND CODE E1 ₁₆	SA	SC	FF ₁₆	

(END OF SITE IS 8 BYTES LONG, AND BEGINS AFTER A FLAG BYTE)
SA IS STATION ADDRESS / SC IS STATUS CODE

BLOCK

BLOCK START COMMAND SCAN	SCAN	SCAN	SCAN		SCAN	END OF BLOCK 8 BYTES OF FF ₁₆	MORE FF'S UP TO NEXT BCH BYTE
-----------------------------------	------	------	------	--	------	--	-------------------------------------

(BLOCK STARTS ARE ALIGNED AFTER A FLAG BYTE, SCAN'S ARE NOT ALIGNED, END OF BLOCKS ARE NOT ALIGNED BUT MAY BE PADDED WITH EXTRA FF'S.)

BLOCK START COMMAND

1	2	3	4	5	6	8
COMMAND CODE EO ₁₆	SA	SC	BLOCK COUNT	TIME		

TIME IS A COUNT IN 2 SECONDS ELAPSED SINCE CLOCK
START TIME AT SITE. TIME AT START OF BLOCK.

SCAN

1	2
TIME	SCAN DATA: LENGTH AND ARRANGEMENT DEPENDS ON SITE

TIME IS LEAST SIGNIFICANT 2 BYTES OF COUNT
IN 2 SECONDS ELAPSED SINCE CLOCK START
TIME AT SITE.

2.7 MANUAL SDAS CONTROL REQUIREMENTS

The ability to manually select and send commands to the SDAS and monitor the reply shall be provided as an aid in troubleshooting SDAS or system anomalies. This capability shall also be used in initially bringing a site on line. The commands provided as operator input from the System/7 teletype shall be as follows:

- o Reinitialize
- o Read Configuration
- o Read Configuration and End of File
- o Disconnect
- o Rewind
- o Disconnect and Rewind
- o Read Tape

The reply from the SDAS and the communication hardware status shall be printed after each command. Printing of the data received from the "Read Tape" command (data written on cassette) shall be under control of the operator.

3. INPUT PROCESSING SOFTWARE REQUIREMENTS

The input processing software, as shown previously in Figure 4, executes in the S/370-145 host computer configuration. The overall function of this software element is to transform raw input into processed information for input into the performance evaluation data base. This transformation requires that the software satisfy the requirements as stated in the following paragraphs.

3.1 FUNCTIONAL REQUIREMENTS

The input processing software, in performing its data processing role within the CDPS, shall perform the following:

- o Accept raw site data from the System/7.
- o Extract variables from scans and convert to engineering units.
- o Test converted variables in accordance with performance analyst inputs.
- o Compute performance analyst defined variables.
- o Compute performance evaluation parameters.
- o Generate input for data base update.
- o Create history/archive tapes.
- o Create input summary reports and error messages.

The detail requirements associated with above functions are described in the following paragraphs:

3.2 ACCEPT RAW DATA FROM THE SYSTEM/7

Software on the S/370 shall communicate with the host forward store software on the System/7 for the transfer of raw data. Communication shall be through a Sensor Based Control Unit (SBCU) attached to the S/370 to a Sensor Based Control Adapter (SBCA) attached to the System/7. Raw data received from the System/7 shall be stored into a S/370 data set on disk for subsequent processing. The input format from the S/7 was shown previously in Figure 8, and the format of the data on the S/370 data set shall be identical to the input. Data shall not be passed to subsequent processing steps if errors are encountered during data transmission. Data transfer shall be attempted five times if errors occur. If transfer is unsuccessful after five tries, the customer engineer shall be notified.

Error conditions which shall be detected during the transfer are shown in Table 3.1.

Table 3-1. System/7 - Host Communication Error Conditions

Error Conditions	Required Actions
1. Channel Control Check	1. Message issued to console. Retry of transmission will depend on sense settings associated with error.
2. Interface Control Check	2. Message issued to console. Retry of transmission will depend on sense settings associated with error.
3. Chaining Check	3. Message issued to console. No retry.
4. Channel Data Check	4. Message issued to console. Retry response on sense settings associated with error.
5. Command Reject	5. Message issued to console. One retry performed.
6. Bus Out Check	6. Message issued to console. One retry performed.
7. Equipment Check	7. Message issued to console. Five retries performed.
8. Data Check	8. Message issued to console. No retry performed.
9. Overrun	9. Message issued to console. No retry performed.
10. Controller Read Timeout	10. Message issued to console. One retry performed.
11. End of Block Response Timeout	11. Message issued to console. No retry performed.
12. Incomplete Read Operation	12. Message issued to console. No retry performed.
13. Invalid Controller Address	13. Message issued to console. No retry performed.
14. Incomplete Sense SBCU	14. Message issued to console. No retry performed.
15. Invalid Order Response	15. Message issued to console. No retry performed.
16. Invalid Branch	16. Message issued to console. No retry Performed.

Table 3-1. System/7 - Host Communication Error Conditions (Continued)

Error Conditions	Required Actions
17. Invalid End-of-Block Response	17. Message issued to console. No retry performed.
18. Invalid Attention Response	18. Message issued to console. No retry performed.
19. No Controller Selected	19. Message issued to console. No retry performed.
20. No Request Code	20. Message issued to console. No retry performed.
21. Order Response Timeout	21. Message issued to console. No retry performed.
22. Request Code Overflow	22. Message issued to console. No retry performed.
23. ALU Check	23. Message issued to console. No retry performed.

3.3 DECOMMUTATE RAW DATA INTO SCANS

Decommutating raw data into scans shall include:

- o Separating BCH's and flags from the data.
- o Determining the location of Block-Starts, End-of-Blocks, and End-of-Sites.
- o Extracting scans from the data.
- o Computing scan times in local standard time at the site from the site base time and the relative time values in block-starts and in the time value preceding each scan.

Error processing shall include:

- o Stopping the processing for a site if the program cannot locate where blocks and scans begin and end. An error message shall also be printed indicating that data has been rejected.
- o Storing a scan into a rejected-scan data set if the time of the scan is uncertain because of BCH error or the time fails time continuity tests. An error message shall also be printed indicating time of scan and reason for rejection.

AND

3.4 EXTRACT VARIABLES CONVERT TO ENGINEERING UNITS

The input processing software shall process variable formats for data variables within scans. The software shall maintain a site description directory to provide a detailed definition of the location of each variable within each site's input data stream.

To extract variables from scans, the scan file created during decommutation shall be used as input. The software shall locate each variable requiring calibration/conversion through use of the site description directory.

Variables shall be calibrated and converted to engineering units using performance-analyst-supplied conversion type and conversion constants for each variable. The following conversion types shall be provided:

Linear:	$\text{Eng-Units} = A + (B \times \text{Raw})$
Quadratic:	$\text{Eng-Units} = A + (B \times \text{Raw}) + (C \times \text{Raw}^2)$
Third Order:	$\text{Eng-Units} = A + (3 \times \text{Raw}) + (C \times \text{Raw}^2) + (D \times \text{Raw}^3)$
Discrete:	$\text{Eng-Units} = 1 \text{ if } A \leq \text{Raw} \leq B$ 0 otherwise

3.5 CONVERTED VARIABLE TESTING

After conversion to engineering units, individual variables shall be tested for:

- o Exceeding limits specified by the performance analyst
- o A change between successive readings which exceeds a maximum specified by the performance analyst
- o A BCH error flag for the portion of the data stream from which the variable was extracted.

A variable which fails two of the above tests shall be rejected. A failure indication value shall replace the computed value in the output used to update the data bank. The rejected computed value, along with identifying information (site id, time, and an indication of which variable the data is for) shall be stored in a rejected variable data set and shall be included in error messages/reports to the analyst.

The capability shall be provided to perform tests for no change in a variable. This capability shall be selectable via performance analyst input. Variables failing this test shall be included in error messages provided to the analyst.

Control over the level of detail of error messages shall be provided to the analyst. Capability shall provide detail messages (to the variable level), summary messages, or no messages.

3.6 COMPUTE PERFORMANCE ANALYST DEFINED VARIABLES

To provide the analyst with flexibility in analytical evaluation of site system performance, the input processing software shall provide the capability to compute new variables which are functions of input variables within the data stream. These variables shall be computed based on input provided by the analyst. Capability to combine up to four input variables mathematically (add, subtract, multiply, or divide) and to multiply the resultant value by a coefficient shall be provided within the software. The software shall be designed to accommodate additional mathematical functions (as required by the analyst).

If any variable specified to be used in a performance analyst defined variable has been rejected during testing, the performance analyst defined variable shall not be computed. The output shall be set to -99999 to indicate that computation was not performed.

Performance analyst defined variables shall be computed on a detailed level (Scan). These variables shall be included in data base update information.

3.7 COMPUTE PERFORMANCE EVALUATION PARAMETERS

Since a standard set of solar heating and cooling system performance evaluation criteria will be used, the input processing software shall utilize the site instrumentation data and manually provided data to compute these evaluation criteria. Instrumentation input to these computations shall consist of input variables after conversion to engineering units and testing functions have been performed.

Variables at the scan level shall be utilized in computations. Manual input of parameters such as system type, collector area and hot water temperature required in computation of performance parameters, shall be provided by the performance analyst. Resulting performance parameters shall be included as output for entry into the data base.

The following performance evaluation parameters shall be computed:

- o Solar energy provided for hot water
- o Auxiliary energy required for hot water
- o Solar energy provided for space heating
- o Auxiliary energy required for space heating
- o Solar energy provided for space cooling
- o Auxiliary energy required for space cooling
- o Hot water subsystem loss
- o Total available solar energy
- o Total collected solar energy
- o Collector array efficiency
- o Total solar energy utilized
- o Solar system conversion efficiency
- o Solar system operating energy required
- o Total auxiliary energy required
- o Percent solar applied to load
- o Conventional energy savings
- o Percent of time dwelling comfortable

o Percent of time hot water available

Table 3-2 contains the equations which shall be utilized in computing the above parameters. Also included in the table is the definition of terms and units shown in the equations.

In the computation of the performance parameters, use of any instrumentation variable which has failed testing criteria shall result in the performance parameter being set to a -9999 value. In this manner, no invalid performance parameter shall be calculated and entered into the data base.

Table 3-2. Page 1 of 3

- 1 SOLHW = FPH·DTPH·CP·FLDENS·K1
- 2 AUXHW = WHWAU
- 3 SOLSH = FHC·DTHC·CP·FLDENS·K1, if DC = 0
0, otherwise
- 4 AUXSH = WAUE , if DC = 1
otherwise
- 5 SOLSC = FHC CP FLDENS K1, if DC = 1
0, otherwise
- 6 AUXSC = WAUE , if DC = 1
0 , if otherwise
- 7 HWLOSS = (SOLHW+AUXHW)-(FHW·THW-TSW)·CPW·DENSW·K1)
- 8 SOLAVL = HT·CLAREA·K2
- 9 SOLCOL = FCA·DTCA·CP·FLDENS·K1
- 10 COLEFF = $\frac{\text{SOLCOL}}{\text{SOLAVL}} \cdot 100$
- 11 SOLUTL = SOLHW+SOLSH+SOLSC
- 12 SOLEFF = $\frac{\text{SOLUTL}}{\text{SOLCOL}} \cdot 100$
- 13 SOLOP = WCP+WPHP+WPCP, if collector type = liquid
WCF+WPHF+WECF, if collector type = air
- 14 AUXTOT = AUXHW+AUXSH+AUXSC
- 15 PCSOL = $\frac{\text{SOLUTL}}{(\text{SOLUTL}+\text{AUXTOT})} \cdot 100$
- 16 SOLSAV = $\frac{\text{SOLUTL}}{(\text{SOLEFF}/100)} - \text{SOLOP}$
- 17 PCTDC = 100, if TID & RHP within comfort limits
(72 ≤ TID ≤ 78, 20 ≤ RHP ≤ 60)
0, if otherwise
- 18 PCHWA = 100, if THW ≥ THWREQ
0, otherwise

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Table 3-2. Page 2 of 3

Code	Description	Units
SOLHW	Solar energy provided for hot water	KW
AUXHW	Auxiliary energy required for hot water	KW
SOLSH	Solar energy provided for space heating	KW
AUXSH	Auxiliary energy required for space heating	KW
SOLSC	Solar energy provided for space cooling	KW
AUXSC	Auxiliary energy required for space cooling	KW
HWLOSS	Hot water subsystem loss	KW
SOLAVL	Total available solar energy	KW
SOLCOL	Total collected solar energy	KW
COLEFF	Collector array efficiency	Percent
SOLUTL	Total solar energy utilized	KW
SOLEFF	Solar system conversion efficiency	Percent
SOLOP	Solar system operating energy required	KW
AUXTOT	Total auxiliary energy required	KW
PCSOL	Percent solar applied to load	Percent
SOLSAV	Conventional energy savings	KW
PCTDC	Percent of time dwelling comfortable	Percent
PCHWA	Percent of time hot water available	Percent
FPH	Preheater heat exchanger flow rate	Gallons Minute in liquid system, Cu. Ft. Minute in air systems
DTPH	Preheater input differential temperature	°F
CP	Specific heat of transfer fluid	BTU Pound -°F
K1	Conversion constant .0176	From BTU to KW Minute
WHWAU	Domestic hot water auxiliary power	KW
FHC	Load heat exchanger flow rate	Gallons Minute in liquid systems, Cu. Ft. Minute in air systems
DTHC	Load heat exchanger differential temperature	°F
WAUE	Auxiliary Electric Power	KW
DC	Cooling subsystem discrete	1 = cooling, 0 not cooling
FHW	Domestic hot water flow rate	Gallon Minute
THW	Hot water supply temperature	°F
TSW	Domestic service water temperature	°F
CPW	Specific heat of water 1	BTU Pound-°F
DENSW	Density of water	Pound Gallon
HT	Collector incident total solar radiation	BTU Sq. Ft. - Hour

Table 3-2. Page 3 of 3

Code	Descriptions	Units
CLAREA	Collector area	Sq. Ft.
K2	Conversion Constant .000293	<u>BTU</u>
		Hour to KW
FCA	Collector array flow rate	<u>Gallon</u>
		Minute in liquid systems,
		<u>Cu Ft</u>
		Minute in air systems
DTCA	Collector array different temperature	°F
WCP	Collector pump power	KW
WPHP	Preheater pump power	KW
WHCP	Load heat exchanger pump power	KW
WCF	Collector fan power	KW
WPHF	Preheater fan power	KW
WHCF	Load heat exchanger fan power	KW
CONEFF	Conventional energy conversion efficiency	Percent
TID	Dwelling indoor dry bulb temperature	°F
RHP	Dwelling indoor relative humidity	Percent
THWREQ	Hot water minimum temperature required	°F

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3.8 GENERATE INPUT FOR DATA BASE UPDATE

The input processing software shall generate input to be used for updating the data base. The input for each detailed scan shall be formatted as shown in Figure 9. These scans shall be blocked such that each input record to the file maintenance software contains six hours of data from the remote site. Each element of the input format shall contain one of the following:

- (1) A value which has passed all testing criteria
- (2) An indication that the element does not apply to the remote site
- (3) An indication that the value has been rejected during processing

The definition of each element's contents, format, and engineering units is shown in Table 3-3.

Data base update records shall consist of:

- (1) Detail data (scan level)
- (2) Hourly data (summarized from detail data)
- (3) Daily data (summarized from hourly data)

The requirements associated with the generation of these data are discussed in the following paragraphs.

Detail Data

Detail records shall contain values of directly-read variables, performance analyst-defined computed variables, and performance evaluation parameters. These data shall be at the scan level (baselined at 5 minutes). All variables, which either are not applicable to this site or have failed processing testing shall be flagged with appropriate indicator fill words.

Hourly Data

Hourly data shall be computed from the detail data described previously. If all values of a variable within the corresponding detail data (12 scans) have either failed testing criteria or are not applicable, the hourly value shall be set to -99999. If values exist which have passed tests and if the detail data is applicable to the site, the hourly computed variable shall be computed as shown in Figure 10 and written to the data base input file.

Daily Data

Daily data shall be computed from the hourly data. If all hourly values of a variable have been set to -99999, as described above, the corresponding daily variable shall be set to -99999. If hourly values exist which have passed testing, a daily data computed value shall be computed as shown in Figure 10.

For these daily variables which are totals, a summation of hourly totals shall be performed.

The data base input shall contain detail records for the past month, hourly records for the past month, and all daily records generated to date. Daily input for data base update shall contain all site operational records to be put into the data base not just new or changed records.


```

DCE 1 NIPS INPUT, /* RECORD FOR INPUT TO NIPS */
2 NIPS CHAR(1), /* CONSTANT 'N' FOR NIPS */
2 SITE ID PIC '99999', /* SITE ID */
2 SYS TYPE CHAR(2), /* SYSTEM TYPE */
2 YEAR PIC '99', /* YEAR OF THIS RECORD */
2 DAY PIC '999', /* DAY OF THIS RECORD */
2 HOUR PIC '99', /* HOUR OF THIS RECORD */
2 MIN PIC '99', /* MINUTE OF THIS RECORD */
2 LEVEL CHAR(1), /* LEVEL: A=DETAIL, B=HOURLY, C=DAILY */
2 PSTU BIN FIXED(31,6), /* STORAGE TANK ULLAGE PRESSURE */
2 PCPO BIN FIXED(31,6), /* COLLECTOR PUMP OUTLET PRESSURE */
2 PCFO BIN FIXED(31,6), /* COLLECTOR FAN OUTLET PRESSURE */
2 PHCPO BIN FIXED(31,6), /* LOAD HEAT EXCHNGR PUMP OUTLET PRES */
2 PHCFC BIN FIXED(31,6), /* LOAD HEAT EXCHANGER FAN OUTLET PRES */
2 PPHPD BIN FIXED(31,6), /* PREHEATER PUMP OUTLET PRESSURE */
2 DPCP BIN FIXED(31,6), /* COLLECTOR PUMP DIFFERENTIAL PRES */
2 DPCF BIN FIXED(31,6), /* COLLECTOR FAN DIFFERENTIAL PRESSURE */
2 DPHCP BIN FIXED(31,6), /* LOAD HEAT EXCHANGER PUMP DIFF PRES */
2 DPHCF BIN FIXED(31,6), /* LOAD HEAT EXCHANGER FAN DIFF PRES */
2 TDB BIN FIXED(31,6), /* OUTDOOR (AMBIENT) DRY BULB TEMP */
2 TWB BIN FIXED(31,6), /* OUTDOOR (AMBIENT) WET BULB TEMP */
2 TID BIN FIXED(31,6), /* DRY BULB TEMP INDOOR */
2 TCAI BIN FIXED(31,6), /* COLLECTOR ARRAY INLET TEMP */
2 TCS BIN FIXED(31,6), /* COLLECTOR SURFACE TEMPERATURE */
2 TPHO BIN FIXED(31,6), /* DOMESTIC PREHEATER OUTLET TEMP */
2 TST BIN FIXED(31,6), /* STORAGE TANK TEMPERATURE */
2 THCI BIN FIXED(31,6), /* LOAD HEAT EXCHANGER INLET TEMP */
2 TCH BIN FIXED(31,6), /* CHILLER OUTLET TEMPERATURE */
2 TCTS BIN FIXED(31,6), /* COOLING TOWER SUPPLY TEMPERATURE */
2 TSW BIN FIXED(31,6), /* DOMESTIC SERVICE WATER TEMPERATURE */
2 THW BIN FIXED(31,6), /* HOT WATER SUPPLY TEMPERATURE */
2 DTPH BIN FIXED(31,6), /* PREHEATER INPUT DIFF TEMPERATURE */
2 DTHC BIN FIXED(31,6), /* LOAD HEAT EXCHANGER DIFF TEMP */
2 DTCT BIN FIXED(31,6), /* COOLING TOWER DIFF TEMPERATURE */
2 DTCE BIN FIXED(31,6), /* ABSORPTN CHILLER EVAPRTR DIFF TEMP */
2 DTCI BIN FIXED(31,6), /* COLLECTOR ARRAY DIFF TEMPERATURE */
2 FHW BIN FIXED(31,6), /* DOMESTIC HOT WATER FLOW RATE */
2 FPH BIN FIXED(31,6), /* PREHEATER HEAT EXCHANGED FLOW RATE */
2 FHC BIN FIXED(31,6), /* LOAD HEAT EXCHANGER FLOW RATE */
2 FCA BIN FIXED(31,6), /* COLLECTOR ARRAY FLOW RATE */
2 WCP BIN FIXED(31,6), /* COLLECTOR PUMP POWER */
2 WCF BIN FIXED(31,6), /* COLLECTOR FAN POWER */
2 WHWAU BIN FIXED(31,6), /* DOMESTIC HOT WATER AUXILIARY POWER */
2 WPHP BIN FIXED(31,6), /* PREHEATER PUMP POWER */
2 WPIF BIN FIXED(31,6), /* PREHEATER FAN POWER */
2 WHCP BIN FIXED(31,6), /* LOAD HEAT EXCHANGER PUMP POWER */
2 WHCF BIN FIXED(31,6), /* LOAD HEAT EXCHANGER FAN POWER */
2 WAUE BIN FIXED(31,6), /* AUXILIARY ELECTRIC POWER */
2 WAUG BIN FIXED(31,6), /* AUXILIARY GAS POWER */
2 WAUD BIN FIXED(31,6), /* AUXILIARY OIL POWER */
2 WCTED BIN FIXED(31,6), /* COOLING TOWER EVAPRTR PUMP POWER */

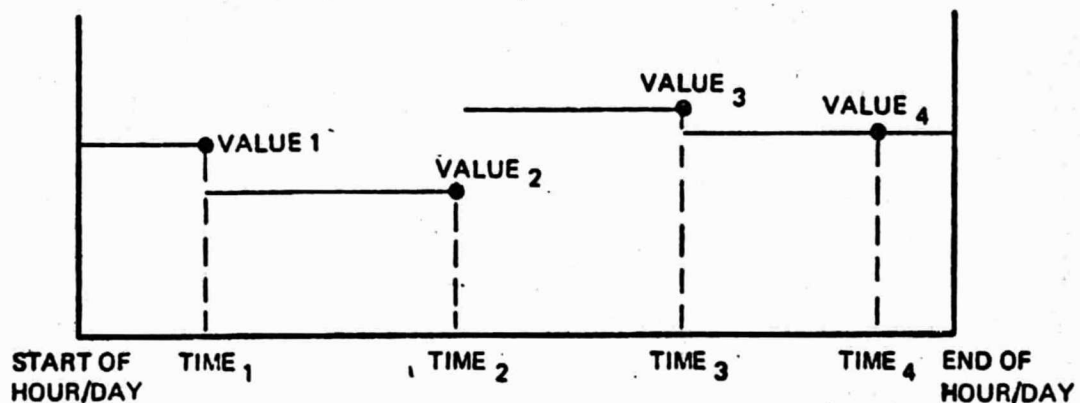
```

Figure 9. Form of Input for Data Base Update

2	WPAF	BIN	FIXED(31.6)	RETURN AIR FAN POWER	*/
2	HT	BIN	FIXED(31.6)	COLLECTOR INCIDENT TOT SOLAR RAD	*/
2	RHP	BIN	FIXED(31.6)	DWELLING INDOOR RELATIVE HUMIDITY	*/
2	DHC	BIN	FIXED(31.6)	LOAD HEAT EXCHANGER ON/OFF DISCRETE	*/
2	DCTP	BIN	FIXED(31.6)	COOLING TOWER PUMP ON/OFF DISCRETE	*/
2	DC	BIN	FIXED(31.6)	COOLING SUBSYSTEM DISCRETE	*/
2	V&ND	BIN	FIXED(31.6)	WIND SPEED	*/
2	D&ND	BIN	FIXED(31.6)	WIND DIRECTION	*/
2	SP1	BIN	FIXED(31.6)	SPARE 1	*/
2	SP2	BIN	FIXED(31.6)	SPARE 2	*/
2	SP3	BIN	FIXED(31.6)	SPARE 3	*/
2	SP4	BIN	FIXED(31.6)	SPARE 4	*/
2	SP5	BIN	FIXED(31.6)	SPARE 5	*/
2	SP6	BIN	FIXED(31.6)	SPARE 6	*/
2	SP7	BIN	FIXED(31.6)	SPARE 7	*/
2	SP8	BIN	FIXED(31.6)	SPARE 8	*/
2	SP9	BIN	FIXED(31.6)	SPARE 9	*/
2	SP10	BIN	FIXED(31.6)	SPARE 10	*/
2	SOLHW	BIN	FIXED(31.6)	SOLAR ENERGY PROV FOR HOT WATER	*/
2	AUXHW	BIN	FIXED(31.6)	AUXIL ENERGY REQ FOR HOT WATER	*/
2	SCLSH	BIN	FIXED(31.6)	SOLAR ENERGY PROV FOR SPACE HEATING	*/
2	AUXSH	BIN	FIXED(31.6)	AUXIL ENERGY REQ FOR SPACE HEATING	*/
2	SCLSC	BIN	FIXED(31.6)	SOLAR ENERGY PROV FOR SPACE COOLING	*/
2	AUXSC	BIN	FIXED(31.6)	AUXIL ENERGY REQ FOR SPACE COOLING	*/
2	HWLOSS	BIN	FIXED(31.6)	HOT WATER SUBSYSTEM LOSS	*/
2	SCLAVL	BIN	FIXED(31.6)	TOTAL AVAILABLE SOLAR ENERGY	*/
2	SCLCOL	BIN	FIXED(31.6)	TOTAL COLLECTED SOLAR ENERGY	*/
2	COLEFF	BIN	FIXED(31.6)	COLLECTOR ARRAY EFFICIENCY	*/
2	SOLUTL	BIN	FIXED(31.6)	TOTAL SOLAR ENERGY UTILIZED	*/
2	SCLFF	BIN	FIXED(31.6)	SOLAR SYSTEM CONVERSION EFFICIENCY	*/
2	SOLOP	BIN	FIXED(31.6)	SOLAR SYSTEM OPERATING ENERGY REQ	*/
2	AUXTOT	BIN	FIXED(31.6)	TOTAL AUXILIARY REQUIRED	*/
2	PCSOL	BIN	FIXED(31.6)	PERCENT SOLAR APPLIED TO LOAD	*/
2	SOLSAV	BIN	FIXED(31.6)	CONVENTIONAL ENERGY SAVINGS	*/
2	RCTDC	BIN	FIXED(31.6)	PERCENT OF TIME DWELLING COMFORTABLE	*/
2	PCHWA	BIN	FIXED(31.6)	PERCENT OF TIME HOT WATER AVAILABL	*/

Figure 9. Form of Input for Data Base Update (Continued)

CODE	VARIABLE DESCRIPTION	UNITS	ESTIMATED AVERAGE PSIG	ESTIMATED AVERAGE PSIG
STU	STORAGE TANK ULLAGE PRESSURE	PSIG		
PCPD	COLLECTOR PUMP OUTLET PRESSURE	PSIG		
PCFO	COLLECTOR FAN OUTLET PRESSURE	PSIG		
PHCPD	LOAD HEAT EXCHNGR PUMP OUTLET PRES	PSIG		
PHCFG	LOAD HEAT EXCHANGER FAN OUTLET PRES	PSIG		
PDHPO	PREHEATER PUMP OUTLET PRESSURE	PSIG		
DPDP	COLLECTOR PUMP DIFFERENTIAL PRES	PSID		
DPDF	COLLECTOR FAN DIFFERENTIAL PRESSURE	PSID		
DPHCP	LOAD HEAT EXCHANGER PUMP DIFF PRES	PSID		
DPHCF	LOAD HEAT EXCHANGER FAN DIFF PRES	PSID		
TDB	OUTDOOR (AMBIENT) DRY BULB TEMP	°F		
TWB	OUTDOOR (AMBIENT) WET BULB TEMP	°F		
TID	DWELLING INDOOR DRY BULB TEMP	°F		
CAI	COLLECTOR ARRAY INLET TEMP	°F		
TCS	COLLECTOR SURFACE TEMPERATURE	°F		
TPHO	DOMESTIC PREHEATER OUTLET TEMP	°F		
IST	STORAGE TANK TEMPERATURE	°F		
THCI	LOAD HEAT EXCHANGER INLET TEMP	°F		
TCO	CHILLER OUTLET TEMPERATURE	°F		
TCTS	COOLING TOWER SUPPLY TEMPERATURE	°F		
TSW	DOMESTIC SERVICE WATER TEMPERATURE	°F		
THW	HOT WATER SUPPLY TEMPERATURE	°F		
TPH	PREHEATER INPUT DIFF TEMPERATURE	°F		
DTHC	LOAD HEAT EXCHANGER DIFF TEMP	°F		
DTCT	COOLING TOWER DIFF TEMPERATURE	°F		
DTCE	ABSORPTN CHILLER EVAPRTR DIFF TEMP	°F		
DTCA	COLLECTOR ARRAY DIFF TEMPERATURE	°F		
FW	DOMESTIC HOT WATER FLOW RATE	GAL/MINUTE	EST AVG GAL/MIN	EST AVG GAL/MIN
FPH	PREHEATER HEAT EXCHANGER FLOW RATE	GAL/MINUTE	EST AVG GAL/MIN	EST AVG GAL/MIN
FHC	LOAD HEAT EXCHANGER FLOW RATE	LIQ SYSTEM OR CU FT/MIN AIR SYSTEM	EST AVG SAME AS DETAIL	EST AVG SAME UNITS AS DETAIL
FCA	COLLECTOR ARRAY FLOW RATE	LIQ SYSTEM OR CU FT/MIN AIR SYSTEM	EST AVG SAME AS DETAIL	EST AVG SAME UNITS AS DETAIL
FCD	COLLECTOR PUMP POWER	KW	KWH EST OF KWH USED THIS HOUR. SAME AS EST. AVG. OF KW	KWH. EST. OF TOTAL KWH USED THIS DAY
WCF	COLLECTOR FAN POWER	KW	KWH EST OF KWH USED THIS HOUR. SAME AS EST. AVG. OF KW	KWH. EST. OF TOTAL KWH USED THIS DAY
WHWAU	DOMESTIC HOT WATER AUXILIARY POWER	KW	KWH EST OF KWH USED THIS HOUR. SAME AS EST. AVG. OF KW	KWH. EST. OF TOTAL KWH USED THIS DAY
WHPD	PREHEATER PUMP POWER	KW	KWH EST OF KWH USED THIS HOUR. SAME AS EST. AVG. OF KW	KWH. EST. OF TOTAL KWH USED THIS DAY
WPHF	PREHEATER FAN POWER	KW	KWH EST OF KWH USED THIS HOUR. SAME AS EST. AVG. OF KW	KWH. EST. OF TOTAL KWH USED THIS DAY
WHCP	LOAD HEAT EXCHANGER PUMP POWER	KW	KWH EST OF KWH USED THIS HOUR. SAME AS EST. AVG. OF KW	KWH. EST. OF TOTAL KWH USED THIS DAY
WHCF	LOAD HEAT EXCHANGER FAN POWER	KW	KWH EST OF KWH USED THIS HOUR. SAME AS EST. AVG. OF KW	KWH. EST. OF TOTAL KWH USED THIS DAY
WAUE	AUXILIARY ELECTRIC POWER	KW	KWH EST OF KWH USED THIS HOUR. SAME AS EST. AVG. OF KW	KWH. EST. OF TOTAL KWH USED THIS DAY
WAUG	AUXILIARY GAS POWER	KW	KWH EST OF KWH USED THIS HOUR. SAME AS EST. AVG. OF KW	KWH. EST. OF TOTAL KWH USED THIS DAY
WAUD	AUXILIARY OIL POWER	KW	KWH EST OF KWH USED THIS HOUR. SAME AS EST. AVG. OF KW	KWH. EST. OF TOTAL KWH USED THIS DAY
WCTED	COOLING TOWER EVAPRTR PUMP POWER	KW	KWH EST OF KWH USED THIS HOUR. SAME AS EST. AVG. OF KW	KWH. EST. OF TOTAL KWH USED THIS DAY
WPAF	RETURN AIR FAN POWER	KW	KWH EST OF KWH USED THIS HOUR. SAME AS EST. AVG. OF KW	KWH. EST. OF TOTAL KWH USED THIS DAY
IT	COLLECTOR INCIDENT TOT SOLAR RAD	BTU/(HR-SQ FT)	EST. AVG.	EST. AVG.
RHP	DWELLING INDOOR RELATIVE HUMIDITY	PERCENT	EST. AVG. PERCENT	EST. AVG. PERCENT
DHC	LOAD HEAT EXCHANGER ON/OFF DISCRETE	1 = ON 0 = OFF	EST. AVG.	EST. AVG.
CTDP	COOLING TOWER PUMP ON/OFF DISCRETE	1 = ON 0 = OFF	EST. AVG.	EST. AVG.
DC	COOLING SUBSYSTEM DISCRETE	1 = ON 0 = OFF	EST. AVG.	EST. AVG.
WIND	WIND SPEED	MILES/HR	EST. AVG. MILES/HR	EST. AVG. MILES/HR
WDND	WIND DIRECTION	FROM CLOCKWISE	EST. AVG	EST. AVG
SP1	SPARE 1	UNKNOWN	EST. AVERAGE	EST. AVERAGE
SP2	SPARE 2	UNKNOWN	EST. AVERAGE	EST. AVERAGE
SP3	SPARE 3	UNKNOWN	EST. AVERAGE	EST. AVERAGE
SP4	SPARE 4	UNKNOWN	EST. AVERAGE	EST. AVERAGE
SP5	SPARE 5	UNKNOWN	EST. AVERAGE	EST. AVERAGE
SP6	SPARE 6	UNKNOWN	EST. AVERAGE	EST. AVERAGE
SP7	SPARE 7	UNKNOWN	EST. AVERAGE	EST. AVERAGE
SP8	SPARE 8	UNKNOWN	EST. AVERAGE	EST. AVERAGE
SP9	SPARE 9	UNKNOWN	EST. AVERAGE	EST. AVERAGE
SP10	SPARE 10	UNKNOWN	EST. AVERAGE	EST. AVERAGE
SOLHW	SOLAR ENERGY PROV FOR HOT WATER	KW	KWH ESTIMATE OF TOTAL KWH USED THIS HOUR SAME AS ESTIMATED AVG. KW.	KWH. ESTIMATE OF TOTAL KWH USED THIS DAY
AUXHW	AUXIL ENERGY REQ FOR HOT WATER	KW	KWH ESTIMATE OF TOTAL KWH USED THIS HOUR SAME AS ESTIMATED AVG. KW.	KWH. ESTIMATE OF TOTAL KWH USED THIS DAY
SOLSH	SOLAR ENERGY PROV FOR SPACE HEATING	KW	KWH ESTIMATE OF TOTAL KWH USED THIS HOUR SAME AS ESTIMATED AVG. KW.	KWH. ESTIMATE OF TOTAL KWH USED THIS DAY
AUXSH	AUXIL ENERGY REQ FOR SPACE HEATING	KW	KWH ESTIMATE OF TOTAL KWH USED THIS HOUR SAME AS ESTIMATED AVG. KW.	KWH. ESTIMATE OF TOTAL KWH USED THIS DAY
SOLSC	SOLAR ENERGY PROV FOR SPACE COOLING	KW	KWH ESTIMATE OF TOTAL KWH USED THIS HOUR SAME AS ESTIMATED AVG. KW.	KWH. ESTIMATE OF TOTAL KWH USED THIS DAY
AUXSC	AUXIL ENERGY REQ FOR SPACE COOLING	KW	KWH ESTIMATE OF TOTAL KWH USED THIS HOUR SAME AS ESTIMATED AVG. KW.	KWH. ESTIMATE OF TOTAL KWH USED THIS DAY
HWLOSS	HOT WATER SUBSYSTEM LOSS	PERCENT	EST. AVG. PERCENT	EST. AVG. PERCENT
SOLAVL	TOTAL AVAILABLE SOLAR ENERGY	KW	KWH	KWH (EST TOT)
SOLCOL	TOTAL COLLECTED SOLAR ENERGY	PERCENT	EST. AVG. PERCENT	EST. AVG. PERCENT
COLEFF	COLLECTOR ARRAY EFFICIENCY	PERCENT	EST. AVG. PERCENT	EST. AVG. PERCENT
SOLUTL	TOTAL SOLAR ENERGY UTILIZED	KW	KWH	KWH (EST. TOT)
SOLEFF	SOLAR SYSTEM CONVERSION EFFICIENCY	PERCENT	EST. AVG. PERCENT	EST. AVG. PERCENT
SOLOP	SOLAR SYSTEM OPERATING ENERGY REQ	KW	KWH	KWH (EST. TOT)
AUXTOT	TOTAL AUXILIARY REQUIRED	PERCENT	EST. AVG. PERCENT	EST. AVG. PERCENT
PCSOL	PERCENT SOLAR APPLIED TO LOAD	KW	KWH	KWH (EST. TOT)
SOLSAV	CONVENTIONAL ENERGY SAVINGS	PERCENT	EST. AVG. PERCENT	EST. AVG. PERCENT
PCTDC	PERCENT OF TIME DALLING COMFORTABLE	PERCENT	EST. AVG. PERCENT	EST. AVG. PERCENT
PCHWA	PERCENT OF TIME HOT WATER AVAILABLE	PERCENT	EST. AVG. PERCENT	EST. AVG. PERCENT



- VALUE 1, VALUE 2, VALUE 3, AND VALUE 4, REPRESENT "GOOD" VALUES READ WITHIN THE SAME HOUR

- HOURLY COMPUTED VALUE = $\frac{1}{60} [(Min_1 + 1) \cdot VALUE_1 + (Min_2 - Min_1) \cdot VALUE_2 + (Min_3 - Min_2) \cdot VALUE_3 + (59 - Min_3) \cdot VALUE_4]$

- MIN_i = MINUTE PORTION OF TIME: ($0 \leq Min_i \leq 59$)

$$\begin{aligned} \text{DAILY COMPUTED VALUE} = & \frac{1}{24} \cdot (HOUR_1 \cdot VALUE_1) + (HOUR_2 - HOUR_1) \cdot VALUE_2 \\ & + (HOUR_3 - HOUR_2) \cdot VALUE_3 + (HOUR_4 - HOUR_3) \cdot VALUE_4 + \dots \\ & + (24 - HOUR_{23}) \cdot VALUE_{24} \end{aligned}$$

Figure 10. Weighting of Values in Computing Hourly/Daily Variables

3.9 CREATE HISTORY/ARCHIVE TAPES

The input processing software shall provide the capability to create and maintain history and archive data (raw data and processed data) on magnetic tapes. Raw data received daily from the S/7 computer shall be written to disk storage and organized into a data set for each day's data. The corresponding site description data file containing calibration/conversion information shall also be written to the data set on a daily basis. On a monthly basis, this data shall be written to magnetic tape for archival purposes. Magnetic tapes shall be cataloged to relate days of information with tape identification for retrieval purposes.

Processed data shall be maintained on tape for history purposes. Monthly, after all data for the month has been processed, the detail records for the month, organized by site ID, shall be stored on detail record archive tape(s). Hourly records for the month, organized by site id, shall be stored on hourly record archive tape(s). Daily summary records remain in the data base, thus there is no requirement to keep them on archive tapes.

3.10 CREATE INPUT SUMMARY REPORTS AND ERROR MESSAGES

To assist the performance analyst and data base maintenance personnel, the input Processing Software shall create input summary reports and error messages. To provide these reports and messages, the software shall:

- o Generate daily reports to specify the number of data base input records by site and scans
- o Generate a report to specify the number of records by site placed in monthly data base detail record history files
- o Generate a daily summary report to specify the number of sites processed and the number of sites for which processing failed
- o Generate daily messages if a site is dropped or a block of data is dropped
- o Support user selection options for site summary reports on raw input processing. These reports shall include the following types of information:
 - Number of blocks
 - Number of scans
 - Time of first and last scan
 - Summary or errors in variables.
- o Support user selection for error messages on individual variable errors (BCH errors, out of limits, variable changing too fast, variable rejected) during raw input processing.
- o Support user selection option for printing data base detail records created by raw input processing.
- o Provide a report of calibration/conversion parameters for each remote site. Report shall include:
 - Calibration/conversion data for each input parameter
 - History of changes in calibration/conversion data

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4. FILE MAINTENANCE SOFTWARE REQUIREMENTS

The file maintenance software shall execute in the S/370-145 host computer and shall provide the capabilities required in support of the performance evaluation data base. The software shall execute in a shared environment under control of the S/370 OS/MVT operating system.

4.1 FUNCTIONAL REQUIREMENTS

To support the management of the performance data base, the file maintenance software shall:

- o Update the data base from the output of the Input Processing Software
- o Provide capability for manual input to the data base for data collection/addition/correction
- o Provide capabilities required in performance of data base maintenance, access, and update functions
- o Provide security of data base contents.

The following paragraphs address the detailed requirements which must be satisfied.

4.2 AUTOMATIC UPDATE OF DATA BASE

The file maintenance software shall accept the output of the input processing software and create the performance evaluation data base. The input to this software shall be of the format shown previously in Figure 9 and shall be sequenced by site identification and all data for each site shall be in time sequence. The input shall contain 30 days information for each remote site and shall be stored onto the disk unit, within the host computer facility, which is dedicated for solar heating and cooling system evaluation data. Directories required for access/update of the contents of the data base shall be created during the update process.

Errors encountered during creation of the data base shall be provided for data base correction activities.

4.3 MANUAL INPUT TO THE DATA BASE

The performance evaluation data base shall contain non-instrumentation data relating to description and performance of solar heating and cooling systems. In addition, manual input for correction of data base contents shall be supported. Both terminal input and batch input techniques shall be provided.

The manual interface capability shall be used to generate initial data files within the data base and shall be used to enter non-instrumentation data, problem descriptions, problem solutions, and other text-type information.

During the manual input of data, the software shall perform editing on format of input to ensure that incorrect data is not entered into the data base. Messages shall be provided to indicate erroneous input (on display tube from terminal input and via printout for batch mode).

4.4 DATA BASE MAINTENANCE, ACCESS, AND UPDATE

The normal data base maintenance, access, and update capabilities shall be provided for support of the performance evaluation data base. The file maintenance software shall provide:

- o Predefined operations to be performed on the data elements when maintenance is being performed.
- o Interface between the data base processing language and user written routines for data editing.
- o Data field editing while performing file maintenance.
- o Indication of errors in data makeup for corrective action.
- o Statistics on system characteristics for use in improving performance.
- o Ability to access multiple files within the same processing sequence.
- o Capability for keyword/secondary indexing of data fields.
- o System recovery/restart.
- o Data migration (archiving) of data from the data base on selected basis.
- o Support of restructuring data files to allow for changes in either file size or content.
- o Data base utility functions for data conversion.

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4.5 DATA BASE SECURITY

The file maintenance software shall provide security in access of the data within the data base. The data base security capabilities shall be utilized in either the terminal or batch mode of operation. Details of the security requirements are contained in the following paragraphs:

Terminal Access

Data base security within the terminal access mode shall consist of sign-on, password, and file classification security techniques.

At sign-on to the terminal, the user shall specify accounting information and name. This information shall be verified for correctness, and if incorrect, a message shall be displayed specifying that incorrect accounting information has been entered. The user shall be allowed to retry three times before the terminal input is ignored. A sign-off shall be required before the terminal will be reactivated within the system.

If a log-on is successful, a password shall be required before proceeding. Three consecutive errors in password entry shall result in terminal being ignored by the system. Error messages shall be provided to the terminal during password editing.

Successful completion of password processing shall result in a user's being allowed to request that a data file be opened for access.

If a data file open request is entered, the software shall ensure that the user has the authority to access the data file being requested through file classification. The software shall allow the user access to: (1) read only, (2) write only, or (3) both based on the access table within the system. If the user does not have proper file classification code, he shall not be allowed to address the data file, and an error message shall be displayed.

Batch Access

Security within the batch mode of operation shall be similar to that described above for terminal access with the exception of "sign-on" security which does not apply to batch operations. For password and file classification protection, erroneous requests shall result in the batch job being terminated and error messages being printed for user action.

Access Authority

Authority to access the data base shall be controlled via formal procedures. Management approval shall be required prior to releasing password information and shall be required to add user's identification to the access list.

5. USER SUPPORT SOFTWARE REQUIREMENTS

The user support software executes in the S/370-145 host computer and provides those capabilities which are critical to the performance evaluation activity. Presentation of information in a form supporting evaluation and satisfying the needs of a diverse user community shall be the overriding objectives of this element of the software.

5.1 FUNCTIONAL REQUIREMENTS

The user support software shall utilize the contents of the performance evaluation data base to provide the following:

- o Information retrieval capability for report generation (non scheduled)
- o Plot capability for support of analysis activities and inclusion in reports
- o Generation of daily, monthly, and annual reports (scheduled output)
- o Generation of magnetic tapes
- o Terminal/Batch capabilities

The detailed requirements in the above capabilities are described in subsequent paragraphs.

5.2 INFORMATION RETRIEVAL

The user support software shall provide the user with the capability to access the data base contents on a non-scheduled basis for generation of reports/plots to support his daily analytical activities. An information retrieval language shall be provided to allow the user to generate queries to satisfy his own unique requirements. The retrieval capability shall be supported in both terminal/batch modes of operation and shall provide the following:

- o Retrievals against single/multiple files.
- o Data qualification via user generated subroutines.
- o Terminal data entry/collection from desired files.
- o Batch processing of large data retrievals/updates.
- o Multiple answer files from one retrieval.
- o Versatile output formatting with headers, labels and boolean processing capability.
- o Library capability for temporarily storing queries for repetitive use.
- o Display statistical summaries of selected parameters.

5.3 PLOT CAPABILITY

The ability to provide the performance analyst with plots of instrumentation shall be an essential capability within the user support software. The software shall provide the ability to:

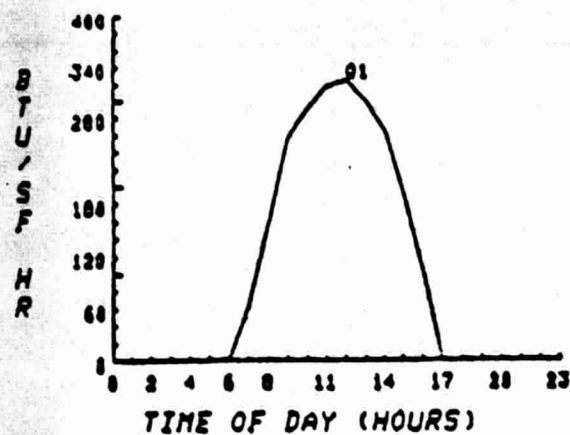
- o Plot selected parameters versus time
- o Plot parameter⁴ versus parameter over time interval
- o Plot multiple parameters against time
- o Provide multiple plots on the same CRT image

The Tektronix 4015/4631 terminal-hardcopy unit shall be supported by the software to provide both plots for analysis on the display and hardcopy of plots for inclusion in reports.

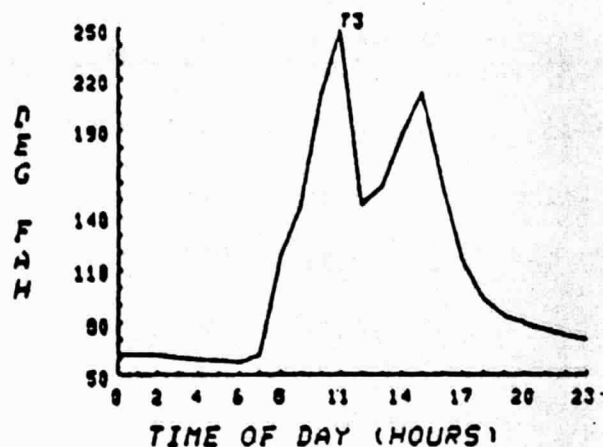
Input to the plot support software shall be a file created through use of the information retrieval capability. The ability to process multiple input files to produce multiple hardcopy reports shall be provided. Interactive capability with data base for plots will not be required.

Representative examples of plot requirements are shown in Figure 11.

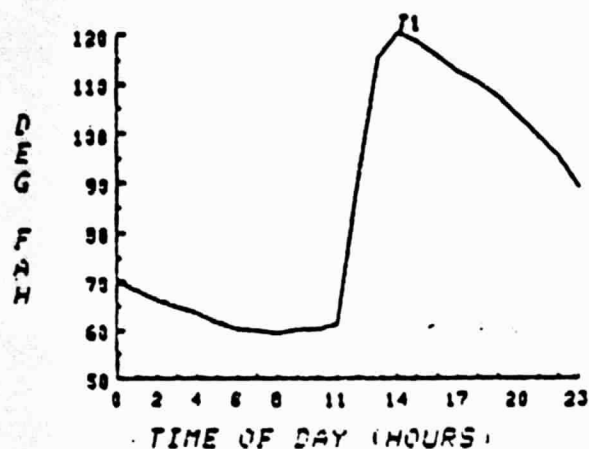
COLLECTOR INCIDENT SOLAR RADIATION



COLLECTOR SURFACE TEMPERATURE



HOT STORAGE TANK TEMPERATURE



OUTDOOR AMBIENT AIR TEMPERATURE

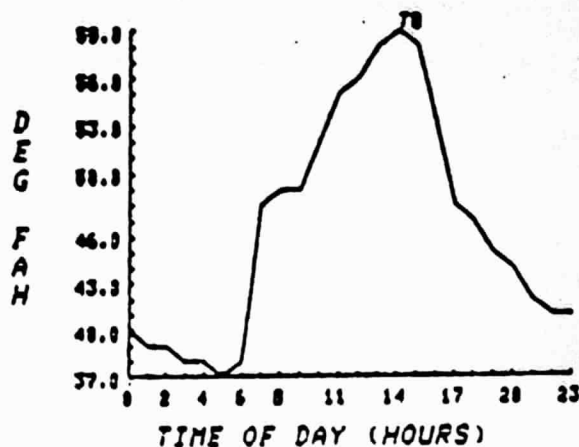


Figure 11. Terminal Graphs and Plots

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5.4 GENERATION OF SCHEDULED REPORTS

The user support software shall provide the capability to access the data base on a planned basis for generation of scheduled output reports. The software shall provide libraries of standard information retrieval queries which create the reports in the required formats. After completion of the daily data base update, the daily summary reports shall be generated and will present data summarized on an hourly basis for analysis.

On a monthly basis, the monthly summary reports shall be generated. These reports shall have data summarized to a daily basis, shall be analyzed for accuracy, and delivered to users for evaluation and archiving.

Capability to generate annual reports shall be provided. Daily summarized data shall be summarized into months and the monthly data presented over the annual reporting period.

A representative example of a scheduled summary report is shown in Figure 12. Reports shall be provided to MSFC, ERDA, and MSFC associate contractors.

SOLAR HEATING AND COOLING PROGRAM

ERDA 1-0037

12/16/76

DAILY SYSTEM PERFORMANCE SUMMARY

PROCESSING DATE: JANUARY 4, 1976

SITE NUMBER: 0037
 SITE LOCATION: 1915 WAXLEAF GREEN, HUNTSVILLE, ALABAMA 35803
 SITE NAME:
 OPERATION START DATE: OCTOBER 17, 1976
 LATITUDE: 34.7°N
 LONGITUDE: 86.6°N

COLLECTOR SIZE: 65 SQUARE METERS
 COLLECTOR TYPE: REVERE COPPER
 STORAGE SIZE: 1200 GALLONS
 STORAGE MEDIA: 100% WATER
 SYSTEM TYPE: HOT WATER, HEATING & COOLING

DATE OF DATA: DECEMBER 16, 1975

A-70 HOUR OF DAY	HOT WATER		HEATING		COOLING		DHW	AVAIL	TOTAL SOLAR			SYSTEM OPER POWER	TOTAL	PER	CONVEN	COMF	DHW
	SOLAR	AUX	SOLAR	AUX	SOLAR	AUX	LOSS		COLLECT	UTILIZE	CONV		AUX	CENT	ENERGY	INDEX	AVA
	KWH	KWH	KWH	KWH	KWH	KWH	WH		KWH	KWH	%		KWH	%	SAVED	%	%
0-1	0.01	0.00	10.13	0.00	0.00	0.00	20	0.00	0.00	10.14	0.0	0.23	0.00	97.1	9.91	100.0	100
1-2	0.00	0.00	11.01	0.00	0.00	0.00	0	0.00	0.00	11.01	0.0	0.25	0.00	96.7	10.76	100.0	100
2-3	0.02	0.00	14.93	0.00	0.00	0.00	32	0.00	0.00	14.95	0.0	0.24	0.00		14.71	98.1	100
3-4	0.01	0.00	15.72	0.00	0.00	0.00	18	0.00	0.00	15.73	0.0	0.26	0.00		15.47	96.3	100
4-5	0.00	0.00	17.41	0.00	0.00	0.00	0	0.00	0.00	17.41	0.0	0.27	0.00		17.14	97.7	100

Figure 12. Representative Scheduled Summary Report

5.5 MAGNETIC TAPE GENERATION

The user support software shall provide the capability to generate magnetic tapes compatible with user (MSFC/ERDA/MSFC associate contractors) computer facilities. Magnetic tapes in either 9-track 1600/800 BPI or 7-track 800 BPI formats shall be generated. The information retrieval capability shall be utilized to access the data bank to create data files containing the required data in the correct format. User support software shall be provided to access the data files and write the data to the magnetic tape for delivery to users.

5.6 TERMINAL/BATCH CAPABILITIES

In support of users, the user support software shall provide access to performance evaluation data bank contents via both terminal and batch modes. The terminal supported shall be IBM 3277 units located with the IBM facility (local terminals). An interactive terminal capability shall be provided for access and display of data base contents. Displays shall be text or numerical information and shall be used for on-line performance evaluation activities. Hardcopy outputs and graphic displays cannot be generated on the interactive terminals but shall be provided via the batch mode (hardcopy) and plot capabilities (graphic on the Tektronix 4015/4631 display unit dedicated to support of performance analysts within the IBM facility.

The terminal processing software shall provide the user the capability to:

- o Generate and execute information retrieval queries
- o Execute predefined information retrieval queries
- o Submit batch jobs via remote job entry
- o Use a display language to define output formats
- o Perform maintenance on existing data files

The batch operating capability shall provide the capability to perform the following:

- o Generate and execute information retrieval queries
- o Execute predefined queries
- o Production of hardcopy reports

6. PERFORMANCE EVALUATION DATA BASE REQUIREMENTS

The performance evaluation data base shall be located on disk storage and magnetic tapes within the S/370-145 host computer and shall contain all data files required in support of performance evaluation activities. Management and access to data within the data base shall be via the data base management and user support software.

6.1 FUNCTIONAL REQUIREMENTS

The performance evaluation data base shall be organized to provide each major data bank user with his own data file yet provide the capability to correlate information among the files. The data contained within the data base shall include both automatically-entered and manually-entered data.

The data base shall provide files for the following:

- o Remote site description
- o Remote site operational data
- o System analysis simulation/weather data
- o System interaction data
- o Subsystem evaluation
- o Configuration management
- o Software development
- o Raw data file

Each of the files shall have the following design requirements:

Fixed Data Elements - Data fields, which represent record keys, site/system characteristics, site/system identification, geographical, and past climatological information, shall remain fixed within data set records for life of the Solar Heating and Cooling Development contract. These fields shall be protected from arbitrary access and inadvertent destruction to avoid propagation of error throughout the remainder of the data base.

Periodic Data Elements - Data values, which represent solar system and subsystem integration and testing data, and data collected from operational sites will recur on a fixed periodic basis as input to the data base. The periodic interval shall be one of the following: five minute sampling interval of raw data readings, summarization intervals such as hourly, daily, etc., and pre-defined intervals in accordance with the schedule for system and subsystem testing. Periodic data shall be pre-processed (converted to engineering units, limit checked, scaled, etc.) prior to being included in the data base.

Variable Information - Variable data fields shall contain text and commentary information and also as pointers to data items in

off-line storage. Of particular importance will be the maintenance of failure history information for each remote site.

Grouped Data Elements - To simplify data manipulation and retrieval, continuous fields of related data shall be grouped and secondarily named as one field when appropriate. For example, the latitude, longitude, and elevation of a site shall be grouped under one name, 'location', to facilitate data operations.

Data Value Modes - Both alphanumeric and numeric data value shall be stored in the data base. Record elements which are defined as alphanumeric mode shall require EBCDIC characters to be stored as bytes. These fields shall not require mathematical processing. Record elements (fields or groups) containing numeric values shall require processing using mathematical operators.

Data Set Record Sizes - One record of each operational data set shall be equated with generated or collected data for each 6-hour period out of a 24-hour day. Since the site operational data set requires the largest data base storage, the maximum physical record size is determined by the volume of data remotely collected in one 6-hour period as shown below:

1 Physical Record = One 6-hour period of data per site

Period 1	00:00 - 06:00 hours
Period 2	06:00 - 12:00 hours
Period 3	12:00 - 18:00 hours
Period 4	18:00 - 24:00 hours

Number of recordings/hr = 12 (1 every 5 minutes)

Number of data parameters read = 42 (maximum) per reading

Avg. number of bytes per parameter = 4 (1 word)

Total bytes per hour = $12 \times 42 \times 4 = 2016$ bytes/hr

Record Overhead = 16 percent

Total Physical Record Size = $1.16 \times 2016 = 2339$ bytes

Catalogued Procedures - To ease the requirement on the user to supply all the necessary job control statements and language whenever a system component is used, cataloged procedures shall be prepared. These procedures are sets of previously written job control statements which will require prior storage into the System Library, uniquely named, and automatically retrieved during execution. Examples of required procedures are those to generate routine and fixed format reports, such as daily, weekly, monthly and quarterly analysis and evaluation reports.

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Assembly and Higher Level Language Routines Support - The data base user shall be provided the flexibility to process his data directly from the data base and optionally update the data base from the calculated results. This requires that the user be provided temporary work files on which to store intermediate evaluations and redefine inputs to the data base. Usage of programming languages will require conforming to the programming linkage conventions as defined in the NIPS File Structuring User's Manual.

Secondary Indexing Capability - Secondary indexing shall provide the user with the capability to index files in the data base by the contents of a field or fields other than the record key identification (e.g., date/ system/site ID). The primary purpose of this capability is to provide a faster response time for qualifying records during retrievals. Representative fields which are required to be indexed due to their frequency of use are:

- o Subsystem (collector, storage, etc.) manufacturer's identification
- o Subsystem type identification
- o Subsystem material type identification
- o Subsystem cost category (economical, marginal, uneconomical)
- o Subsystem efficiency category (very high, high, average, low, very low)

IBM Standard 370 Software - The System/370 Partition Data Set (PDS) access method shall be utilized to support software development and configuration management. The Partition Access Method allows rapid access to software modules and configuration management reports by "name" alone. Each name and its associated data is a member of a PDS.

Interfile Output - Interfile output (IFO) is the capability to combine data from several related files (data sets) during output processing. This capability shall be required when the user requires information from several files to satisfy a complex information retrieval query.

6.2 REMOTE SITE DESCRIPTION

The remote site description file shall contain physical characteristics of the remote site, description of the solar heating and cooling system, auxiliary power costs, and other characteristics needed to evaluate performance of the system. Since no instrumentation data is included within this file, manual input shall be required to generate, update, and maintain the file. Correlation information shall also be included to allow interfile access to satisfy complex queries requiring information from several files. Pointers shall also be included for correlation to off-line documents pertinent to each site.

The remote site description file shall reside on the disc and be immediately available throughout the life of a remote site.

6.3 REMOTE SITE OPERATIONAL DATA FILE

The remote site operational data file shall contain the daily processed instrumentation data from each remote site. Because of the volume of data, only one month's input shall be maintained on disk for immediate access. Data more than one month old shall be maintained on magnetic tape.

This file shall be organized by remote site ID and operational data shall be in chronological order over the month interval. In addition to the detailed instrumentation data, the file shall contain hourly summaries (over previous month interval), daily summaries (over life of remote site), performance evaluation parameters computer during the input processing activities, and correlation information to support interfile queries. This file shall also contain correlation information to files which contain manual input such as non-instrumented data, site anomalies, failures, etc. The file shall be automatically updated on a daily basis.

Because this file shall contain the data of most interest to the performance analyst, the design shall optimize data organization to minimize retrieval/ access times in generation of reports/plots.

6.4 SYSTEMS ANALYSIS SIMULATION/WEATHER DATA

In the prediction of system performance at a remote site, systems analysis simulations will be performed. The results of the simulations performed for reference with operational performance shall be maintained in this data file. Weather data (US Weather Service Data) used during development of reference predictions shall reside on magnetic tapes; however, the data file shall contain reference to weather data used.

The results of remote site predicted performance simulations shall be provided in summary form for correlation with data reports generated from the remote site description and remote site operational data files. The results of reference simulations shall be organized by site ID and automatically entered into the data file by the simulation software.

6.5 SYSTEM INTEGRATION DATA

Each solar heating and cooling system installed in remote sites shall be assigned a unique identification for evaluation purposes. The file shall contain the identification of subsystems comprising the system, characteristics of the system as determined during testing or from vendor provided information and pertinent test data.

This data file shall be manually updated and shall reside on disk for lifetime of the solar heating and cooling system.

6.6 SUBSYSTEM EVALUATION DATA

Each subsystem provided to IBM by MSFC for use in systems integration shall be included within this data file. Characteristics of the subsystem (both vendor data and MSFC test results) shall be included within this data file. The file shall be organized according to subsystem type (collectors, storage, hot water, cooling, heating, etc.).

The data file shall reside on disk and shall be manually maintained. The file entry for each subsystem shall remain active throughout the utilization of the subsystem.

6.7 CONFIGURATION MANAGEMENT

The configuration management data file shall provide the capability to maintain historical data pertaining to change activity. Both hardware and software changes shall be maintained on disk within the host computer. Upon release of first articles for use, an entry within the configuration management data file shall be established. All changes made to these baselines shall be entered into the file along with associated documentation.

6.8 SOFTWARE DEVELOPMENT DATA

The software development data file shall contain the library of baselined software deliveries and shall be modified only through configuration management approval. Both source and load modules shall be included and shall be identified by 'name' within the file. Security shall be provided to ensure controlled access to the file.

6.9 RAW DATA FILE

The Raw Data File shall reside on magnetic tape and disk storage within the IBM facility and shall contain a history of all raw data received from each remote site. The data less than one month old shall be maintained on disk and shall be dumped to magnetic tape on a monthly basis. Raw data shall be organized according to day of

receipt and shall be sequenced in the order in which remote site data was collected.

7. SOFTWARE VERIFICATION REQUIREMENTS

Verification of the CDPS software shall be performed prior to the overall CDPS becoming operational. This verification shall be performed while utilizing the CDPS hardware and shall consist of three phases:

Development Verification - Analysis and testing performed to ensure that elements of the CDPS software satisfy requirements.

Qualification Verification - Testing to ensure that the software system satisfies overall design requirements.

Acceptance Verification - Testing to ensure that the software system satisfies normal operational requirements.

During qualification and acceptance verification, test procedures shall be prepared and followed. Test results shall also be documented.

Details of the verification plan and approach are contained in the "CDPS Verification Plan" and other CDPS documentation.

APPENDIX A
PROGRAMMING
STANDARDS

1. INTRODUCTION

During the development, documentation, and maintenance activities associated with providing an operational CDPS capability throughout the lifetime of the demonstration program, a set of programming standards shall be utilized. The use of these standards results in an organized and systematic approach which provides reliable software which is easily understood and maintained.

1.1 SOFTWARE IMPLEMENTATION STANDARDS

The standards/conventions/procedures established for the software implementation phase are to provide continuity among the many programmers assigned. The implementation phase is usually the most difficult to control because of the individuality involved. A significant objective of standards is to establish a more structured approach to the coding process and to obtain program listings more easily understood and transferable.

Standards to be utilized during software development are discussed in more detail in the subsequent paragraphs.

1.1.1 Structured Coding Technique

In concept, structured coding is an extension of the approach utilized in hardware design and development, of constructing complex circuits from elementary AND, OR, and NOT gates. The software analogies to the hardware components are:

- o Sequence of two operations.
- o Conditional branch to one of two operations and return.

Programs written using structured code can be literally read from top to bottom typographically; there is never in line branching as is typical in trying to read code which contains "GO TO" statements.

An important task in assuring that a program meets its design requirements is the detailed audit procedure. Since this audit is best performed by someone not intimately in the program development, readability of the code is of prime importance. One of the advantages of the structured code technique is that it provides a basis for systematic reading of the program. The reading sequence within each segment is strictly from top to bottom. As a result, audit procedures are made more systematic and result in higher software reliability.

1.1.2 Program Support Library

The programming support library (PSL) is a set of clerical and computer procedures designed for use in a software development environment, plus the clerical support needed to make it work. The principal objective of the library is to provide up-to-date representations of the programs and test data in both computer and human readable forms. The design of the procedures permits most of the clerical and recordkeeping operations associated with programming to be isolated from the programmer.

The principal advantages gained from use of the program library on software development are:

- o Frees the programmer from clerical duties.
- o Centralizes the software system development activity.
- o Provides discipline to system development process.
- o Increases management visibility and control over software development.

1.1.3 Top-Down Development

The top-down development technique is the application of the natural system design approach. This technique requires the software control architecture and interfaces be established and developed first and succeeding levels of detailed logic implemented in a downward fashion. Top-down development provides an ordering which allows for continual software integration of system components and provides for well-defined interfaces at each level.

In top-down development, the system is organized into a tree structure of segments. The top segment contains the highest level of control logic and decisions within the program and either passes control to lower level segments, or identifies lower level segments for inline inclusion. The process continues for as many levels as required until all functions within a system are defined in executable code.

Many system interfaces may occur either through data base definition or calling sequence parameters. The top-down approach requires the data base definition statements be coded and actual data records be generated before exercising any segment which references them.

The top-down approach provides the capability of evolving the product in a manner which maintains the characteristic of being always operable, modular, and always available for the successive levels of testing that accompany the corresponding levels of implementation. The quality of a system produced using this approach is increased, as reflected in fewer errors in the module integration process.

Inconsistencies are eliminated, and lower level segments can be generated by referencing implemented code.

1.1.4 Coding Standards

A critical item in the production of software which is easily understood, transferable, and maintainable is the establishment of standards to be utilized during the coding process. The output of the coding process, the program listing, is the most highly utilized portion of the documentation package and must be controlled through the application of standards. High order languages, which support the structured programming concept, shall be used.

1.2 SOFTWARE TESTING STANDARDS

The software shall be tested in an atmosphere which emphasizes the need for planning of testing. Because of the emphasis of high quality in the operational use of software, a highly structured approach must be followed to ensure that, in addition to satisfying user requirements, the operational system satisfies the objectives of maintainability and transferrability.

1.2.1 Top-Down Testing

Top-down testing concentrates all testing activities on verifying functional capabilities of the software in the system environment. The benefits are increased system reliability, reduced testing cost, and a more visible testing process.

Using the top-down approach to software system development and a programming support library, all tests shall be performed in the system environment. The top-down approach ensures that all interfaces needed to execute are available when testing begins. Hence, program interface assumptions are never made and all testing verifies the real interfaces. Testing new programs or program changes in a temporary mode, without permanently modifying the systems, is easily done. When the program is tested, it shall be incorporated into the master system via the system build after receiving IBM management/NASA review for change control. Performing all tests against the master system accomplishes integration testing continuously as the functional capabilities are verified.

1.3 SOFTWARE DOCUMENTATION STANDARDS

The software documentation shall be generated in a continuing fashion throughout the software development phase. As was discussed, the programming support library will provide the central facility for generation of documentation. The primary documentation output shall consist of:

- o Software Requirements Document
- o Software Design Document
- o Users Manual

1.3.1 Structured Documentation

Documentation consists of the products of the definition and design activity. Implementation, verification, validation, and delivery will only modify design documentation. Employing top-down design will require that documentation be developed in a hierarchical, tree-like fashion. Top-level descriptions will reflect functional software operations. These high level descriptions will, in turn, be explained and/or expanded by lower level descriptions, and the process continued to the lowest module level. This produces documents that can be read and understood at any level. In addition, physically seaprate documentation required by volume can be done without impacting readability.

Readability shall be provided by describing software operation in the following manner:

- o Visual Table of Contents
- o Overview diagrams
- o Detail diagrams
- o Supporting text and annotated data

Functional documentation proceeds from a top level Visual Table of Contents diagram down to a basic module diagram of input, Processing, Output, functional chart. For each task to be performed, a module diagram shall be developed.

1.3.2 Flow Chart Standards

Although use of high-level language for software development reduces the usefulness of flow charts, flow charts will be required for deliverable documentation. The flow charts will depict how the software performs in the satisfaction of requirements.

To provide ease of correspondence between program listings and flow charts, the picture-on-a-page technique applied during coding will be applied to the generation of flow charts. Through this technique, a flow chart will exist for each routine of the software, and both the flow charts and listing will provide direct correspondence.

APPENDIX B
CDPS OPERATIONS APPROACH

1. INTRODUCTION

The CDPS must satisfy the processing and user support requirements resulting from daily data collection from all remote sites. To provide data to analysts by the beginning of first shift each day, an operations procedure has been established and is discussed in the following paragraphs.

1.1 DATA COLLECTION

SDAS data collection will occur during the evening hours (beginning at 2000). The collecting will continue until approximately 2330 (60 sites require approximately 3.5 hours) and upon completion, will be transferred via data link to the S/370-145 (requires 30 seconds). Computer operator intervention will be performed at the start of data collection time period to initiate the System 7 software. During the data collection time period, the communication interface computer console will be monitored for indications of telecommunications progress in contacting and receiving data from the SDAS equipment. In the event of communications difficulties, effort will be undertaken to resolve the problem during the hours dedicated to data collection. The communication operations personnel will be guided in the problem resolution by directions from the S/7 software analyst. The operator will, as required, interface with the MSFC Telecommunications Systems Status Center (TSSC) for resolution of communications difficulties.

1.2 DATA PROCESSING

Data processing on the host computer will occur between the hours of midnight and 0700 each day in order to provide error reports and summary reports and performance reports for SIMS analysts at the beginning of first shift (0800). The Input Processing portion of the CDPS software system will be executed, upon completion of data communication and retrieval by the Communication Interface computer, and will process the forwarded data from the System/7. All processed data containing no errors will be converted into engineering units, performance calculations performed, and data made ready for insertion into the performance evaluation data bank. Errors encountered during processing will be flagged such that erroneous data will not be entered into the data base, and error messages/reports will be provided for analysts.

1.3 DATA BANK PROCESSING

Upon completion of the Input Processing phase, the Data Base/User Support software will be executed in a batch environment under control of computer operations personnel. This processing will be accomplished in a manner to satisfy data availability requirements and output distribution.

To ensure timely completion, a high priority will be assigned to the processing of input data and will be monitored by operations personnel. If conflicts occur, the processing will be assigned the highest priority and will override any other processing.

Archiving of data will be provided through the use of software within the host computer. Raw data, processed data, and performance reports will be maintained within the computing facility and will be distributed as required for analysis/storage.

1.4 USER SUPPORT

User support will require that the data base management software allow ready access to the data base contents via local terminals and support batch job access to data for special analysis activities. When the IBM performance analyst requires a terminal capability to access the performance evaluation data base the computer operations personnel will, upon request, initiate the terminal processing capability of the NIPS 360 software. This will free computer resources (core memory) for use by other processing requirements instead of tying those resources up when terminal activity is not required.

1.5 DATA BASE MAINTENANCE

In addition to the daily scheduled updating of the Performance Evaluation Data Base with input from the Input Processing Software there will be the capability to perform selected maintenance on an as required basis.

1.5.1 Error Correction

Error conditions on data fields within the data bank corrected during first shift will be entered into the data base via local terminals (for small data volume) or via batch job submission. Upon completion of error correction, the performance evaluation data within the data base will be formatted and written to magnetic tape for transfer to the MSFC Solar Energy Data Base.

1.5.2 Non-Instrumentation Data Handling

Data elements to be added to the data base which are not gathered by the SDAS and processed in the CDPS, such as site location, site equipment availability, weather data, etc., will be entered into the data base via terminal or batch mode using the NIPS-360 File Maintenance capability. This will allow for text type data to become part of the data base and available for reporting purposes.

SECTION B

**CENTRAL DATA PROCESSING SYSTEM
HARDWARE PERFORMANCE SPECIFICATION**

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The Central Data Processing System (CDPS), through its hardware and software, shall provide the data collection, data processing, data archiving, and data distribution functions associated with performance evaluation of Solar Heating and Cooling Systems. The hardware, included within the CDPS, shall reside at IBM's FSD facility at Huntsville, Alabama and shall consist of two elements - a communications interface configuration and a host computer configuration. The performance specifications associated with this hardware, in support of the Systems Integration of Marketable Subsystems (SIMS) contract, are discussed in the following sections of this performance specification document.

The hardware, to be used within the CDPS, shall consist of commercially available hardware.

3.0 COMMUNICATION INTERFACE CONFIGURATION

The Communication Interface Configuration shall provide:

- (1) Hardware required to interface with the Site Data Acquisition Subsystem (SDAS) via telephone lines for data collection.
- (2) The computational capability to control automatic call-up of each remote site on a daily basis, to control communication protocol with the SDAS, perform error checks on incorrect data, format data for subsequent processing on the host computer configuration, and store data for transmission to the host.
- (3) Input/output capability for operator intervention in event of errors and for logging of communications activity and error conditions.
- (4) A multiprogram environment for software execution.
- (5) Hardware for transmission of recorded data to the host computer configuration.
- (6) Mass storage for temporary storage of recorded data.
- (7) Operational environment which requires minimum operator support during the data collection activities.

The performance specifications relative to the above capabilities are discussed in the following paragraphs:

3.1 SDAS INTERFACE

The SDAS interface hardware shall provide the capability to: (1) accept automatic dial signals from the communication interface computer, (2) perform the automatic dial function, (3) provide interface to a modem compatible with the modem contained within the SDAS, (4) receive data from the SDAS via the telephone lines, and (5) interface the data to the communication interface computer. A feedback mechanism shall exist in all hardware for signalling correct/incorrect operation.

The hardware associated with the above functions shall consist of:

- (1) Teleprocessing multiplexer (TPMM) for computer controlled operations.
- (2) Auto-call unit to support automatic dialup feature.
- (3) Modem for telephone line interface.

The specifications of these hardware elements are discussed below.

3.1.1 Teleprocessing Multiplexer Performance Specifications

The Teleprocessing Multiplexer shall provide the following capabilities in support of computer functions:

- (1) Software selection of operation (asynchronous mode for SIMS).
- (2) Internal mode of clocking to support asynchronous transmission.
- (3) Receive/transmit at 1200 Baud Rate on telephone.
- (4) Automatic call of Remote Sites under software control.
- (5) Interrupt communication processor on each byte of data transmitted/received (serial to parallel and parallel to serial conversions).
- (6) Status information regarding communications status.

3.1.2 Automatic Call Unit Specifications

The Automatic Call Unit (ACU) shall accept the above signals from the TPMM hardware under control of the computer software and perform the Automatic Dial Functions. The Automatic Call Unit shall provide the TPMM with control information regarding the dial function.

The sequence of operations between the TPMM and the Automatic Call Unit shall consist of:

- (1) Call Request (CRQ) line - activated by the computer to indicate that a call is to be placed.
- (2) Present Next Digit (PND) - activated by the ACU to signal the computer that the ACU is ready to accept the next digit for dialing.
- (3) Digit leads (NB1, NB2, NB4, NB8) - activated corresponding to the digit to be dialed.
- (4) Digit Present (DPR) lead - activated by the computer to signal that a digit has been placed on the Digit leads (NB1-NB8).
- (5) Data Line Occupied (DLO) lead - indicates to the computer whether the line is busy or not.
- (6) Abandon Call and Retry (ACR) lead - indicates to the computer that the called party does not answer or that, for some reason or other, the call is not completed.
- (7) Data Set Status (DSS) lead - activated by the ACU when the connection has been established.

The ACU within the CDPS shall be Bell 801 or equivalent.

3.1.3 Modem Specifications

The modem within the CDPS shall be the Bell 202C or equivalent and shall be compatible with the modem within the SDAS.

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3.2 COMPUTER PERFORMANCE SPECIFICATIONS

The communications interface computer shall provide the control, interface, and application programs necessary for complete control of the Communications Interface. The computer shall be interrupt driven, provide cycle capture of data to memory, and have growth potential in both storage and processor CPU cycles.

3.2.1 Processor CPU Specifications

The CPU shall provide support for priority level processing through the use of an interrupt handling system within the hardware. When an interrupt occurs, the current status of the processor shall be automatically saved within specific save areas for continuation of processing after interrupt servicing. Four levels of priority processing shall be provided with the capability to define 16 sublevels of priority within each primary level.

The instruction set provided by the CPU shall include the following classes of instructions:

- (1) Load and Store
- (2) Arithmetic
- (3) Logical
- (4) Shift
- (5) Branch
- (6) Register-to-Register
- (7) Input/Output

The CPU shall be capable of handling multiple input lines simultaneously.

The CPU shall perform parity checks on all data stored or retrieved from the Memory Unit of the computer. An odd-parity technique shall be provided.

The CPU shall provide capability for addressing storage and for maintaining computer status within the computer.

The following registers and indicators shall be provided:

- (1) Storage Address Register
- (2) Instruction Address Register
- (3) Index Registers
- (4) Accumulation Registers

- (5) Interrupt Registers
- (6) Carry Indicator
- (7) Overflow Indicator
- (8) Result-Zero Indicator
- (9) Result-Even Indicator
- (10) Result-Positive Indicator
- (11) Result-Negative Indicator
- (12) Interval Timer Registers

3.2.2 Memory

The memory of the computer shall be sufficient to support the anticipated needs of the software (approximately 24K 16-bit words) and shall provide the capability for expansion through field modification to the baseline system. Maximum required memory shall be 65K 16-bit words.

3.3 INPUT/OUTPUT SPECIFICATIONS

A complement of peripheral I/O devices shall provide support to the software executing in the processor to satisfy the operational requirements of the CDPS.

3.3.1 Operator Console

The operator console shall provide hard copy for information inquiries, status messages, memory dumps, and control and maintenance of the Communication Interface Software.

3.3.2 Direct Access Storage

A direct access storage device shall provide on-line storage for the Communications Interface Software and provide temporary storage for incoming input data. The direct access disk shall provide the capability to store information from 60 sites.

3.3.3 Additional Devices

The Communication Interface Processor shall have adequate growth capability and flexibility in terms of new I/O modules/devices. This growth shall be supported by the initial computer architecture and shall not require any significant reprogramming or hardware design effort.

3.4 HOST COMMUNICATIONS

An interface or data link from the Communication Interface Processor to the host computer shall be provided. The communications interface shall not

require constant host communication and shall support a stand-alone environment. The host communication link shall be a coaxial cable, and the distance supported shall be less than one mile.

3.5 OPERATIONS

After manual initiation, the communication interface configuration shall be capable of unattended operation during daily data collection from remote sites. In the event of errors which cannot be circumvented under automatic control, operator intervention shall be required.

4.0 HOST COMPUTER PERFORMANCE SPECIFICATIONS

The host computer shall provide the capabilities, through its peripheral devices and processing capabilities, to create, support and maintain the SIMS performance evaluation data base. The host computer shall receive remote site data from the communication interface computer over the Host/Communications Interface data link and accept manual inputs via cards or terminals for non-instrumentation data. The following sections specify the functional performance requirements of these elements.

4.1 MAIN MEMORY

Main memory shall provide the host computer with fast access, directly addressable storage of data. Main memory shall be of sufficient size to allow both SIMS data and programs to be loaded and processed. Main memory shall also have growth capability. The maximum storage requirements is estimated to be 256K bytes.

4.2 CENTRAL PROCESSING UNIT

The CPU shall be the controlling element for the host computer and shall provide facilities for:

- o Addressing main storage
- o Fetching and storage of data
- o Executing instructions
- o Initiating communications between main storage and I/O devices

The CPU shall support both fixed and floating point arithmetic operations as well as logical operations and shall be sufficient speed to support the SIMS data processing requirements.

4.3 INTERRUPTS

The host computer shall have an interrupt system to allow efficient use of I/O devices and for dynamic and fast response to peripheral equipment requirements. The interrupt system shall be used in a manner that results in a multi-program environment for the host computer.

4.4 INPUT/OUTPUT

The host computer shall have an input/output system that will adequately handle SIMS data transfers between main storage and the I/O devices. The input/output system shall be flexible and allow for additional devices to be added with minimal system impact.

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4.4.1 I/O Channels

Channels are the direct controllers of I/O devices and control units. The host computer shall provide channels with the ability to read, write, and compute and relieve the CPU of the task of directly communicating with the I/O devices.

4.4.2 Direct Access Storage

The host computer shall have direct access storage available to provide auxiliary storage for the performance evaluation data base and off-line storage for program storage. Direct access space required for SIMS is estimated to be 200 million bytes.

4.4.3 Display Terminal

The host computer shall provide high speed, visual, interactive communications between the host computer and the user via display. The terminals shall provide the SIMS user with the means for entry and change of information in the host computer. The interactive mode shall be provided via IBM terminals. Graphics capability shall be provided via a Tektronix 4015/4631 Display Unit or equivalent.

4.4.4 Magnetic Tape

The host computer configuration shall support the production and delivery of magnetic tapes containing performance evaluation data. These tape units shall support 9-track 1600/800 BPI density and 7-track 800 BPI density.

4.4.5 Printer

The host computer shall provide high-speed printers (1100 lines per minute) for creation of reports to be delivered to users of performance evaluation data.

4.4.6 Card Reader/Punch

The host computer shall provide a card reader/punch for program and data input to the system.

4.4.7 Communications Interface

A communication data link shall be provided from the host computer to the communications interface configuration for high-speed transfer of data collected and buffered by the communications interface (see Paragraph 3.4).

4.5 OPERATIONS

The host computer shall be shared with other users. To insure that SIMS data processing is processed within specific time constraints, a high priority level will be assigned.

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SECTION C

**CENTRAL DATA PROCESSING SYSTEM
SOFTWARE VERIFICATION PLAN**

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1.0 INTRODUCTION

The Central Data Processing System (CDPS), which is comprised of both hardware and software, provides the essential capabilities of data collection, data processing and storage, and data user support for the SIMS Program. Because of its criticality in Solar Heating and Cooling System performance evaluation, the system must be verified prior to becoming an operational element of the program.

The objectives of the CDPS verification activity are to ensure that each element of the system, as well as the overall system, satisfies or exceeds the requirements established in the CDPS Performance Specification Documentation. The verification activity, therefore, requires a systematic approach to analysis and testing and sufficient documentation to provide traceability of test results. The approach, however, must ensure maximum confidence in system operation with the minimum expenditure of resources.

Within this document, all descriptions of and references to the CDPS hardware configuration are only to facilitate explanation of the software requirements and not to control the configuration of the hardware. The CDPS hardware is controlled by IBM and is used for support of multiple contract programs. To support this varying utilization environment, IBM must maintain the flexibility to modify the configuration as required. Because of this flexibility requirement, the CDPS hardware configuration may vary during the performance of the SIMS contract, but the capability to satisfy all SIMS processing requirements contained within the CDPS Hardware Performance Specification will be maintained.

1.1 PURPOSE

The purpose of this CDPS Verification Plan is to define the approach to be utilized in verification of the CDPS and to delineate the schedules to be followed in providing a verified CDPS.

1.2 SCOPE

This verification plan addresses the verification activities required of the CDPS. In addition, configuration control techniques and test plans are defined to provide management and NASA visibility into the verification activities.

1.3 APPLICABLE DOCUMENTS

The following documents are required in support of CDPS verification:

- (1) CDPS Hardware Performance Specification Document
- (2) System/7 Functional Characteristics
- (3) Site Data Acquisition Subsystem Performance Specification
- (4) Guide to S/370-145
- (5) System/370-145 Functional Characteristics
- (6) NMCS Information Processing System Manuals
- (7) S/7 Teleprocessing Description
- (8) CDPS Software Performance Specification
- (9) Programming Guide for System/7 Teleprocessing Feature (GC34-1549)

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2.0 CDPS DESCRIPTION

Within the overall Solar Heating and Cooling Demonstration Program, the CDPS performs the following functions:

Data Collection - The CDPS daily collects instrumentation data from all remote sites via standard voice-grade 1200 Baud telephone lines. In addition, non-instrumentation data available from MSFC, ERDA, HUD, etc., which is needed in performing overall system evaluation, is collected via manual means.

Data Processing - The CDPS accepts raw data, as collected by the data collection function, and performs the data processing functions required to transform the raw data into processed information for use in system evaluation/analysis activities. The CDPS also provides the resources to maintain a performance evaluation data base, containing both raw data and processed information, for use in support of performance analysts.

Data Archiving - To provide capability for detailed analyses of system performance and to maintain data for historical purposes, the CDPS provides the capabilities to archive data collected and processed. Both raw data and processed data is retained on magnetic tape, and formal reports are archived in a library.

Data Distribution - In addition to collection, processing, and archiving of data, the CDPS provides the essential function of distributing the data to the appropriate organizations. Distribution is in the form of printed reports, data plots, and magnetic tapes.

3.0 VERIFICATION APPROACH

The verification of the CDPS will consist of a systematic testing/analysis approach which will ensure that system specifications/requirements are achieved or exceeded. Test procedures will be generated and followed during testing of each CDPS component and test results will be documented in a qualification report for review by management and MSFC. Verification cross-reference matrices will be used to ensure that all CDPS requirements/specifications are addressed during verification.

Three phases of verification will be performed on the CDPS as defined in the following paragraphs:

DEVELOPMENT - Analysis and testing of design approaches to ensure that approach selection will meet system specifications.

QUALIFICATION - Analysis and testing of CDPS to design limits. Performed prior to entry to acceptance testing of the system.

ACCEPTANCE - Testing of the operational CDPS as a system to ensure that overall system satisfies system performance specifications.

The development and verification activities associated with the CDPS are shown in Figure 1.

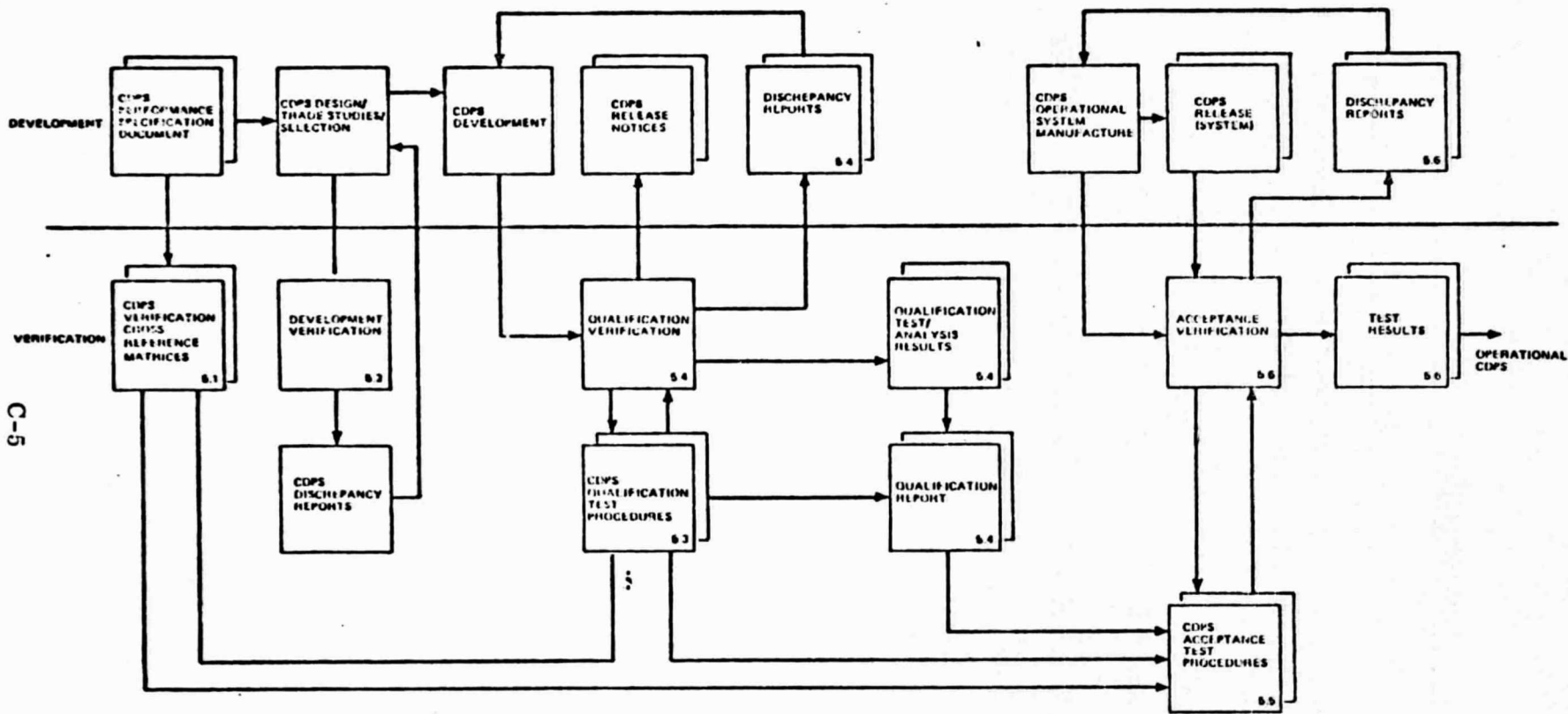


Figure 1. CDPS Verification Approach

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4.0 DEVELOPMENT/VERIFICATION SCHEDULES

The CDPS is scheduled to be fully operational by 9/1/76. To achieve this program milestone, development and verification schedules have been defined and are shown in Figure 2. Discussion of the schedules is given in the following paragraphs.

4.1 DEVELOPMENT SCHEDULE

Development activities have been scheduled to provide software elements which have undergone preliminary development verification activities by 7/1/76.

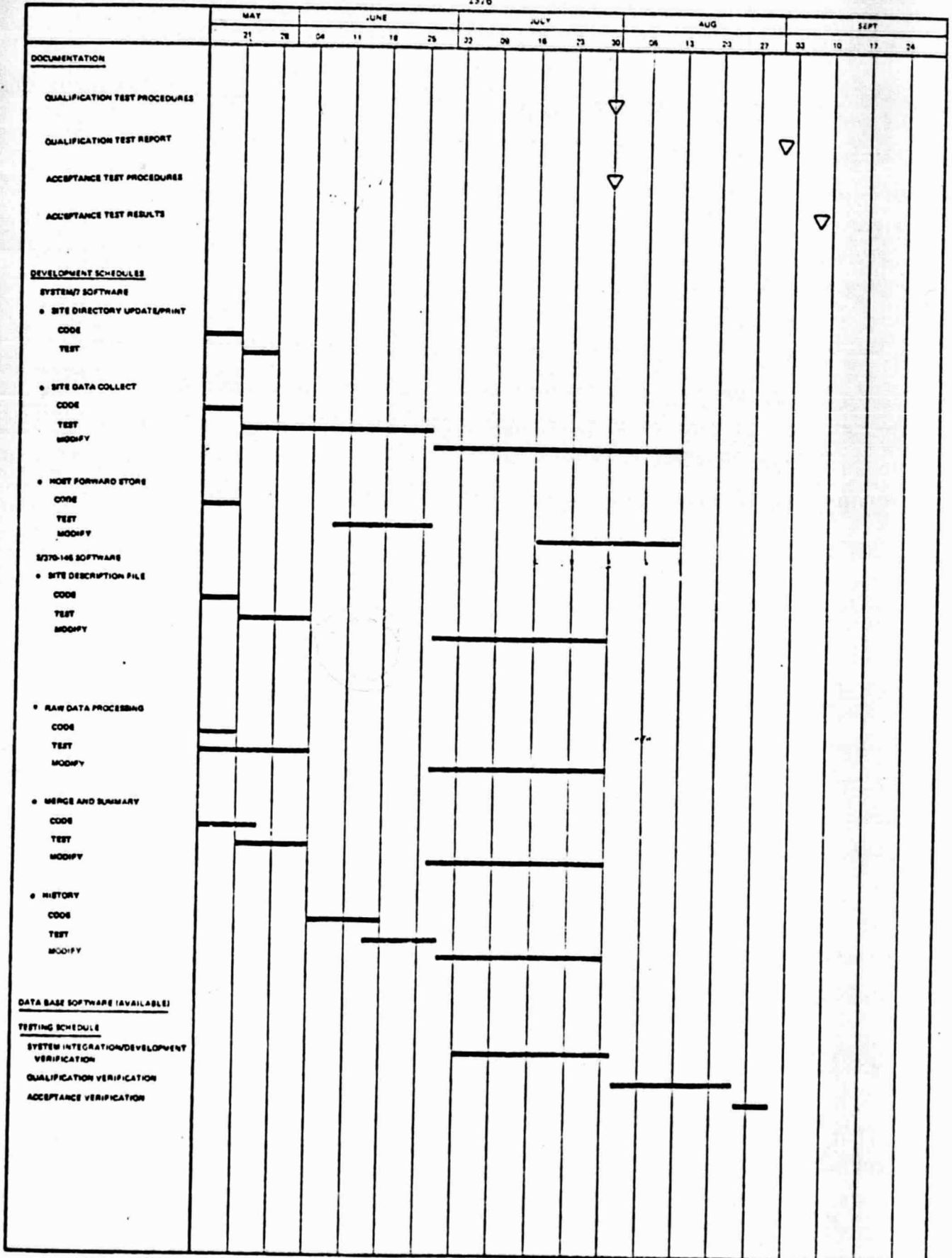
4.2 VERIFICATION SCHEDULE

Development verification will be accomplished during June on individual software/system elements and during July on system integration activities for the overall CDPS.

Qualification verification will commence on 8/1/76, and will extend until approximately 8/25/76. During this period detailed verification will be performed to test the system to design limits.

Acceptance verification will commence on 8/25/76 and extend to 9/1/76. Upon completion of acceptance verification, the CDPS will be considered operational to support the overall program.

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Figure 2. Development Schedule

5.0 TESTING CONFIGURATION/UTILIZATION

The testing configuration for use in verification of the CDPS capabilities relating to data collection/data processing/data base update/user support is shown in Figure 3. As can be seen in the figure, the configuration consists of the following elements:

- o System/7 Test Software
- o Controlled Signal Generation Equipment
- o Prototype Site Data Acquisition System (SDAS)
- o Telephone Line Interface
- o Communication Interface Configurations
- o Host Computer Configuration
- o Performance Evaluation Data Base

A description of each of these elements and the rationale for their use during verification activities is discussed in subsequent paragraphs.

5.1 SYSTEM/7 TEST SOFTWARE

To provide the CDPS verification activity with reasonable sensor data, a System/7 test software package will be required. This software will allow an SDAS sensor configuration to be simulated for the purpose of generating CDPS test data. These simulator signals will be recorded for reference with CDPS output. The use of the System/7 software for sensor simulation results in a significant reduction in CDPS verification complexity and provides flexibility to easily reconfigure the simulation to address varying SDAS applications (increased sensors, varying formats, etc.).

5.2 CONTROLLED SIGNAL GENERATION EQUIPMENT

The Controlled Signal Generation Equipment will be utilized to provide laboratory controlled voltages to the input multiplexer channels of the SDAS and thus will simulate signals which would be generated by sensors. This simulation capability is required because no sensors are connected to the SDAS until

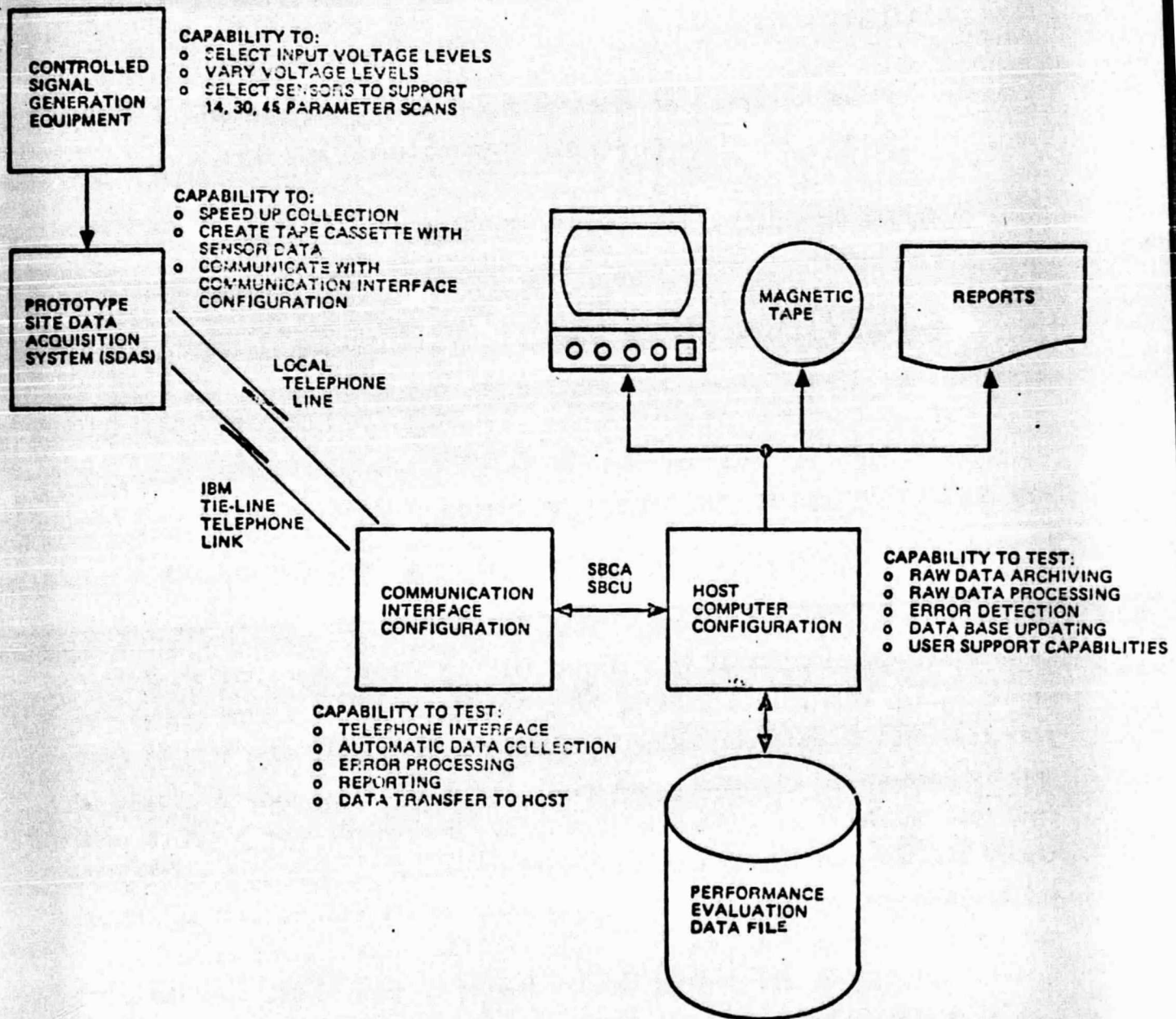


Figure 3. Test Configuration for Data Collection/Data Processing/Data Base Update/User Support Verification

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either system testing at MSFC or installation at a remote site. In support of CDPS verification activities, the Controlled Signal Generation Equipment will have the following capabilities:

- o Place voltages onto selected input multiplexer channels of SDAS
- o Support interface to all input multiplexer channels

5.3 PROTOTYPE SITE DATA ACQUISITION SYSTEM (SDAS)

The prototype SDAS will provide the capability to read the simulated sensor inputs from the Controlled Signal Generation Equipment and record them on cassette tape for subsequent transmission via telephone lines. The prototype SDAS will provide the capability to reduce the sample time to 8 seconds to speed up the data recording process (24 hours of data gathered in .6 hours) and reduce significantly the duration of tests.

5.4 TELEPHONE LINE INTERFACE

To simulate the operational CDPS environment, telephone lines are provided for communication with the prototype SDAS. Two lines (a local line and an IBM tie-line) will be utilized during verification. The local line will be used for development verification to perform debug of SDAS/communication interface configuration interface. The use of a local line reduces communication line errors and thus provides a more controlled environment. During qualification and acceptance verification testing, the IBM tie-line will be used to simulate the use of a long-distance telephone line. These lines are not of high-quality and will provide a realistic testing environment. Calls to the prototype SDAS via the tie-line will be routed to New Jersey and back to the Huntsville facility. This technique is widely used within IBM to test communications between teleprocessing elements and presents a worse-case telecommunication environment for testing.

5.5 COMMUNICATION INTERFACE CONFIGURATION

The communication interface configuration will contain the operational hardware and software undergoing verification. The operational system will perform in an unmodified form and will collect data from the prototype SDAS via the telephone interface equipment. Communication reports/error messages obtained during data collection can be compared to the reference data provided during the sensor simulation/SDAS data gathering phase. Upon completion of data collection, the data will be transmitted to the host for subsequent processing.

5.6 HOST COMPUTER CONFIGURATION

The host computer configuration (hardware and software) will be an unmodified operational system. Data transmitted to the host from the communications interface configuration will be processed and entered into the performance evaluation data base. Error messages/reports generated will be compared with System/7 test reference data for verification purposes.

5.7 PERFORMANCE EVALUATION FILE BASE

The data collected and processed will be entered into the data files and will provide the basis for user support interface verification. Plots/reports/magnetic tapes will be generated from the data and analyzed for correct content/format/etc. SDAS sensor test reference data will be used for reference with user output.

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6.0 VERIFICATION CROSS-REFERENCE MATRIX

A verification cross-reference matrix provides the correlation among the CDPS performance specification and the corresponding verification techniques and phases. The verification matrixes for the CDPS are shown in Table 6-1. The matrices, therefore, provide the base for development of test procedures to address all performance requirements/specification. A separate verification matrix is provided for each CDPS element.

The verification matrix also indicates the test procedures and test results documents which correspond to the Performance Requirement. This approach will allow ready access to the verification data relating to each entry in the matrix. Visibility and traceability will be achieved and will aid in maintaining the complete verification history throughout the maintenance/utilization of the system. In addition, as changes are made to requirements, updating of test procedures will be simplified.

ITEM (NAME AND PART NO.)
CENTRAL DATA PROCESSING
SYSTEM SOFTWARE

VERIFICATION CROSS
REFERENCE MATRIX
(Communications Interface)

VERIFICATION METHOD 1. SIMILARITY 3. INSPECTION N/A NOT APPLICABLE
2. ANALYSIS 4. TEST

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS	
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	APPLICABLE TEST PROCEDURES	APPLICABLE TEST DOCUMENTS
2.2 Site Directory					
2.2.1 Site Directory Information	4	4	4	2.2.1-1	
2.2.2 Site Directory Update	4	4	4	2.2.2-1	
2.2.3 Site Directory Print	4	4	4	2.2.3-1	
2.3 Communications Hardware Inter face					
2.3.1 Interface Commands	1,4	4	4	2.3.1-1	
2.3.2 Data Integrity	2,4	4	4	2.3.2-1	
2.3.3 Status	4	4	4	2.3.3-1	
2.4 SDAS Communica- tions	4	4	4	2.4-1	
2.5 Data Store	4	4	4	2.5-1	
2.6 Host Trans- mission	1,4	4	4	2.6-1	
2.7 Manual SDAS Control	4	4	4	2.7-1	

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Table 6-1. Verification matrixes (Sheet 1 of 4).

ITEM (NAME AND PART NO.)
CENTRAL DATA PROCESSING
SYSTEM SOFTWARE

VERIFICATION CROSS
REFERENCE MATRIX
(Input Processing)

VERIFICATION METHOD		1. SIMILARITY 2. ANALYSIS		3. INSPECTION 4. TEST	N/A NOT APPLICABLE	
		VERIFICATION PHASE			REMARKS	
PERFORMANCE REQUIREMENT		DEVELOPMENT	QUALIFICATION	ACCEPTANCE	APPLICABLE TEST PROCEDURES	APPLICABLE TEST DOCUMENTS
3.2	Receive Data from Communica- tion Interface	1	4	4	3.2-1	
3.3	Decommutating Data into Scans	4	4	4	3.3-1	
3.4	Conversion to Engineering Units	4	4	4	3.4-1	
3.5	Limit Checking	4	4	4	3.5-1	
3.6	Computed Var- iables	4	4	4	3.6-1	
3.7	Performance Evaluation Parameters	4	4	4	3.7-1	
3.8	Data Base Input	4	4	4	3.8-1	
3.9	History/Archive	4	4	4	3.9-1	
3.10	Reports	4	4	4	3.10-1	

Table 6-1. Verification matrixes (Sheet 2 of 4).

VERIFICATION METHOD 1. SIMILARITY 3. INSPECTION N/A NOT APPLICABLE
2. ANALYSIS 4. TEST

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS	
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	APPLICABLE TEST PROCEDURES	APPLICABLE TEST DOCUMENTS
4.2 Automatic Update of Data Base	1,4	1,4	4	4.2-1	OS-GC28-6550
4.3 Manual Batch Input to Data Base	1	1	4		
4.3 Manual Terminal Input to Data Base	1	1	4		
4.4 Data Base Maintenance	1	1	4		
4.5 Batch Security	1	1	4		
4.5 Terminal Security	1,4	1,4	4	4.5-1	
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Table 6-1. Verification matrixes (Sheet 3 of 4)

ITEM (NAME AND PART NO.)
CENTRAL DATA PROCESSING
SYSTEM SOFTWARE

VERIFICATION CROSS
REFERENCE MATRIX
(User Support)

VERIFICATION METHOD		1. SIMILARITY 2. ANALYSIS	3. INSPECTION 4. TEST	N/A NOT APPLICABLE	
PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS	
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	APPLICABLE TEST PROCEDURES	APPLICABLE TEST DOCUMENTS
5.2 Information Retrieval	1	1,4	4	5.2-1	
5.3 Plot Capability	4	4	4	5.3-1	
5.4 Report Generation	1	1,4	4	5.4-1	
5.5 Magnetic Tape Generation	1	1,4	4	5.5-1	
5.6 Terminal/Batch Capabilities	1	1	4		

Table 6-1. Verification matrixes (Sheet 4 of 4).

7.0 DEVELOPMENT VERIFICATION PLAN

Development verification will be performed as a part of the initial CDPS design activities. Analysis of the proposed designs and testing of initial concepts will be performed to ensure that the CDPS approach selected provides the growth and flexibility to address system specifications in a cost effective manner.

Of prime consideration in development verification will be the utilization of commercially available hardware and software to satisfy CDPS requirements. Trade analysis, and performance testing of available capabilities against CDPS System Performance Specifications will provide the bases for selection.

Development verification will consist of detailed testing of each software element, under simulated input conditions, to ensure that the design satisfies the software requirements. These tests will be executed in a standalone environment and will test error paths as well as the normal processing paths.

Upon completion of development verification activities on each software element, detailed tests will be performed, using simulated data, to test interfaces among the software elements. As a result of this interface verification testing, the overall CDPS design will be proven and the system will be available for qualification verification.

Development verification of the hardware will be performed in conjunction with software verification. Ability to satisfactorily perform software development verification will prove the hardware can satisfy the design requirements for each system element.

An interactive relationship will exist among development verification and CDPS design/trade studies/selection processes. Any deficiencies noted in the approach will be discussed and resolved to the satisfaction of the development verification personnel. The interactive relationships will be internal to IEM; however, the results of development verification will be discussed with MSFC at periodic meetings/design reviews.

8.0 QUALIFICATION VERIFICATION PLAN

Upon completion of development verification, qualification verification will be performed. The qualification verification activities will consist of formal tasks performed in the analyses and testing of the elements of the CDPS. Qualification test procedures will be followed throughout the testing phase.

Qualification verification will be performed in a building-block concept. Each system function (hardware and software) will be tested as a unit, and the units combined in an orderly manner to achieve an overall CDPS operational capability. The order in which the elements will be combined and tested during qualification testing is as follows:

- (1) S/7 configuration and SDAS for communication and data collection
- (2) S/7 - S/370 communication to achieve data flow to S/370-1-5
- (3) Input processing software process data accumulated from S/7
- (4) Data base update capability for user support verification.

Upon completion of qualification testing, the system will be ready to undergo acceptance verification.

Test/analysis results achieved as a result of qualification testing will be compiled into a CDPS Qualification Report. Test procedures will also be contained in the report.

8.1 QUALIFICATION TEST PROCEDURES

Formal qualification test procedures will be generated, provided to MSFC, and utilized during qualification verification activities. The verification cross-reference matrices and the CDPS Performance Specification Document will provide input required to define and detail these procedures.

During CDPS qualification testing, the procedure will be updated, as required, to ensure that CDPS elements are thoroughly verified. This update procedure

will be closely controlled and documented. The test procedures will be reviewed with MSFC prior to utilization in testing. The procedures will also be included in the Qualification Report for delivery to MSFC.

Program Trouble and Corrective Action Reports will be generated for each problem encountered. A sample of the form to be completed for discrepancy reporting is shown in Figure 4. Discrepancy reports must be investigated and resolved prior to completion of qualification verification. Reports on status of discrepancies will be included in the qualification report.

8.2 S/7-SDAS CONFIGURATION QUALIFICATION VERIFICATION TESTING

The qualification verification for the S/7-SDAS configuration will ensure that the CDPS can perform the functions associated with telecommunications, data collection, and data transmission to the host computer for processing. Table 8-1 contains the list of tests to be performed, estimated test duration time, and test descriptions associated with this qualification verification activity. These tests have been organized according to function performed by the CDPS.

- (1) Site Directory Requirements
- (2) Communication Hardware Interface
- (3) S/7-SDAS Communications
- (4) Data Store
- (5) Transmit to Host
- (6) Manual SDAS Control

PROGRAM NAME		DATE	
INITIATOR		TEST CASE	PROGRAM MODULE ID
DEPT	LOCATION	CLOSURE	DATE

DESCRIPTION OF PROBLEM:

REVIEWER'S SIGNATURE	DATE
----------------------	------

RESULTS OF INVESTIGATION/RECOMMENDATIONS:

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INVESTIGATOR	DATE
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Figure 4. Program Trouble And Corrective Action Report (PTR)

CDPS SOFTWARE VERIFICATION PLAN

CDPS ELEMENT:	COMMUNICATION INTERFACE	☒	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☐	USER SUPPORT	☐	ACCEPTANCE	☐

SOFTWARE FUNCTIONAL AREA: Site Directory

DATE: June 7, 1976

PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 2.2

APPROVAL:

TEST NUMBERDESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

2.2.1-1

Verify that each of the fields within the site directory is properly maintained during normal and abnormal site data collection and host transmission sessions.

2.2.2-1

Verify that new site directory entries may be created, and specified fields updated.

2.2.3-1

Verify that the site directory may be printed.

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CDPS SOFTWARE VERIFICATION PLAN

DPS ELEMENT:	COMMUNICATION INTERFACE	☒	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☐	USER SUPPORT	☐	ACCEPTANCE	☐
SOFTWARE FUNCTIONAL AREA: Communications Hardware Interface				DATE: June 8, 1976		
PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 2.3				APPROVAL:		

EST NUMBER

DESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

- | | |
|---------|--|
| 2.3.1-1 | Each of the TPMM commands shall be exercised and proper operation verified. |
| 2.3.2-1 | BCH encoding and error detection shall be verified. |
| 2.3.3-1 | Failures shall be introduced to force each hardware status bit to become active. Proper software response shall be verified. |

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CDPS SOFTWARE VERIFICATION PLAN

CDPS ELEMENT:	COMMUNICATION INTERFACE	☒	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☐	USER SUPPORT	☐	ACCEPTANCE	☐
SOFTWARE FUNCTIONAL AREA: SDAS Communications				DATE: June 8, 1976		
PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 2.4				APPROVAL:		

TEST NUMBERDESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

2.4-1

Verify communication between the SDAS and S/7 by exercising each of the SDAS commands and replies with and without the introduction of anticipated errors.

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CDPS SOFTWARE VERIFICATION PLAN

DPS ELEMENT:	COMMUNICATION INTERFACE	☒	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☐	USER SUPPORT	☐	ACCEPTANCE	☐
SOFTWARE FUNCTIONAL AREA: Data Store					DATE: June 8, 1976	
PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 2.5					APPROVAL:	

EST NUMBERDESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

2.5-1

The data store routine shall be tested to verify that data is stored onto disk in the proper order, both with and without retransmissions from the SDAS.

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CDPS SOFTWARE VERIFICATION PLAN

CDPS ELEMENT:	COMMUNICATION INTERFACE	☒	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☐	USER SUPPORT	☐	ACCEPTANCE	☐
SOFTWARE FUNCTIONAL AREA: Data Transmission to Host				DATE: June 8, 1976		
PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 2.6				APPROVAL:		

TEST NUMBER

DESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

2.6-1

Data transmission to the Host shall be verified with and without the introduction of transmission errors. S/370 CDPS software shall be used to verify transmission format and accuracy.

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CDP : SOFTWARE VERIFICATION PLAN

CDPS ELEMENT:	COMMUNICATION INTERFACE	☒	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☐	USER SUPPORT	☐	ACCEPTANCE	☐

SOFTWARE FUNCTIONAL AREA: Manual SDAS Control

DATE: June 9, 1976

PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 2.7

APPROVAL:

TEST NUMBER

DESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

2.7-1

The exercise of each of the manual commands in both normal and error conditions during debug of the SDAS engineering model hardware shall be the final test of this program.

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8.3 HOST COMPUTER INPUT PROCESSING QUALIFICATION TESTING

The host computer input processing qualification testing will ensure that the CDPS host computer configuration satisfies all design requirements in the following functional areas:

- (1) S/370-145 to S/7 communication
- (2) Archiving of Raw Data
- (3) Processing of Raw Data
- (4) Computation of Analyst-Requested Variables
- (5) Computation of Performance Evaluation Parameters
- (6) Generation of Data Base Update
- (7) Summary Reports/Error Messages
- (8) Historical Data Archiving

The test to be performed in qualification verification of these capabilities is given in Table 8-2.

CDPS : SOFTWARE VERIFICATION PLAN

CDPS ELEMENT:	COMMUNICATION INTERFACE	☐	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☒	USER SUPPORT	☐	ACCEPTANCE	☐
SOFTWARE FUNCTIONAL AREA: Receive Data from System/7					DATE: June 9, 1976	
PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 3.2					APPROVAL:	

TEST NUMBERDESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

3.2-1

Receipt of data transmitted from the System/7 Communication Interface shall be verified with and without transmission errors and retransmissions. The output data base shall be tested with the file maintenance system.

CDPS SOFTWARE VERIFICATION PLAN

DPS ELEMENT:	COMMUNICATION INTERFACE	☐	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☒	USER SUPPORT	☐	ACCEPTANCE	☐
SOFTWARE FUNCTIONAL AREA: Raw Data Deconvolution					DATE: June 9, 1976	
PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 3.3					APPROVAL:	

TEST NUMBER

DESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

3.3-1	Raw data deconvolution and scan time computation shall be verified with valid input data and with data containing BCH errors in each portion of a record.
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CDPS SOFTWARE VERIFICATION PLAN

CDPS ELEMENT:	COMMUNICATION INTERFACE	☐	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☒	USER SUPPORT	☐	ACCEPTANCE	☐
SOFTWARE FUNCTIONAL AREA: Conversion to Engineering Units					DATE:	
PERFORMANCE SPECIFICATION DOCUMENT REFERENCE:					APPROVAL:	

TEST NUMBERDESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

3.4-1

Verify that scan variables can be extracted and properly converted to engineering units through the use of the supported conversion techniques.

CDPS SOFTWARE VERIFICATION PLAN

S ELEMENT:	COMMUNICATION INTERFACE	☐	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☒	USER SUPPORT	☐	ACCEPTANCE	☐
SOFTWARE FUNCTIONAL AREA: Limit Checking					DATE: June 9, 1976	
PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 3.5					APPROVAL:	

ST NUMBER

DESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

0-1 Variables within limits, out of limits, and changing too rapidly, and stuck shall be tested with and without BCH errors.

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CDPS SOFTWARE VERIFICATION PLAN

CDPS ELEMENT:	COMMUNICATION INTERFACE	☐	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☒	USER SUPPORT	☐	ACCEPTANCE	☐
SOFTWARE FUNCTIONAL AREA: Computed Variables					DATE: June 9, 1976	
PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 3.6					APPROVAL:	

TEST NUMBER

DESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

3.6-1

Computed variables shall be tested with representative algorithms using both valid and invalid input variables.

CDPS SOFTWARE VERIFICATION PLAN

DPS ELEMENT:	COMMUNICATION INTERFACE	☐	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☒	USER SUPPORT	☐	ACCEPTANCE	☐
SOFTWARE FUNCTIONAL AREA: Performance Evaluation Parameters					DATE: June 9, 1976	
PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 3.7					APPROVAL:	

TEST NUMBER

DESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

3.7-1

The computation of performance evaluation parameters shall be tested using both valid and invalid input variables.

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CDPS SOFTWARE VERIFICATION PLAN

CDPS ELEMENT:	COMMUNICATION INTERFACE	☐	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☒	USER SUPPORT	☐	ACCEPTANCE	☐

SOFTWARE FUNCTIONAL AREA: Data Base Input

DATE: June 9, 1976

PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 3.8

APPROVAL:

TEST NUMBER

DESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

8-1

The merge of the latest detail data with earlier detail data shall be verified. The hourly and daily summary data shall be computed using both normal and abnormal (missing) detail data.

CDPS SOFTWARE VERIFICATION PLAN

CDPS ELEMENT:	COMMUNICATION INTERFACE	☐	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☒	USER SUPPORT	☐	ACCEPTANCE	☐

SOFTWARE FUNCTIONAL AREA:	History/Archive Tapes	DATE:	June 9, 1976
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PERFORMANCE SPECIFICATION DOCUMENT REFERENCE:	3.9	APPROVAL:	
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TEST NUMBER

DESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

3.9-1

The creation of the history and archive tapes shall be verified with at least 30 days data from at least 2 sites.

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CDPS : SOFTWARE VERIFICATION PLAN

CDPS ELEMENT:	COMMUNICATION INTERFACE	☐	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☒	USER SUPPORT	☐	ACCEPTANCE	☐
SOFTWARE FUNCTIONAL AREA: Summary Reports					DATE: June 9, 1976	
PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 3.10					APPROVAL:	

TEST NUMBER

DESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

3.10-1

All reports shall be verified for readability and accuracy.
Error messages shall be verified as erroneous data is introduced in other CDPS Input Processing Verification tests.

8.4 FILE MAINTENANCE QUALIFICATION TESTING

The CDPS file maintenance capabilities utilize an existing data base management system which has been proven on other activities. For this reason, qualification testing will consist of a functional test under maximum input conditions to ensure that the capability satisfies the design requirements. Test plans for qualification testing of the file maintenance capability are shown in Table 8-3.

Functional capabilities to be tested are:

- (1) Automatic Update of Data Base
- (2) Manual Input to the Data Base
- (3) Data Base Maintenance, Access, and Update
- (4) Data Base Security

CDPS SOFTWARE VERIFICATION PLAN

CDPS ELEMENT:	COMMUNICATION INTERFACE	☐	FILE MAINTENANCE	☒	QUALIFICATION	☒
	INPUT PROCESSING	☒	USER SUPPORT	☐	ACCEPTANCE	☐

SOFTWARE FUNCTIONAL AREA:	Input Processing/File Maintenance Interface	DATE:	June 7, 1976
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PERFORMANCE SPECIFICATION DOCUMENT REFERENCE:	4.2	APPROVAL:
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TEST NUMBER

DESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

4.2-1

Input processing shall process test data for 2 sites.
File maintenance shall use the processed data to update the data base.

CDPS SOFTWARE VERIFICATION PLAN

CDPS ELEMENT:	COMMUNICATION INTERFACE	☐	FILE MAINTENANCE	☒	QUALIFICATION	☒
	INPUT PROCESSING	☐	USER SUPPORT	☐	ACCEPTANCE	☐
SOFTWARE FUNCTIONAL AREA: File Maintenance Terminal Security					DATE: June 7, 1976	
PERFORMANCE SPECIFICATION DOCUMENT REFERENCE: 4.5					APPROVAL:	

TEST NUMBER

DESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

4.5-1

Read only and read/write access shall be tested for proper authorization

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8.5 USER SUPPORT QUALIFICATION VERIFICATION

The user support qualification verification will ensure that the CDPS satisfies the requirements associated with support of data base users. These verification tests will address the following areas:

- (1) Information Retrieval for Report Generation
- (2) Plot Capability
- (3) Daily, Monthly, Annual Reports
- (4) Magnetic Tape Generation
- (5) Terminal/Batch Capabilities

Test plans for each of the above functional areas are shown in Table 8-4.

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CDPS SOFTWARE VERIFICATION PLAN

CDPS ELEMENT:	COMMUNICATION INTERFACE	☐	FILE MAINTENANCE	☐	QUALIFICATION	☒
	INPUT PROCESSING	☐	USER SUPPORT	☒	ACCEPTANCE	☐
SOFTWARE FUNCTIONAL AREA: User Support					DATE: June 7, 1976	
PERFORMANCE SPECIFICATION DOCUMENT REFERENCE:					APPROVAL:	

TEST NUMBER

DESCRIPTION (INPUT/OUTPUT/TECHNIQUE)

2-1

Varied representative queries shall be made of the data base in both batch and terminal modes.

3-1

Representative quantities in the detail and summary data base shall be plotted and verified.

4-1

All scheduled reports shall be generated and clarity and accuracy verified.

5-1

Magnetic tapes shall be created with the information and format necessary to feed into the MSFC data base.

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8.6 OVERALL CDPS QUALIFICATION VERIFICATION TESTING

Upon completion of qualification verification of each of the CDPS elements, overall end-to-end tests will be performed on the system. The test configuration will be as discussed in Section 5 of this report, and the SDAS input will be simulated to provide reference input data. These data will provide the following capabilities:

- (1) Nominal (No Error) Conditions
- (2) Off-Nominal (Error) Conditions
- (3) Variable Formats (14, 30, 46.)

Through use of these reference data, system tests can be performed which will provide the basis for entering acceptance testing.

9.0 ACCEPTANCE VERIFICATION PLAN

Upon completion of qualification verification, the CDPS will enter the acceptance verification phase. This phase will exercise the CDPS in a normal operational environment and will provide the capability for testing of operational procedures. The testing configuration will be as shown in Section 5 of this plan, and test data will consist of nominal reference data. Successful completion of acceptance verification will provide an operational CDPS.

The prototype SDAS will be called via IBM tie-lines and data collected by the communication interface configuration. This data will, in turn, be transmitted to the host computer, processed, stored in the data base, and user support functions performed. Output will be provided to analysts to ensure proper content and format.

9.1 ACCEPTANCE VERIFICATION PROCEDURES

CDPS Acceptance Test Procedures shall be developed and used and will provide the test/analysis environment for demonstrating the overall capability of the CDPS in an operational environment. These procedures will be developed based on results of qualification verification and on system performance specifications. Final approval of the procedures will be the result of IBM/MSFC reviews.

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10.0 CDPS MAINTENANCE VERIFICATION APPROACH

After the CDPS has been declared operational, each requirement change which results in modification to the system will be evaluated for reverification purposes. Those changes which do not impact CDPS inter-element interfaces will undergo development and qualification verification; whereas, those resulting in interface modifications will undergo all verification phases to ensure overall system continuity. Test procedures and test results will be retained for all maintenance verification activities.