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AIRCRAFT INTERROGATION AND DISPLAY SYSTEM:
A GROUND SUPPORT EQUIPMENT FOR DIGITAL FLIGHT SYSTEMS

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INTRODUCTION

The National Aeronautics and Space Administration (NASA) is conducting research in many areas involving advanced digital systems for both manned and unmanned aircraft, and in ground-based simulators. As these various types of digital flight systems have become more complex, the need has arisen for more sophisticated ground support equipment (GSE) for systems integration, software verification and validation, pre- and postflight testing, and system maintenance. Until recently, the approach taken was for each project to procure special purpose GSE, resulting in a multiplicity of different types of equipment of varying capability. These types of GSE generally were single purpose and were surplussed at the termination of the project. Usually, none of the GSE development investment could be recouped for the next project.

As an approach to a resolution of this problem, the NASA Dryden Flight Research Facility undertook the development of a microprocessor-based user-programmable general purpose GSE, termed aircraft interrogation and display system (AIDS). A prototype was constructed, interfaced with the F-8 digital fly-by-wire (F-8 DFBW) iron bird simulator, and used successfully to support F-8 flight software verification and validation. The general purpose utility of the AIDS was confirmed when applied to the highly maneuverable aircraft technology (HiMAT) project. Using new software, the prototype was easily interfaced with the HiMAT aircraft, and it quickly demonstrated its capability by providing a fortyfold increase in random access memory (RAM) data display bandwidth.

The utility of the AIDS during HiMAT flight control computer testing and systems integration validated the flexibility of the system and led to plans to apply it to other projects. Two AIDS systems are in service, and a third is under construction. The total number of present and planned users is five. This paper describes the AIDS design and mechanization, summarizes operational experience to date, and discusses plans for the future.

SYMBOLS AND ABBREVIATIONS

A/D	analog-to-digital converter
AFTI	advanced fighter technology integration
AIDS	aircraft interrogation and display system
ARW	advanced research wing
ASCII	American standard code for information interchange
ASEG	absolute segment
C&D	controls and displays
CPU	central processing unit

CRT	cathode ray tube (display)
CSEG	control segment
DAC	digital-to-analog converter
DAST	drones for aerodynamic and structural test
DFBW	digital fly-by-wire
DSEG	data segment
DSPM	dispersed sensor processing mesh
GSE	ground support equipment
HiMAT	highly maneuverable aircraft technology
HSMU	high speed math unit
I/F	interface
I/O	input/output
KB	keyboard
LED	light-emitting diode
MDS	microprocessor development system
PROM	programmable read-only memory
RAM	random access memory
RTMTX	real-time multitasking executive
STC	system test console
TTL	transistor-transistor logic
USART	universal synchronous/asynchronous receiver-transmitter

EXPERIENCE WITH SPECIAL PURPOSE GSE

A significant amount of experience was gained during the F-8 DFBW program in the formulation and use of display and driver GSE devices for flight control design, development, verification and validation, troubleshooting, maintenance, preflight testing, and research experimentation (ref. 1). The ground display software was implemented in the F-8 DFBW flight computer itself and consisted of several dedicated and special purpose displays, including system redundancy management status, dynamic sensor data, aircraft system status, failure status, and preflight test and maintenance results.

Although the display system was highly refined and was a key element in the successful development of the fly-by-wire system, it had several drawbacks. First, the display system was designed to operate integrally with the triple-redundant digital fly-by-wire control system, and as such it had to be nonintrusive; that is, the display functions could not alter flight control system operation. This complicated the display system software. Second, the display system required a modest but not negligible share of the flight computer cycle time and memory resources. Third, the display software required a relatively high level of verification because it resided in the flight computer, even though it was never executed in flight. Finally, the system was not portable, and it could not be used on other aircraft programs.

The driver software used for verification and validation tests, such as triplex sensor fault detection, isolation, and recovery, was implemented in the mainframe computer used for aerodynamic simulation. Special purpose pulses, waveforms, and noise signature signals were generated by the driver software and interfaced to the flight computer sensor input processor. Although highly successful, this approach required substantial amounts of simulation computer time for relatively simple computational tasks at a time when the simulation computer served multiple users.

The experience, advantages, and disadvantages of the various approaches used on the F-8 DFBW program, as well as other flight system research projects, laid the foundation for the AIDS design.

DESIGN OBJECTIVES

The AIDS was originally conceived as a stand-alone general purpose ground support equipment device for aircraft digital flight control systems that had the display and driver capabilities of the GSE used for the F-8 DFBW. Early in the conceptual design it was determined that many other applications would be possible for this device. For that reason, design objectives were established that would guarantee the system's generality and flexibility. These design objectives included:

Mobility. The system should be capable of being moved between laboratories, iron bird, and aircraft.

Flexible input/output. The system should be easy to interface with digital and analog systems, be independent of the system-under-test architecture, and minimize that system's servicing burden.

Common core software support package. The system should provide a large share of commonly used display and driver functions for digital flight systems, including (a) number conversion to any desired format and engineering units calibration, (b) bit unpacking and display as event, (c) snapshot block data, (d) parameter trace, (e) data recording or plotting as stripchart or X-Y parameters, and (f) waveform drivers for redundant flight control sensors.

User-oriented displays. The displays should have dynamically refreshed display and provide for user formatting and labeling. Free-form display formats should be available that can be easily constructed in real time (during a test procedure) as new requirements develop. The operator should have the ability to interrupt a display at any time, make modifications to the format, and resume the display within a few seconds. In addition, the operator should have the ability to make display hard copies at any time. Such hard copies should be labeled with date, time, test title, and any other user-determined information.

Utilization of commercial components. Where possible, the system should use commercially available card-level microcomputer hardware and commercial software. This enhances long-term maintenance and minimizes development costs.

Speed. The system should be able to service flight control systems with cycle rates on the order of 50 to 100 samples per second.

Synchronization. The system should acquire and display snapshots of several data words occurring within one computer cycle frame (10 to 20 milliseconds).

Maintenance. The system should contain an integral diagnostic and maintenance support capability.

Operational modes. The system should be easily and quickly convertible between the operating modes shown in figure 1, including real-time data display, open-loop function generator, redundant sensor simulator, and simple closed-loop simulation (a simulation at a single flight condition with linear equations of motion).

FUNCTIONAL DESCRIPTION

The first AIDS device that was developed generally met the design objectives. The AIDS was designed around an 8085A microprocessor system. A diskette subsystem was incorporated which was fully compatible with the off-line support software used to create the AIDS software load modules. A commercially available real-time multitasking executive (RTMTX) was also incorporated, mainly for the management of the diskette drives and diskette directory services.

Figure 2 illustrates the functional arrangement of the AIDS. The particular operating mode is defined by the software modules contained on the system diskette. Any user displays that were previously created are stored on the scratch diskette. These two diskettes are accessed via the real-time multitasking executive software that is permanently recorded on programmable read-only memory (PROM) integrated circuits. The remaining system software is loaded from the system diskette by the RTMTX, and the display formats are loaded from the scratch diskette by the RTMTX as needed. The RTMTX then transfers control of the system to the software loaded, but remains available for subsequent diskette operations and other multitasking as required.

The AIDS supervisor module and companion operator input/output (I/O) modules are software that is common to all users. The supervisor provides command interpreting, software linking, a date register, an updated time-of-day register, and various system control functions. The I/O package provides the main operator interfaces to the control keyboard, the cathode ray tube (CRT) data display, and the hard copy peripherals. The operator enters system commands and display setup instructions via the control keyboard (KB). All displays are presented on the CRT display, which is refreshed at high speed on those areas of the screen which contain active (nonstatic) fields. Hard copies of any display may be made either by operator command or under supervisor control as desired.

User-unique software includes the user application supervisor, user timing control, and one or more user I/O modules. The user application supervisor provides servicing for user interrupts and interfaces with the RTMTX as required. The user timing control module provides basic timing for all user I/O and supporting computation. The user I/O servicing module services the data path to and from the system under test and provides for auxiliary analog outputs to nonAIDS peripheral devices as required.

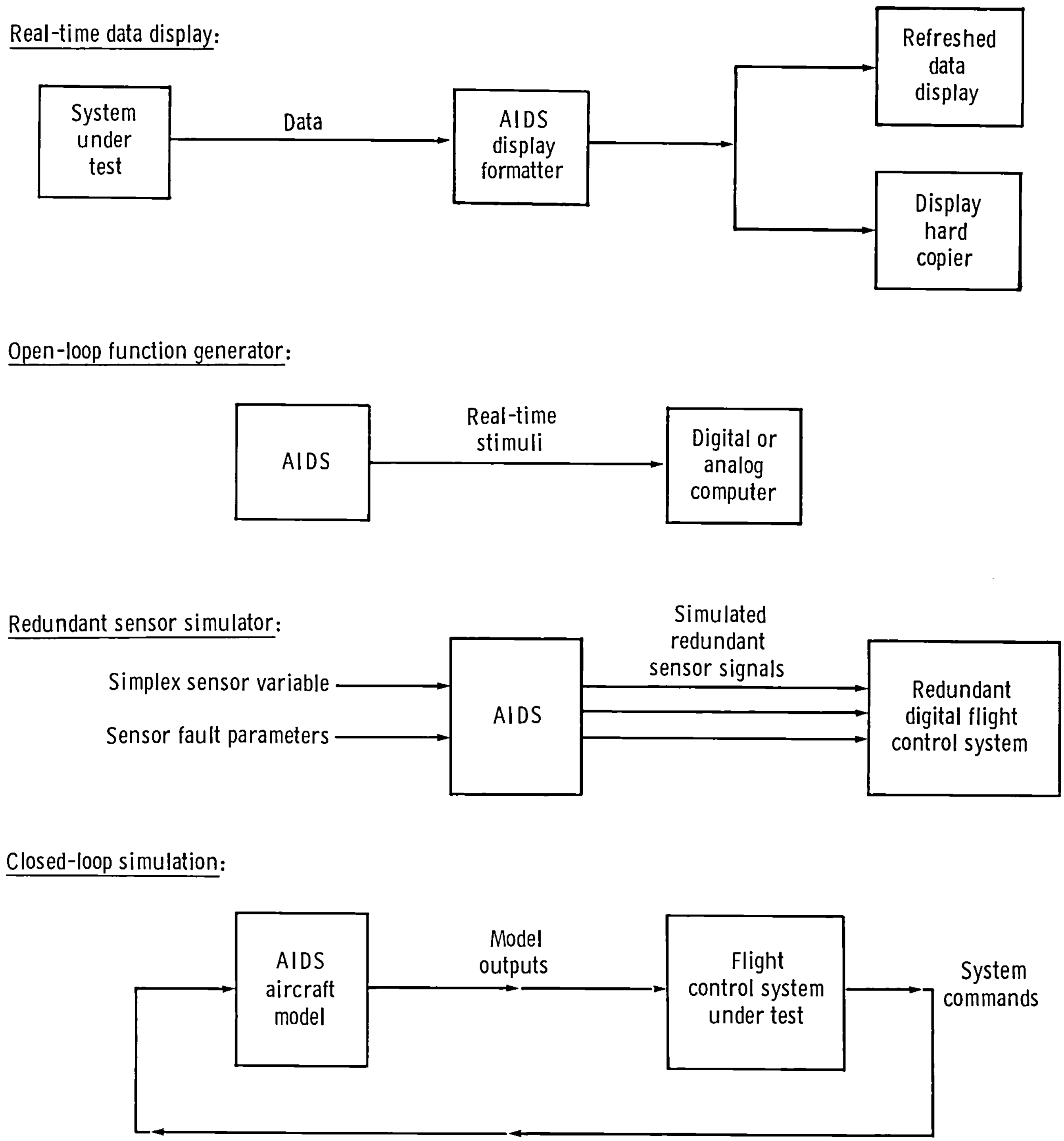

Figure 1. Examples of conceptual AIDS applications.

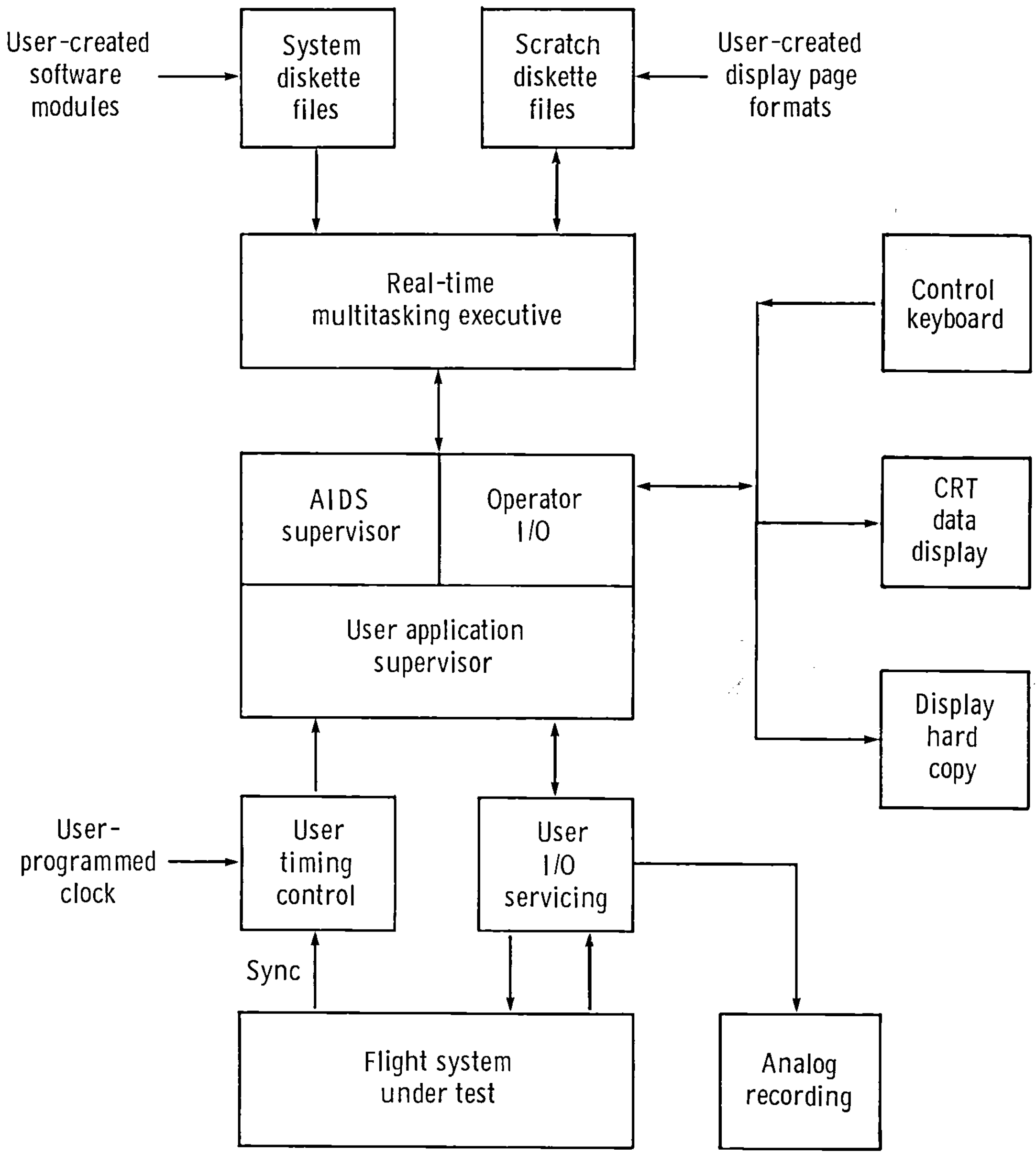

Figure 2. AIDS functional overview.

HARDWARE DESCRIPTION

Figure 3 shows the mechanization of the current AIDS design. The entire system is mounted in a two-bay console that is mounted on wheels for mobility. The five major components are the computing subsystem, the I/O panel, the diskette drive subsystem, the operator terminal, and the line printer. The user must supply the appropriate cable(s) to mate the system under test to the I/O panel.

Appendix A contains a bill of materials for the major components of the present AIDS mechanization. The fabrication of the computing subsystem was quickly achieved using an industrial chassis incorporating a 12-slot card cage and integral power supply. Minor modifications to the chassis control panel were required to provide for a PROM set select switch, a bus timeout monitor indicator, and several test points. These additions are interfaced to the computing subsystem via circuitry on the universal prototype board.

The various computing subsystem boards listed in appendix A are I/O mapped as shown in figure 4 and memory mapped as shown in figure 5. The central processor unit (CPU) board contains an 8085A microprocessor, which provides adequate computational capability for currently planned operating modes. Table 1 shows the assignment of system interrupts.

The floppy diskette drive unit is a dual-drive single density standard sized diskette system. It interfaces directly to the floppy diskette controller board in the computing subsystem. The single density format provides more than ample storage capability. One drive is used for system program modules, and the other is used for scratch file storage.

The operator terminal is a single unit with a full sized black and white CRT screen and full keyboard. The CRT and keyboard are interfaced to the computing subsystem via a full duplex serial port on system expansion board A. High speed refresh of the CRT display is performed in vectored cursor mode at 1920 characters per second. A minor terminal modification was necessary to provide software control over the cursor marker on the screen. This was achieved by rewiring the keyboard enable/disable flip-flop, which is under software control, to the cursor blanking circuit. This allows the cursor to be blanked during screen refresh operations, resulting in a flicker-free display. The keyboard has been wired permanently enabled.

The line printer is a 5 by 7 dot matrix printer with a dual channel vertical forms unit that allows the proper pagination of all system printouts. The interface to the computing subsystem is via a parallel discretes port on the central processor board.

The I/O panel is a NASA-designed and -constructed unit which provides the user an interface with the computing subsystem for analog and discrete signals. Figure 6 shows the signal paths within the I/O panel. The connectors for the user interface cable(s) are located on the rear of the AIDS cabinet. For each discrete, monitoring jacks and light-emitting diode (LED) indicator lamps are provided on the front of the I/O panel. Internal to the I/O panel are line drivers and receivers for the discretes, which provide the user with a balanced differential double-rail interface. The receivers interface to the computing subsystem via system expansion board A, and the drivers interface via system expansion board B. With regard to analog trunks, the I/O panel is passive and provides only breakout jacks on the front panel. The analog inputs interface with the computing subsystem via the analog input board, which scans the inputs using a ±10 volt balanced multiplexer. The ±10 volt unbalanced analog outputs from the computing subsystem are fed from the four analog output boards.

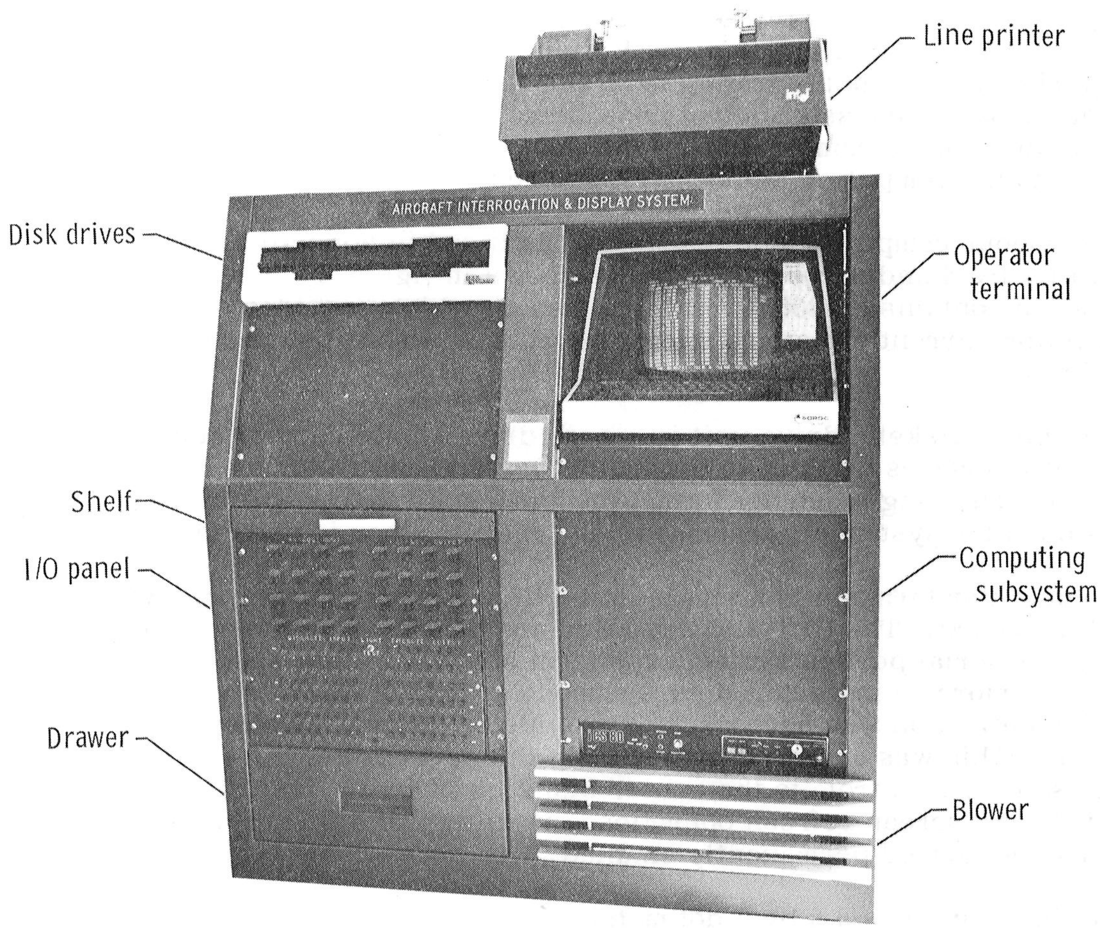

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Figure 3. Aircraft interrogation and display system.

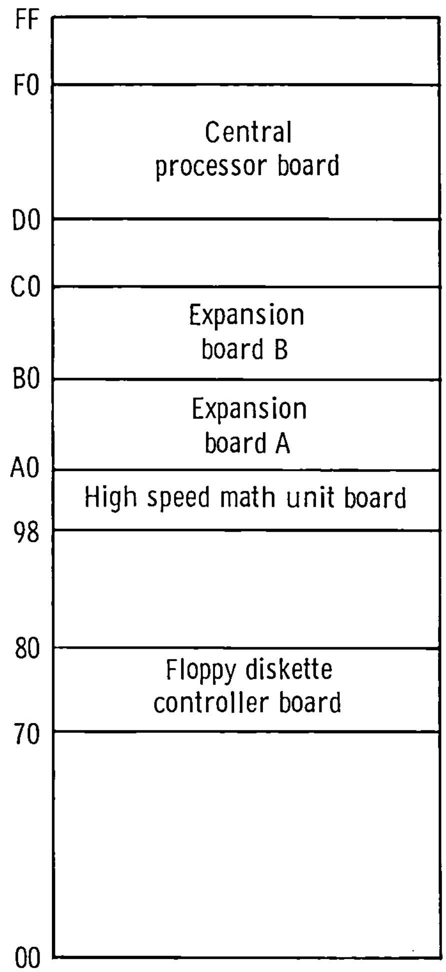

Figure 4. AIDS I/O address map.

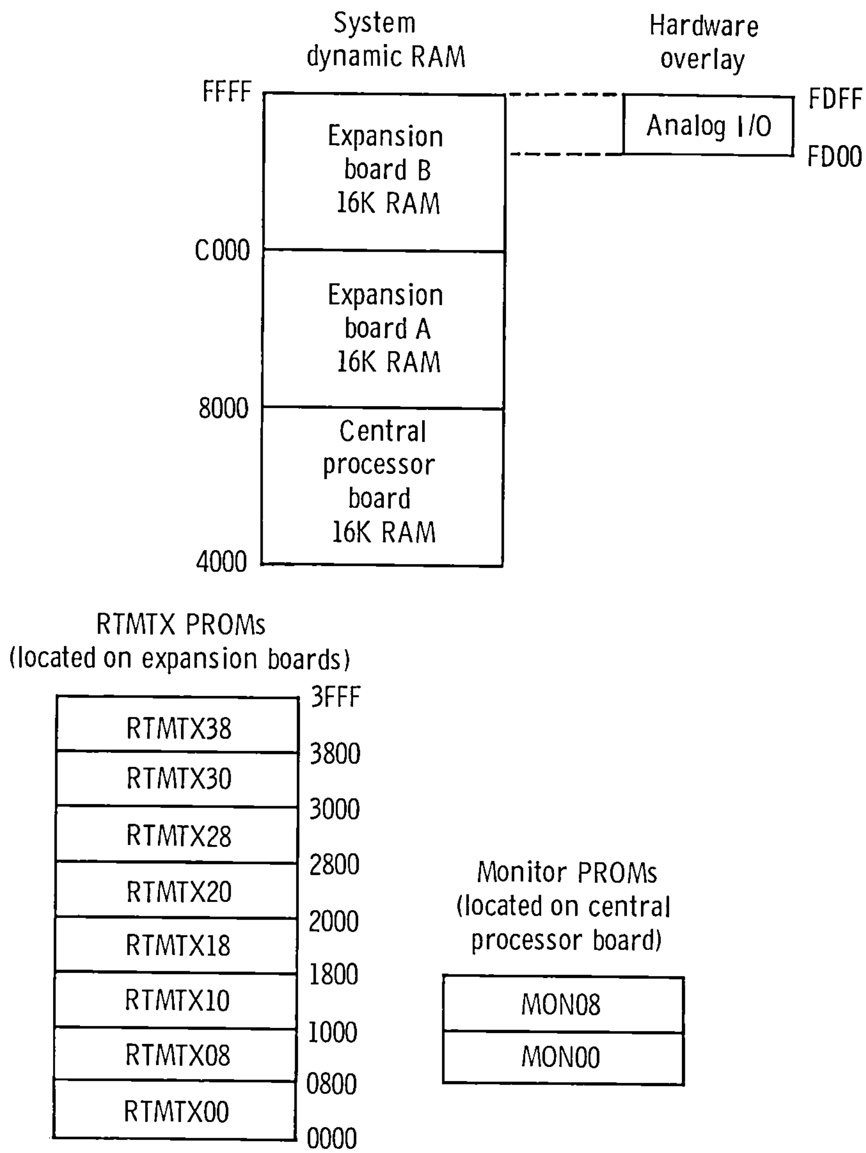

Figure 5. AIDS memory map.

TABLE 1.—AIDS INTERRUPT ALLOCATION

Level	Assignment	Application
Trap	Not used	-----
A	Bus timeout	AIDS tally only
B	Not used	-----
C	Not used	-----
0	INTR pushbutton	User manual interrupt
1	Timer no. 0	RTMTX task wait timer
2	Disk controller	RTMTX diskette I/O
3	Timer no. 1	User clock
4	External interrupt	User sync
5	1 Hz interrupt	AIDS time of day clock
6	USART C receiver	RTMTX terminal handler
7	USART C transmitter	RTMTX terminal handler

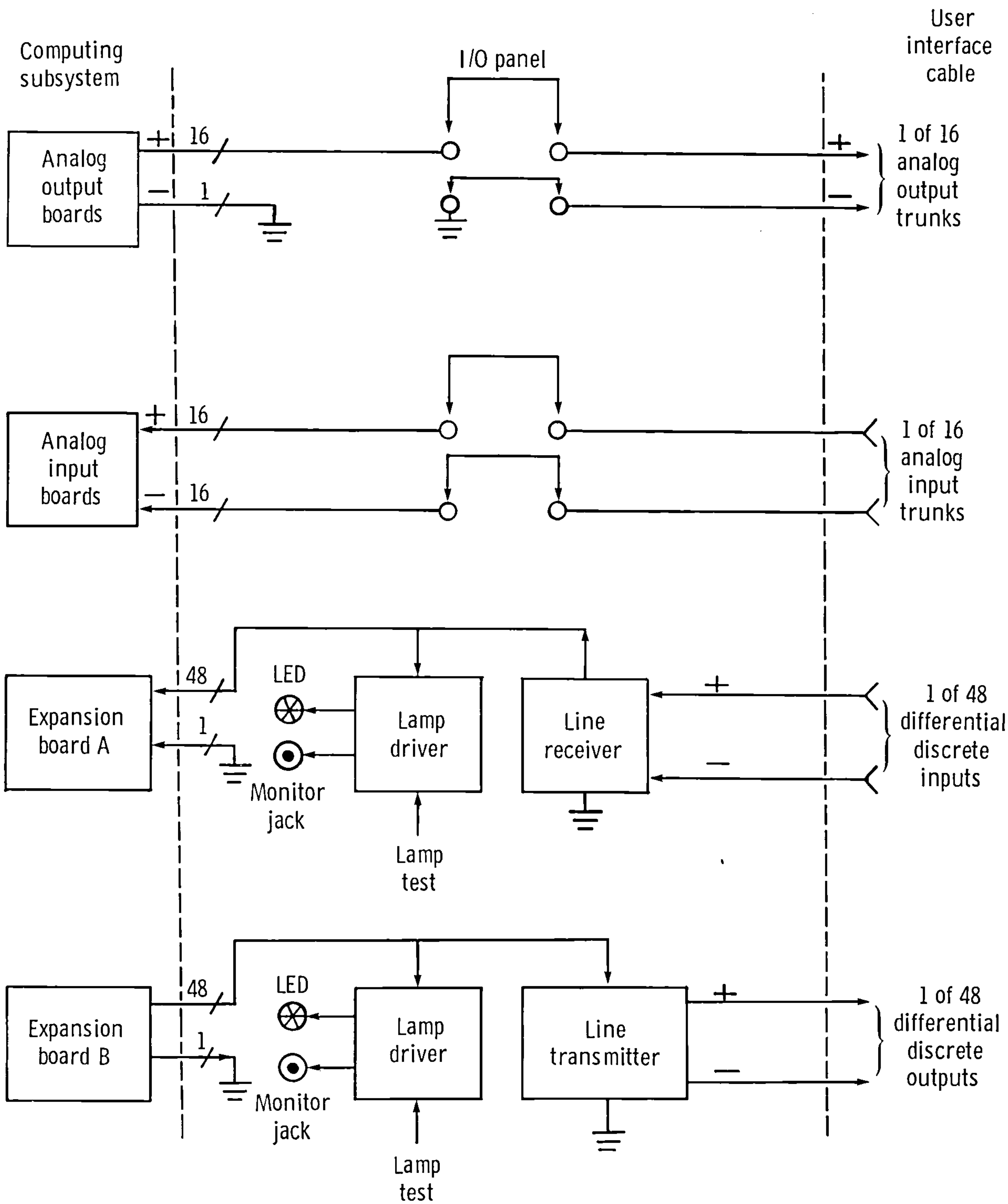

Figure 6. AIDS I/O paths.

SOFTWARE DESIGN

Two separate software systems are resident within the AIDS. They are alternately accessible to the operator via a PROM select switch on the front of the computing subsystem chassis. One system is the maintenance and diagnostic software system, which consists of a commercial monitor package designed for the central processor board plus a NASA-designed set of extension routines. This package, which is stored as firmware on two PROMs that are installed on the central processor board, is executed when the PROM select switch is in the "monitor" position. This software provides basic AIDS troubleshooting services and diskette subsystem test routines.

The second software system is the main AIDS hierarchy, which consists of the components shown in figure 7. This software structure is shown from bottom to top in the order the four components become active in the system. The first component to execute is the RTMTX, which is a commercial package designed to be used with the central processor board and provides diskette subsystem services. This package is stored as firmware on eight PROMs installed on the system expansion boards and is executed when the PROM select switch is in the "disk" position. The remaining three software components are loaded into the AIDS memory from the system diskette in drive 0, and are mapped as shown in figure 8.

Embedded in the RTMTX firmware is a configuration module that defines the characteristics and mapping of the diskette subsystem hardware. It also specifies the tasks to be created when the system is initialized. The task list includes the diskette drive controller board handler, the diskette I/O handler, several diskette directory servicing routines, the full terminal handler, and the bootstrap loader. These routines and associated variables are accessible via PUBLIC labels, which can be linked to user code. Since the RTMTX code requires no maintenance, the PROM set never requires reprogramming and the integrity of the hardware is enhanced. Appendix B contains a listing of the configuration module and the SUBMIT file used to create the RTMTX firmware.

When the AIDS is powered up (or reset) with the PROM select switch in the "disk" position, the RTMTX begins executing and sets up the tasks specified by the configuration module. When the bootstrap loader becomes the active task, it seeks a file called RMXSYS on the system diskette, loads it into random access memory, and starts executing it. The file :F0:RMXSYS always contains the AIDS supervisor task module component of the AIDS software hierarchy. Once loaded, this module assumes central control of the system and is the point to which all other components return when execution is completed.

The AIDS supervisor contains an initialization routine followed by a looping command interpreter routine. It also contains many routines which are commonly needed by the different AIDS users. These include the CRT/KB handler, printer handler, analog I/O drivers, scratch diskette librarian, time-of-day clock, display data formatters, and utility routines. These can be accessed by a user via hard-mapped linkages in the common data area.

One of the functions performed by the AIDS supervisor during the initialization procedure is to request the RTMTX to load a module called USER from the system diskette. The file :F0:USER always contains the user main module component of the software hierarchy. Within it are contained the user interrupt servicing routines, user I/O packages, and an initialization subroutine. It also contains tables defining the syntax for user commands and user scratch file load control.

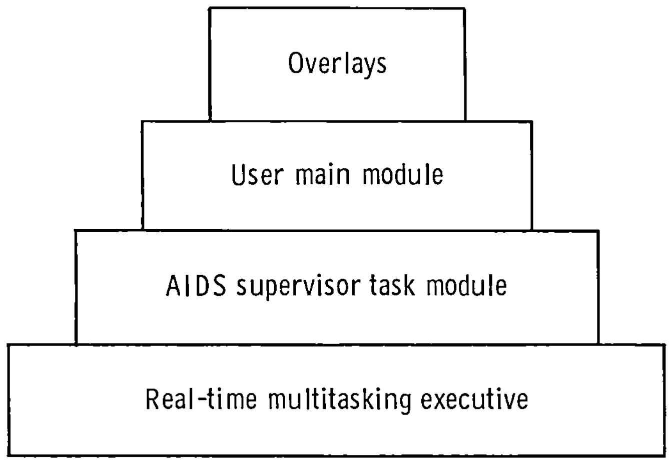

Figure 7. AIDS software hierarchy.

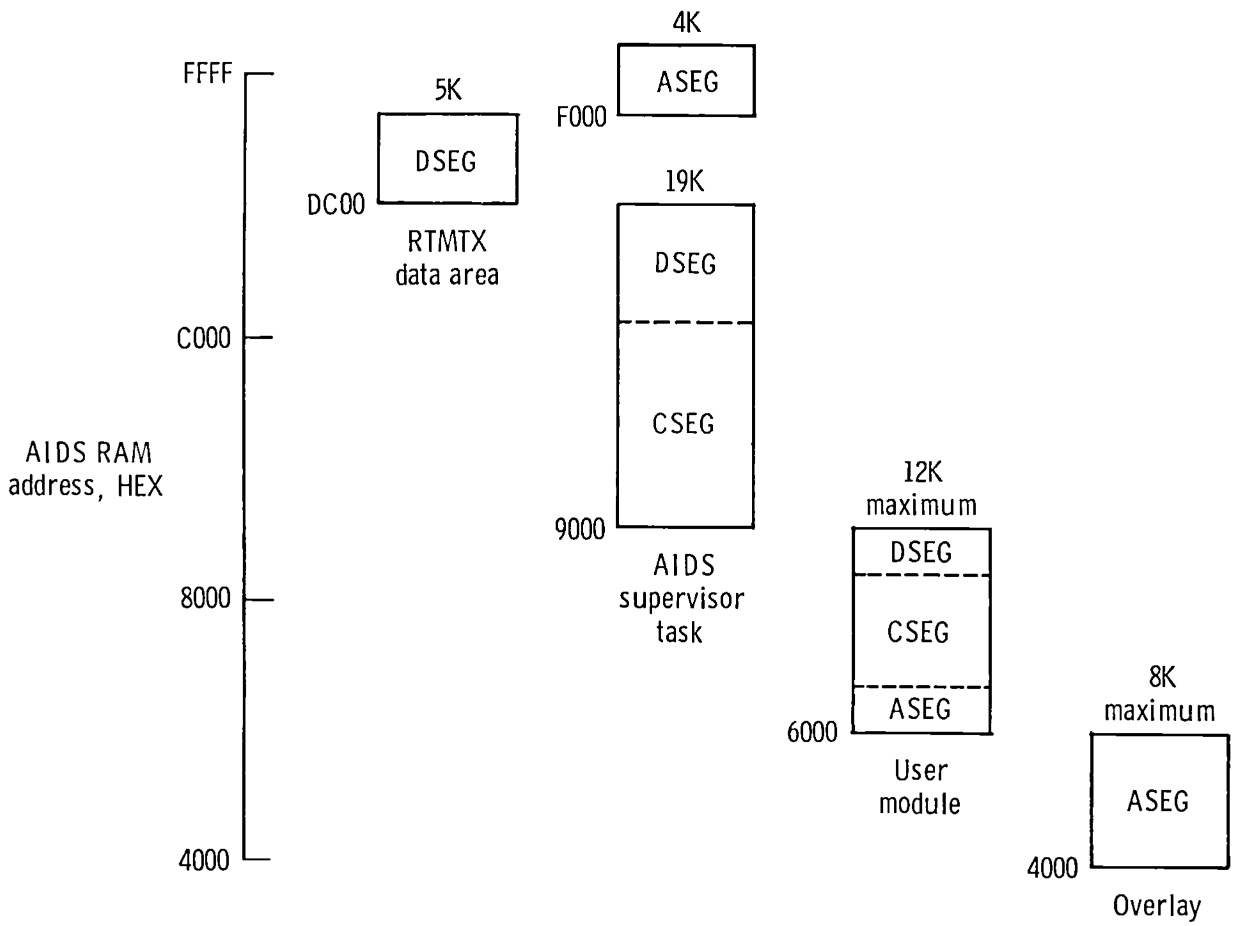

Figure 8. AIDS RAM allocation.

The fourth component of the AIDS software hierarchy are overlays. Overlay modules are generally loaded and executed in response to a keyboard command, and they always provide a specific function. They are linked to the remaining software via absolute entry addresses within the overlay area and, like the USER main module, have access to AIDS supervisor subroutines and variables via the common area. In general, each overlay has associated with it a unique display which is presented on the CRT. Overlays may be either system or user related. Most are operator interactive, and all must exit back to the AIDS supervisor when the KB escape key is pressed. System overlays provide functions such as interrupt control, printer moding, clock management, and I/O panel monitoring. User overlays are not restricted as to function but must conform to the mapping, linkage, and escape conventions required of all AIDS overlays.

Taken as a whole, the design of the AIDS software is intended to provide a multitasking environment within which the various system and user tasks can share a single CPU. The lowest priority task is always the servicing of the operator interface, which includes the CRT, KB, and printer. All higher priority tasks are invoked by interrupts, which require temporarily halting the operator I/O. A typical user application might involve responding to a sync interrupt from the system under test, inputting data, performing computations, outputting data, and setting up a data buffer for the current operator display. As the amount of time required to service such an interrupt increases, the most noticeable effect is the slowing of CRT screen refresh. Another variable that affects screen refresh is the amount of data being displayed, since there is computational overhead associated with formatting as well as screen write operations. The performance of the AIDS in various applications will be later quantified as a duty cycle or percentage of time which is devoted to interrupt-driven code execution as opposed to operator I/O.

USER EXPERIENCE

Since 1978, the AIDS has been employed in support of three research projects and is planned for use in at least two others. Two AIDS units are in active use, and a third unit is soon to enter service. The F-8 DFBW iron bird application (ref. 1) allows closed-loop aerodynamic simulation and redundant sensor fault emulation, providing valuable support in software verification and validation. The HiMAT remotely piloted research vehicle application (ref. 2) provides open-loop display of onboard computer memory data. It is used extensively in support of simulation, preflight testing, and system troubleshooting. Another user project is an experimental nodal network data bus breadboard (ref. 3). For this project the AIDS provides test set capability for the I/O processor in each node and monitors bus message traffic. A planned future application is support for the AFTI/F-111 project (ref. 4) where the AIDS will monitor the interchannel message traffic within the redundant flight system. Another future application is support for the DAST ARW-II project (ref. 5), where the AIDS will provide test set capability for a multiprocessor flight computer as well as provide the usual data display functions.

One measure of the performance of the AIDS is the loading or level of saturation of its central processor for each application. Loading may be defined as the duty cycle or percentage of time required to perform time-critical (interrupt-linked) computational tasks as opposed to operator I/O functions. The duty cycle ranges from 90 percent for the F-8 DFBW simulation to 10 percent for the HiMAT data display function. Screen refresh rates for the F-8 DFBW are very low (typically 0.5 per second). For a typical HiMAT display, however, the refresh rate is comfortably high (4 per second). The time required to perform a line printer hard copy of a display snapshot is roughly proportional to the refresh rate of the display and varies from 20 seconds to 5 seconds.

The HiMAT application best demonstrates the capabilities of the AIDS, and it has accumulated the most AIDS operating time, with over 2000 hours in a 3 year period. This application grew out of the need to augment the data display capability of the manufacturer-supplied GSE, called the system test console (STC). The STC mates with the HiMAT aircraft umbilical connector, and one of its functions is to allow the contents of the onboard computer memory to be examined. However, the STC can only display a single byte as a bit pattern expressed in octal digits, severely limiting the visibility of the functioning of the onboard computer.

To provide the needed additional display capability, the AIDS was connected to the STC as shown in figure 9. The 16 address lines are tied in common to the STC thumbwheels used for manual RAM address selection. The 8 data lines are tied to the output from the onboard computer, which feeds the decoders driving the STC octal display. The AIDS sequentially outputs an address, waits for a sync pulse from the onboard computer, and then reads the RAM data byte output by the computer. This sequence is repeated every 20 milliseconds, which is the rate at which the onboard program services the test console interface.

The AIDS operator controls which addresses are to be read by creating with KB inputs a formatted CRT display (called a page) that specifies by data type and RAM memory location, which items are desired. Table 2 shows the different data display formats available to the operator. Of these, only codes VG and DG (specially scaled fixed-point formats for the vertical gyro and directional gyro, respectively) are unique to HiMAT. Note that a single data item causes from 1 to 15 successive RAM addresses to be read. The AIDS software builds an address table based on the display requirements and scans this table repetitively. As the data is returned, it is buffered, formatted for display, and presented on the CRT in a continuously refreshed mode.

Appendix C contains hard copies of representative HiMAT displays. Also shown is a typical scratch diskette directory page and a hard copy of the command interpreter display, which lists the system and user commands available. The HiMAT project uses these display pages and others to support software verification and validation, system maintenance, preflight and postflight tests, and closed-loop simulations. Over 100 display page formats of various types have been created and placed on scratch diskette. The AIDS has become an integral part of such critical testing as the preflight test, where AIDS data dumps are written into several procedure sequences. The ability to select a scratch diskette and quickly (in 1 to 3 seconds) load any of up to 45 display page files has been of great benefit to the HiMAT project. In addition, the inherent flexibility of the software system has been demonstrated repeatedly by the changes that have easily been implemented in response to project engineering request.

CONCLUDING REMARKS

General purpose user-programmable ground support equipment has been developed and placed in service in support of both aircraft and simulation facilities. Three years' experience involving several users has demonstrated the utitlity of the system concept and created a demand for additional systems to support future users. The flexibility of the concept has been demonstrated in a wide range of applications, including real-time data acquisition, software verification and validation, system integration testing, and real-time closed-loop simulation.

The major contribution of the system, known as the aircraft interrogation and display system (AIDS), has been its ability to make visible the functioning of a digital flight

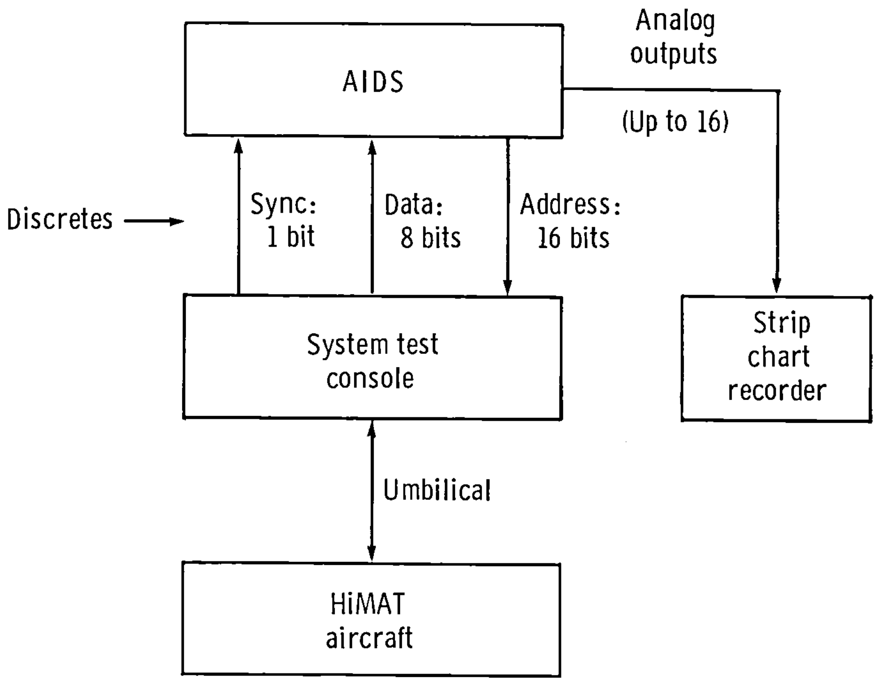

Figure 9. AIDS to HiMAT interface.

TABLE 2.—AIDS DATA DISPLAY FORMATS

Number	Code	Number of bytes	Number of bits	Data type	Sign?	Number of columns	Display format
1	H1	1	8	Any	---	2	HH
2	H2	2	16	Any	---	4	HHHH
3	H3	3	24	Any	---	6	HHHHHH
4	H4	4	32	Any	---	8	HHHHHHHH
5	B1	1	8	Any	---	8	BBBBBBBB
6	B2	2	16	Any	---	16	BBBBBBBBBBBBBBBB
7	F4	4	32	Floating point	Y	10	[-]DDDDD.DDD
8	I1	1	8	Integer	N	4	_DDD
9	I2	2	16	Integer	N	6	¯DDDDD
10	D1	1	8	Integer	Y	4	[-]DDD
11	D2	2	16	Integer	Y	6	[-]DDDDD
12	DD	2	12	DAC value	Y	6	[-]DDDDD
13	DH	2	12	DAC value	---	3	HHH
14	DV	2	12	DAC value	Y	7	[-]DD.DDD
15	O1	1	8	Any	---	3	OOO
16	O2	2	16	Any	---	6	OOOOOO
17	A1	1	---	ASCII string	---	1	A
18	A2	2	---	ASCII string	---	2	AA
19	A3	3	---	ASCII string	---	3	AAA
20	A4	4	---	ASCII string	---	4	AAAA
21	A5	5	---	ASCII string	---	5	AAAAA
22	A6	6	---	ASCII string	---	6	AAAAAA
23	A7	7	---	ASCII string	---	7	AAAAAAA
24	A8	8	---	ASCII string	---	8	AAAAAAAA
25	A9	9	---	ASCII string	---	9	AAAAAAAAA
26	AA	10	---	ASCII string	---	10	AAAAAAAAAA
27	AB	11	---	ASCII string	---	11	AAAAAAAAAAA
28	AC	12	---	ASCII string	---	12	AAAAAAAAAAAA
29	AD	13	---	ASCII string	---	13	AAAAAAAAAAAAA
30	AE	14	---	ASCII string	---	14	AAAAAAAAAAAAAA
31	AF	15	---	ASCII string	---	15	AAAAAAAAAAAAAAA
32	E0	1	1	Event bit 0	---	4	" ONE" or "ZERO"
33	E1	1	1	Event bit 1	---	4	" ONE" or "ZERO"
34	E2	1	1	Event bit 2	---	4	" ONE" or "ZERO"
35	E3	1	1	Event bit 3	---	4	" ONE" or "ZERO"
36	E4	1	1	Event bit 4	---	4	" ONE" or "ZERO"
37	E5	1	1	Event bit 5	---	4	" ONE" or "ZERO"
38	E6	1	1	Event bit 6	---	4	" ONE" or "ZERO"
39	E7	1	1	Event bit 7	---	4	" ONE" or "ZERO"
40	F1	1	8	Fixed point	Y	10	[-]DDDDD.DDD
41	F2	2	16	Fixed point	Y	10	[-]DDDDD.DDD
42	DG	2	16	Directional gyro	Y	10	_ _[-]DDD.DDD
43	VG	2	16	Vertical gyro	Y	10	_ _[-]DDD.DDD

Display format key:
H = hexadecimal digit 0 to 9, A to F
B = binary digit 0 or 1
D = decimal digit 0 to 9
O = octal digit 0 to 7
A = any ASCII character

system, thus enhancing test coverage, troubleshooting, and the efficiency with which experiments are conducted.

The use of off-the-shelf commercial hardware and operating system software greatly reduced the development effort and cost of ownership.

Because of the capabilities of AIDS and its user-oriented operational features, experience to date, which has involved a complex flight development and integration project, has been excellent, with extremely high acceptance.

National Aeronautics and Space Administration
Ames Research Center
Dryden Flight Research Facility
February 3, 1982

APPENDIX A.—AIDS COMPONENTS

This appendix lists the components of AIDS.

The major computing subsystem components, which are from the Intel Corporation, are as follows:

ICS-80 KIT 640 Chassis and Power Supply (1 each)
Rack mount chassis, control panel, heavy duty power supply, four-slot card cage module, multibus backplane

SBC 614 Card Cage Modules (2 each)
Expands above kit to 12 slots capacity

SBC 80/30 Central Processor Board (1 each)
8085A CPU, 16K bytes RAM, 4K bytes PROM, serial port, 24 discrete I/O lines, interval timer, interrupt controller

SBC 116 Expansion Boards (2 each)
16K bytes RAM, 8K bytes PROM, 48 discretes I/O, serial port

SBC 724 Analog Output Boards (4 each)
Each board provides four 12-bit DAC channels, range ±10 volts

SBC 711 Analog Input Board (1 each)
Provides 16 balanced channels, range ±10 volts, 12-bit A/D

SBC 204 Floppy Diskette Controller Board (1 each)
Provides control of two single-density standard sized drives

SBC 310 High Speed Math Unit Board (1 each)
Provides 16-bit and 32-bit arithmetic, fixed and floating point

SBC 905 Universal Prototype Board (1 each)
1 Hz clock circuitry, bus timeout monitor circuit, PROM switching control logic, external interrupt termination

RMX80 Real-Time Multitasking Executive (1 each)
RMX830.LIB, BOT830.LIB, BOTUNR.LIB, DFSDIR.LIB, DIO830.LIB, DFSUNR.LIB, THI830.LIB, THO830.LIB, PLM80.LIB

Additional components of the AIDS are as follows:

Floppy Diskette Drive Unit

Manufacturer:	Data Systems Design, Inc.
Type:	DSD-110-IN-2A drive unit (1 each) DSD-CM chassis mount for rack (1 each)
Interface:	Cable provided to mate with SBC-204 controller
Characteristics:	Dual drives, standard sized floppy diskettes, single density IBM soft-sectored

Operator Terminal

Manufacturer:	SOROC Technology
Type:	IQ-120
Interface:	RS-232C serial
Characteristics:	19,200 baud rate, 24 lines by 80 columns, vectored cursor capability

Line Printer

Manufacturer:	Centronics Data Computer Corp.
Type:	306C
Interface:	Standard Centronics parallel TTL interface
Characteristics:	5 X 7 dot matrix, tractor feed, 80/132 character/line, 120 character/second print rate, two-channel vertical forms unit

APPENDIX B.—AIDS REAL-TIME MULTITASKING EXECUTIVE LISTINGS

Following are printer listings generated during the building of the AIDS real-time multitasking executive firmware.

This listing shows the software components which together comprise the software system create table. It defines the initial task table, the initial exchange table, several hardware definition tables, and miscellaneous data storage area declarations.

```
ASM80 :F1:CONFIG


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        CONFIG   PAGE    1
AIDS RMX SYSTEM CONFIGURATION MODULE   12 DEC 1979

 LOC  OBJ         LINE        SOURCE STATEMENT

                       $       TITLE('AIDS RMX SYSTEM CONFIGURATION MODULE   12 DEC 1979')

                               NAME    CONFIG          ; R GLOVER
                               PUBLIC  RQCRTB
                               PUBLIC  RQL0EX,RQL3EX,RQL4EX,RQL5EX,RQLAEX,RQLBEX,RQLCEX

                               CSEG

 0000 0600     C         RQCRTB: DW      ITT             ; INITIAL TASK TABLE
 0002 0A                       DB      10
 0003 B000     C               DW      IET             ; INITIAL EXCHANGE TABLE
 0005 12                       DB      18

                         ITT:

                       ;       DISK CONTROLLER TASK

                               PUBLIC  RQL2EX,CNTL1X
                               EXTRN   RQHD4

 0006 53424332           TASK1:  DB      'SBC204'        ; DISK CONTROLLER BOARD HANDLER
 000A 3034
 000C 0000     E               DW      RQHD4
 000E 9600     D               DW      STK1
 0010 5000                     DW      80
 0012 21                       DB      33              ; INTERRUPT LEVEL 2 USED FOR 204 BOARD
 0013 7B00     D               DW      CNTL1X
 0015 EA02     D               DW      TD1

                       ;       TERMINAL HANDLER TASK

                               PUBLIC  UREADX,UWRITX
                               EXTRN   RQTHDI,RQINPX,RQOUTX,RQWAKE,RQDBUG,RQALRM,RQL6EX,RQL7EX

 0017 5445524D           TASK2:  DB      'TERMIO'
 001B 494F
 001D 0000     E               DW      RQTHDI
 001F E600     D               DW      STK2
 0021 2400                     DW      36
 0023 70                       DB      112             ; INTERRUPT LEVEL 6 USED FOR KEYBOARD INPUT
 0024 0000     E               DW      RQOUTX
 0026 FE02     D               DW      TD2

                       ;       DISK I/O MAIN TASK

                               EXTRN   RQPDSK,RQDSKX

 002B 4449534B           TASK3:  DB      'DISKIO'
 002C 494F
 002E 0000     E               DW      RQPDSK
 0030 0A01     D               DW      STK3
 0032 3000                     DW      48
 0034 81                       DB      129
 0035 0000     E               DW      RQDSKX
```

```
 LOC  OBJ          LINE        SOURCE STATEMENT

 0037 1203     D     52          DW      TD3
                     53
                     54 ;        DISK SERVICES TASKS (6)
                     55
                     56          PUBLIC  RQDBUF,RQBAB
                     57          EXTRN   RQPDIR,RQPATR,RQPDEL,RQPFMT,RQPLD,RQPRNM
                     58          EXTRN   RQDIRX,RQATRX,RQDELX,RQFMTX,RQLDX,RQRNMX
                     59
 0039 44495253       60 TASK4:   DB      'DIRSVC'                ; DIRECTORY SERVICES
 003D 5643
 003F 0000     E     61          DW      RQPDIR
 0041 3A01     D     62          DW      STK4
 0043 3000           63          DW      48
 0045 82             64          DB      130
 0046 0000     E     65          DW      RQDIRX
 0048 2603     D     66          DW      TD4
                     67
 004A 41545452       68 TASK5:   DB      'ATTRIB'                ; ATTRIBUTES
 004E 4942
 0050 0000     E     69          DW      RQPATR
 0052 6A01     D     70          DW      STK5
 0054 4000           71          DW      64
 0056 83             72          DB      131
 0057 0000     E     73          DW      RQATRX
 0059 3A03     D     74          DW      TD5
                     75
 005B 44454C45       76 TASK6:   DB      'DELETE'
 005F 5445
 0061 0000     E     77          DW      RQPDEL
 0063 AA01     D     78          DW      STK6
 0065 4000           79          DW      64
 0067 84             80          DB      132
 0068 0000     E     81          DW      RQDELX
 006A 4E03     D     82          DW      TD6
                     83
 006C 464F524D       84 TASK7:   DB      'FORMAT'
 0070 4154
 0072 0000     E     85          DW      RQPFMT
 0074 EA01     D     86          DW      STK7
 0076 4000           87          DW      64
 0078 85             88          DB      133
 0079 0000     E     89          DW      RQFMTX
 007B 6203     D     90          DW      TD7
                     91
 007D 4C4F4144       92 TASK8:   DB      'LOAD  '
 0081 2020
 0083 0000     E     93          DW      RQPLD
 0085 2A02     D     94          DW      STK8
 0087 4000           95          DW      64
 0089 86             96          DB      134
 008A 0000     E     97          DW      RQLDX
 008C 7603     D     98          DW      TD8
                     99
 008E 52454E41      100 TASK9:   DB      'RENAME'
 0092 4D45
```

```
  LOC  OBJ         LINE        SOURCE STATEMENT

  0094 0000     E   101          DW      RQPKNM
  0096 6A02     D   102          DW      STK9
  0098 4000         103          DW      64
  009A 87           104          DB      135
  009B 0000     E   105          DW      RQRNMX
  009D 8A03     D   106          DW      TD9
                    107
                    108 ;        BOOTSTRAP LOADER TASK
                    109
                    110          PUBLIC  RQPOOL
                    111          EXTRN   RQBOOT
                    112
  009F 424F4F54     113 TASK10:  DB      'BOOT  '
  00A3 2020
  00A5 0000     E   114          DW      RQBOOT
  00A7 AA02     D   115          DW      STK10
  00A9 4000         116          DW      64
  00AB FE           117          DB      254
  00AC 0000         118          DW      0
  00AE 9E03     D   119          DW      TD10
                    120
                    121 ;        INITIAL EXCHANGE TABLE
                    122
  00B0 0F00     D   123 IET:     DW      RQL2EX
  00B2 7800     D   124          DW      CNTL1X
  00B4 0000     E   125          DW      RQINPX
  00B6 0000     E   126          DW      RQOUTX
  00B8 0000     E   127          DW      RQWAKE
  00BA 0000     E   128          DW      RQDBUG
  00BC 0000     E   129          DW      RQALRM
  00BE 0000     E   130          DW      RQL6EX
  00C0 0000     E   131          DW      RQL7EX
  00C2 8200     D   132          DW      UREADX
  00C4 BC00     D   133          DW      UWRITX
  00C6 0000     E   134          DW      RQDSKX
  00C8 0000     E   135          DW      RQDIRX
  00CA 0000     E   136          DW      RQATRX
  00CC 0000     E   137          DW      RQDELX
  00CE 0000     E   138          DW      RQFMTX
  00D0 0000     E   139          DW      RQLDX
  00D2 0000     E   140          DW      RQRNMX
                    141
                    142 ;        TABLES FOR DISK CONTROLLER TASK
                    143
                    144          PUBLIC  RQCST,RQNDEV,RQDCT,RQDRC4
                    145
  00D4 02           146 RQCST:   DB      2                  ; CONTROLLER SPECIFICATION TABLE
  00D5 70           147          DB      70H                ; 204 BOARD I/O ADDRESS
  00D6 02           148          DB      2                  ; INTERRUPT LEVEL 2
  00D7 0F00     D   149          DW      RQL2EX
  00D9 7800     D   150          DW      CNTL1X
                    151
  00DB 02           152 RQNDEV:  DB      2                  ; NUMBER OF DRIVES
                    153
  00DC 4630         154 RQDCT:   DB      'F0'               ; DEVICE CONFIGURATION TABLE
```

```
 LOC  OBJ         LINE        SOURCE STATEMENT

 00DE 00           155         DB      0,0,0
 00DF 00
 00E0 00
 00E1 4631         156         DB      'F1'
 00E3 00           157         DB      0,0,1
 00E4 00
 00E5 01
                   158
 00E6 01           159 RQDRC4: DB      1               ; DRIVE CHARACTERISTICS TABLE
 00E7 70           160         DB      70H             ; 204 BOARD I/O ADDRESS
 00E8 00           161         DB      0               ; CONTROLLER CHIP 0
 00E9 08           162         DB      8               ; TRACK STEP TIME = 8 MS
 00EA 08           163         DB      8               ; HEAD SETTLING TIME = 8 MS
 00EB 49           164         DB      49H             ; INDEX COUNT = 4 , LOAD TIME = 35 MS
                   165
                   166 ;       BUFFER ALLOCATION BLOCK
                   167
 00EC 0000         168 RQBAB:  DW      0,0             ; STATIC MODE
 00EE 0000
 00F0 02           169         DB      2               ; MAXIMUM OF 2 FILES CONCURRENTLY OPEN
 00F1 6E07     D   170         DW      BABRAM
                   171
                   172         DSEG
                   173
 0000              174 RQL0EX: DS      15              ; EXCHANGE AREA
 000F              175 RQL2EX: DS      15
 001E              176 RQL3EX: DS      15
 002D              177 RQL4EX: DS      15
 003C              178 RQL5EX: DS      15
 004B              179 RQLAEX: DS      15
 005A              180 RQLBEX: DS      15
 0069              181 RQLCEX: DS      15
 0078              182 CNTL1X: DS      10
 0082              183 UREADX: DS      10
 008C              184 UWRITX: DS      10
                   185
 0096              186 STK1:   DS      80              ; STACK AREA
 00E6              187 STK2:   DS      36
 010A              188 STK3:   DS      48
 013A              189 STK4:   DS      48
 016A              190 STK5:   DS      64
 01AA              191 STK6:   DS      64
 01EA              192 STK7:   DS      64
 022A              193 STK8:   DS      64
 026A              194 STK9:   DS      64
 02AA              195 STK10:  DS      64
                   196
 02EA              197 TD1:    DS      20              ; TASK DESCRIPTOR AREA
 02FE              198 TD2:    DS      20
 0312              199 TD3:    DS      20
 0326              200 TD4:    DS      20
 033A              201 TD5:    DS      20
 034E              202 TD6:    DS      20
 0362              203 TD7:    DS      20
 0376              204 TD8:    DS      20
```

```
  LOC  OBJ          LINE         SOURCE STATEMENT

  038A                205 TD9:     DS       20
  039E                206 TD10:    DS       20
                      207
  03B2                208 RQPOOL: DS        256           ; BOOTSTRAP LOADER BUFFER
  04B2                209 RQDBUF: DS        700           ; DIRSVC BUFFER
  076E                210 BABRAM: DS        800           ; BAB BUFFER
                      211
                      212          END


PUBLIC SYMBOLS
CNTL1X D 0078   RQBAB  C 00EC   RQCRTB C 0000   RQCST  C 00D4   RQDBUF D 04B2   RQDCT  C 00DC   RQDRC4 C 00E6
RQL0EX D 0000   RQL2EX D 000F   RQL3EX D 001E   RQL4EX D 002D   RQL5EX D 003C   RQLAEX D 004B   RQLBEX D 005A
RQLCEX D 0069   RQNDEV C 00DB   RQPOOL D 03B2   UREADX D 0082   UWRITX D 008C

EXTERNAL SYMBOLS
RQALRM E 0000   RQATRX E 0000   RQBOOT E 0000   RQDBUG E 0000   RQDELX E 0000   RQDIRX E 0000   RQDSKX E 0000
RQFMTX E 0000   RQHD4  E 0000   RQINPX E 0000   RQL6EX E 0000   RQL7EX E 0000   RQLDX  E 0000   RQOUTX E 0000
RQPATR E 0000   RQPDEL E 0000   RQPDIR E 0000   RQPDSK E 0000   RQPFMT E 0000   RQPLD  E 0000   RQPRNM E 0000
RQRNMX E 0000   RQTHDI E 0000   RQWAKE E 0000

USER SYMBOLS
BABRAM D 076E   CNTL1X D 0078   IET    C 00B0   ITT    C 0006   RQALRM E 0000   RQATRX E 0000   RQBAB  C 00EC
RQBOOT E 0000   RQCRTB C 0000   RQCST  C 00D4   RQDBUF D 04B2   RQDBUG E 0000   RQDCT  C 00DC   RQDELX E 0000
RQDIRX E 0000   RQDRC4 C 00E6   RQDSKX E 0000   RQFMTX E 0000   RQHD4  E 0000   RQINPX E 0000   RQL0EX D 0000
RQL2EX D 000F   RQL3EX D 001E   RQL4EX D 002D   RQL5EX D 003C   RQL6EX E 0000   RQL7EX E 0000   RQLAEX D 004B
RQLBEX D 005A   RQLCEX D 0069   RQLDX  E 0000   RQNDEV C 00DB   RQOUTX E 0000   RQPATR E 0000   RQPDEL E 0000
RQPDIR E 0000   RQPDSK E 0000   RQPFMT E 0000   RQPLD  E 0000   RQPOOL D 03B2   RQPRNM E 0000   RQRNMX E 0000
RQTHDI E 0000   RQWAKE E 0000   STK1   D 0096   STK10  D 02AA   STK2   D 00E6   STK3   D 010A   STK4   D 013A
STK5   D 016A   STK6   D 01AA   STK7   D 01EA   STK8   D 022A   STK9   D 026A   TASK1  C 0006   TASK10 C 009F
TASK2  C 0017   TASK3  C 0028   TASK4  C 0039   TASK5  C 004A   TASK6  C 005B   TASK7  C 006C   TASK8  C 007D
TASK9  C 008E   TD1    D 02EA   TD10   D 039E   TD2    D 02FE   TD3    D 0312   TD4    D 0326   TD5    D 033A
TD6    D 034E   TD7    D 0362   TD8    D 0376   TD9    D 038A   UREADX D 0082   UWRITX D 008C

ASSEMBLY COMPLETE,    NO ERRORS
```

SUBMIT File Listing

This listing defines the sequence of operations performed by the MDS in building the firmware. The configuration module is linked with the other RTMTX modules, located at address 40H, and finally converted to a HEX file, which is used to program the PROMs.

```
LINK  &
   :F1:BOT830.LIB(VECRST),  &
   :F1:RMX830.LIB(START),  &
   :F1:RMX830.LIB(SUSPND,RESUME,DLTASK,DLEXCH),  &
   :F1:CONFIG.OBJ,  &
   :F1:BOT830.LIB,  &
   :F1:DFSDIR.LIB(SEEK,DIRECTORY,ATTRIB,DELETE,RENAME,LOAD),  &
   :F1:DFSDIR.LIB(FORMAT,FORMAT201,FMTTABLE),  &
   :F1:DIO830.LIB,  &
   :F1:DFSUNR.LIB,  &
   :F1:THI830.LIB,  &
   :F1:THO830.LIB,  &
   :F1:RMX830.LIB,  &
   :F1:BOTUNR.LIB,  &
   :F1:PLM80.LIB  &
       TO  &
   :F1:ROM.OBJ  &
       MAP  &
       PRINT(:F1:ROMLNK.LST)
LOCATE  &
   :F1:ROM.OBJ  &
       TO  &
   :F1:ROM.ABS  &
       CODE(40H)  &
       STACKSIZE(0)  &
       DATA(0DC00H)  &
       MAP  &
       PUBLICS  &
       SYMBOLS  &
       LINES  &
       PRINT(:F1:ROMLOC.LST)
ATTRIB :F1:ROM.HEX W0
DELETE :F1:ROM.HEX
OBJHEX :F1:ROM.ABS TO :F1:ROM.HEX
ATTRIB :F1:ROM.HEX W1
COPY :F1:ROMLNK.LST TO :LP:
COPY :F1:NAME TO :LP:
COPY :F1:DATE TO :LP:
COPY :F1:ROMLOC.LST TO :LP:
```

Linker Listing

This listing is generated by the object linker and provides a list of all modules included.

```
ISIS-II OBJECT LINKER V3.0 INVOKED BY:
-LINK  &
**  :F1:BOT830.LIB(VECRST),  &
**  :F1:RMX830.LIB(START),  &
**  :F1:RMX830.LIB(SUSPND,RESUME,DLTASK,DLEXCH),  &
**  :F1:CONFIG.OBJ,  &
**  :F1:BOT830.LIB,  &
**  :F1:DFSDIR.LIB(SEEK,DIRECTORY,ATTRIB,DELETE,RENAME,LOAD),  &
**  :F1:DFSDIR.LIB(FORMAT,FORMAT201,FMTTABLE),  &
**  :F1:DIO830.LIB,  &
**  :F1:DFSUNR.LIB,  &
**  :F1:THI830.LIB,  &
**  :F1:THO830.LIB,  &
**  :F1:RMX830.LIB,  &
**  :F1:BOTUNR.LIB,  &
**  :F1:PLM80.LIB  &
**      TO  &
**  :F1:ROM.OBJ  &
**      MAP  &
**      PRINT(:F1:ROMLNK.LST)

LINK MAP OF MODULE ROM
WRITTEN TO FILE :F1:ROM.OBJ
MODULE IS A MAIN MODULE

SEGMENT INFORMATION:
START   STOP LENGTH REL NAME

               3EFBH  B  CODE
               1275H  B  DATA
                 60H  B  STACK
0000H  0002H      3H  A  ABSOLUTE
0008H  000AH      3H  A  ABSOLUTE
0010H  0012H      3H  A  ABSOLUTE
0018H  001AH      3H  A  ABSOLUTE
0020H  0022H      3H  A  ABSOLUTE
0024H  002EH      BH  A  ABSOLUTE
0030H  0032H      3H  A  ABSOLUTE
0034H  0036H      3H  A  ABSOLUTE
0038H  003AH      3H  A  ABSOLUTE
003CH  003EH      3H  A  ABSOLUTE

INPUT MODULES INCLUDED:
 :F1:BOT830.LIB(VECRST)
 :F1:RMX830.LIB(START)
 :F1:RMX830.LIB(SUSPND)
 :F1:RMX830.LIB(RESUME)
 :F1:RMX830.LIB(DLTASK)
 :F1:RMX830.LIB(DLEXCH)
 :F1:CONFIG.OBJ(CONFIG)
 :F1:BOT830.LIB(IN830P)
 :F1:BOT830.LIB(RQBOOT)
 :F1:BOT830.LIB(FILNAM)
 :F1:BOT830.LIB(RDSECT)
 :F1:DFSDIR.LIB(SEEK)
 :F1:DFSDIR.LIB(DIRECTORY)
 :F1:DFSDIR.LIB(ATTRIB)
 :F1:DFSDIR.LIB(DELETE)
 :F1:DFSDIR.LIB(RENAME)
 :F1:DFSDIR.LIB(LOAD)
 :F1:DFSDIR.LIB(FORMAT)
 :F1:DFSDIR.LIB(FORMAT201)
```

```
:F1:DFSDIR.LIB(FMTTABLE)
:F1:DIO830.LIB(DISKIO)
:F1:DIO830.LIB(HAN204)
:F1:DFSUNR.LIB(NOFORMAT202)
:F1:DFSUNR.LIB(NOFORMAT204)
:F1:DFSUNR.LIB(NOFORMAT206)
:F1:DFSUNR.LIB(DRIVETIMEOUTVAL)
:F1:DFSUNR.LIB(MINISTARTUP)
:F1:THI830.LIB(THDINI)
:F1:THI830.LIB(ECHO)
:F1:THI830.LIB(STDINP)
:F1:THI830.LIB(PRIINP)
:F1:THI830.LIB(SCANBAUDRATE)
:F1:THI830.LIB(LNEDIT)
:F1:THO830.LIB(THDINO)
:F1:THO830.LIB(CONTROL)
:F1:THO830.LIB(USART8030)
:F1:THO830.LIB(CNTRLTABLE)
:F1:THO830.LIB(MERGER)
:F1:RMX830.LIB(SYNCH)
:F1:RMX830.LIB(RDYLST)
:F1:RMX830.LIB(DLYLST)
:F1:RMX830.LIB(OBJMAN)
:F1:RMX830.LIB(SL)
:F1:RMX830.LIB(RMVSLL)
:F1:RMX830.LIB(ENTSLL)
:F1:RMX830.LIB(TB8030)
:F1:BOTUNR.LIB(THRATE)
:F1:BOTUNR.LIB(RESETV)
:F1:BOTUNR.LIB(NODBGR)
:F1:BOTUNR.LIB(FILUNR)
:F1:PLM80.LIB(@P0011)
:F1:PLM80.LIB(@P0014)
:F1:PLM80.LIB(@P0018)
:F1:PLM80.LIB(@P0025)
:F1:PLM80.LIB(@P0029)
:F1:PLM80.LIB(@P0034)
:F1:PLM80.LIB(@P0086)
:F1:PLM80.LIB(@P0091)
:F1:PLM80.LIB(@P0094)
:F1:PLM80.LIB(@P0096)
:F1:PLM80.LIB(@P0098)
:F1:PLM80.LIB(@P0101)
:F1:PLM80.LIB(@P0103)
```

Locater Listing

This listing is generated by the object locater and provides a complete list of all PUBLIC symbols.

```
ISIS-II OBJECT LOCATER V3.0 INVOKED BY:
-LOCATE  &
**  :F1:ROM.OBJ  &
**       TO  &
**  :F1:ROM.ABS  &
**       CODE(40H)  &
**       STACKSIZE(0)  &
**       DATA(0DC00H)  &
**       MAP  &
**       PUBLICS  &
**       SYMBOLS  &
**       LINES  &
**       PRINT(:F1:ROMLOC.LST)

SYMBOL TABLE OF MODULE ROM
READ FROM FILE :F1:ROM.OBJ
WRITTEN TO FILE :F1:ROM.ABS

VALUE TYPE SYMBOL

0000H PUB  R?VECRST
0040H PUB  RQSTRT
00C1H PUB  RQSUSP
00EFH PUB  RQRESM
011DH PUB  RQDTSK
0166H PUB  RQDXCH
0271H PUB  RQBAB
0185H PUB  RQCRTB
0259H PUB  RQCST
0261H PUB  RQDCT
026BH PUB  RQDRC4
0260H PUB  RQNDEV
044EH PUB  R?INTDI
03FFH PUB  R?INTEI
037FH PUB  R?INTINI
03E7H PUB  R?LMASK
0463H PUB  RQDLVL
0448H PUB  RQELVL
0285H PUB  RQENDI
0469H PUB  RQSETV
02F3H PUB  R?UDPRI
0483H PUB  RQBOOT
0615H PUB  R?BOTSTR
061EH PUB  R?RDSECT
0674H PUB  R?ISEEK
0A8AH PUB  R?GETBLK
1095H PUB  R?RLSMAP
0AB0H PUB  R?MAPDBP
159DH PUB  R?FILEOPENCHECK
18BAH PUB  R???DEL
1CE1H PUB  RQPOPN
1071H PUB  R?OBTDIR
1382H PUB  R?ADJEOF
109FH PUB  R?OBTFCB
160BH PUB  R?VALIDATEREQUEST
12B2H PUB  R?PBREAD
149CH PUB  R?FILENAMECHECK
123BH PUB  R?DPTTSK
107EH PUB  R?RLSDIR
0E28H PUB  R?DIRGET
0C82H PUB  R?IFREBK
1283H PUB  R?DBSAVE
0A0DH PUB  R?ABSIO
```

```
16A0H PUB  R???IRW
0A9CH PUB  R?MAPSAV
0D22H PUB  R?ICLOSE
10ACH PUB  R?RLSFCB
0A93H PUB  R?FREBLK
0ED8H PUB  R?DLOOK
0EA0H PUB  R?DIRUPD
131FH PUB  R?CHKEOF
1258H PUB  R?DBREAD
13A2H PUB  R?CALLOC
12E8H PUB  R?PBSAVE
18A1H PUB  R???RW1
1088H PUB  R?OBTMAP
0AA8H PUB  R?MASKARRAY
124BH PUB  R?CLRBUF
0B83H PUB  R?IGETBK
10B6H PUB  RQPDIR
141AH PUB  R?FTCHPB
1D9DH PUB  RQPATR
1E07H PUB  RQPDEL
1F21H PUB  RQPRNM
2199H PUB  RQPLD
2943H PUB  RQPFMT
294DH PUB  R?FMT201
29A8H PUB  R?FMTTABLE
2A9CH PUB  R?REQXCH
29CCH PUB  R???DST
29B0H PUB  R???IOW
29B7H PUB  R???IOR
2A13H PUB  RQPDSK
2A6DH PUB  R?SVCDIS
2D99H PUB  RQHD4
2DA9H PUB  R?FMT202
2DABH PUB  R?FMT204
2DADH PUB  R?FMT206
2DAFH PUB  RQTOV
2DB1H PUB  RQMOTM
2DC6H PUB  R?INPLIV
2E0BH PUB  RQTHDI
2FDCH PUB  R??ECHO
2FFCH PUB  R?STDINPUT
30E4H PUB  R?PRIINPUT
320AH PUB  R?SCANBAUDRATE
328FH PUB  R?SETUPLNED
32A4H PUB  R?CLEARANDREAD
339CH PUB  R?LINEEDIT
35FEH PUB  RQTHDO
37A6H PUB  R?TESTFORCONTROL
37D6H PUB  R?PROGRAMTHEUSART
381AH PUB  RQCTAB
3826H PUB  R?MERGER
395FH PUB  R?CONNCT
3A56H PUB  R?RMVXCH
3A65H PUB  RQACPT
3A89H PUB  RQISND
399CH PUB  RQSEND
39C3H PUB  RQWAIT
3AF8H PUB  R?DSPTCH
3B27H PUB  R?ENTRDY
3B74H PUB  R?RLINI
3B63H PUB  R?RMVRDY
3C2AH PUB  R?CANDLY
3C76H PUB  R?DLINI
```

```
3BAEH PUB  R?ENTDLY
3CA5H PUB  R?STPDLY
3D99H PUB  R?OBJINI
3D6EH PUB  RQCTSK
3D75H PUB  RQCXCH
3CE5H PUB  R?SETUP
3DB8H PUB  R?ENTSUS
3DC2H PUB  R?RMVSUS
3DCCH PUB  R?RMVSLL
3E0FH PUB  R?ENTSLL
3E31H PUB  R??TICK
3E5EH PUB  R?STRCLK
3E64H PUB  R?STPCLK
3E6AH PUB  R?TCKINI
3E77H PUB  RQRATE
3E79H PUB  R?RST5HD
3E7CH PUB  RQFILE
3E85H PUB  @P0011
3E87H PUB  @P0012
3E8AH PUB  @P0013
3E92H PUB  @P0014
3E93H PUB  @P0015
3E96H PUB  @P0016
3E97H PUB  @P0017
3E9FH PUB  @P0018
3EA2H PUB  @P0019
3EA9H PUB  @P0025
3EAAH PUB  @P0026
3EADH PUB  @P0027
3EAEH PUB  @P0028
3EB6H PUB  @P0029
3EB8H PUB  @P0030
3ED5H PUB  @P0034
3ED7H PUB  @P0035
3EE9H PUB  @P0086
3EECH PUB  @P0087
3EEDH PUB  @P0088
3EF3H PUB  @P0091
3EF6H PUB  @P0092
3EF7H PUB  @P0093
3F03H PUB  @P0094
3F06H PUB  @P0095
3F0DH PUB  @P0096
3F10H PUB  @P0097
3F17H PUB  @P0098
3F19H PUB  @P0099
3F1CH PUB  @P0100
3F24H PUB  @P0101
3F27H PUB  @P0102
3F2FH PUB  @P0103
3F32H PUB  @P0104
DC00H PUB  RQRSTV
DCE8H PUB  CNTL1X
E122H PUB  RQDBUF
DC70H PUB  RQL0EX
DC7FH PUB  RQL2EX
DC8EH PUB  RQL3EX
DC9DH PUB  RQL4EX
DCACH PUB  RQL5EX
DCBBH PUB  RQLAEX
DCCAH PUB  RQLBEX
DCD9H PUB  RQLCEX
E022H PUB  RQPOOL
```

```
DCF2H PUB  UREADX
DCFCH PUB  UWRITX
E753H PUB  R?ADRXCH
E751H PUB  R?INITM
E73FH PUB  R?SIMVEC
E769H PUB  R?RESPEX
E75FH PUB  RQBOTX
E755H PUB  RQLODX
E775H PUB  R?SLPMSG
E77EH PUB  RQNAME
E7E6H PUB  R?CLSKIL
E7F2H PUB  R?FREEBUFXCH
E932H PUB  RQOPNX
E7DCH PUB  RQDIRX
E7F0H PUB  R?FBLORG
E8EFH PUB  R?FCBLISTLOCK
E903H PUB  R?BITMAPLOCK
E7FCH PUB  R?RETURNBUFXCH
E8D8H PUB  R?DISPTSKSTD
E8F9H PUB  R?DIRECTORYLOCK
E87AH PUB  R?ABSIOM
E99DH PUB  RQATRX
E9C0H PUB  RQDELX
E9E1H PUB  RQRNMX
EA09H PUB  RQLDX
EA48H PUB  RQFMTX
EA7BH PUB  R?ENTX1
EA7CH PUB  RQDSKX
EA7AH PUB  R?ENT204
EA95H PUB  RQINPX
EA9FH PUB  RQWAKE
EAA9H PUB  RQL6EX
EAB8H PUB  RQDBUG
EAC2H PUB  R?LINES
EACCH PUB  R?LINESS
EAD6H PUB  R?CHARSS
EAE0H PUB  R?CHARINPEXC
EAEAH PUB  R?ECHOEXC
ED6DH PUB  R?ALARMSS
ED77H PUB  R?CNTRL
ED81H PUB  RQOUTX
ED8BH PUB  RQALRM
ED95H PUB  RQL7EX
EE08H PUB  R???RLR
EE08H PUB  RQACTV
EE24H PUB  R???DLH
EE36H PUB  RQL1EX
EE60H PUB  R???ELR
EE4AH PUB  R???TLR
EE6CH PUB  R???SLR

MEMORY MAP OF MODULE ROM
READ FROM FILE :F1:ROM.OBJ
WRITTEN TO FILE :F1:ROM.ABS
MODULE START ADDRESS 0040H

START   STOP LENGTH REL NAME

0000H  0002H     3H  A  ABSOLUTE
0008H  000AH     3H  A  ABSOLUTE
0010H  0012H     3H  A  ABSOLUTE
0018H  001AH     3H  A  ABSOLUTE
0020H  0022H     3H  A  ABSOLUTE
0024H  002EH     BH  A  ABSOLUTE
0030H  0032H     3H  A  ABSOLUTE
0034H  0036H     3H  A  ABSOLUTE
0038H  003AH     3H  A  ABSOLUTE
003CH  003EH     3H  A  ABSOLUTE
0040H  3F3AH  3EFBH  B  CODE
DC00H  EE74H  1275H  B  DATA
EE75H  F6BFH   84BH  B  MEMORY
```

APPENDIX C.—TYPICAL HiMAT DISPLAYS

This appendix describes some of the displays used in the HiMAT program.

Command Interpreter Display

This is the display to which the AIDS executive returns when the user has terminated the previous operation. This display provides the operator with the following information: (1) the version of the AIDS executive, (2) the name and version number of the user module, (3) a list of the available user commands, and (4) a list of the available system commands. The operator enters the desired command, and the corresponding overlay is loaded and executed. A special case is the command "LD" which is used to activate the displays stored on the scratch diskette: (1) the scratch diskette directory is examined to determine the page number of the file specified, (2) the corresponding overlay is loaded, (3) the display templates are copied from the scratch diskette file into the overlay, and (4) the display is activated in refreshed mode.

Hard copy of the HiMAT command interpreter display:

```
AIRCRAFT INTERROGATION & DISPLAY SYSTEM

AIDS-II SYSTEM EXECUTIVE   16 SEPT 1980   R GLOVER

USER LOAD MODULE NAME : HIMAT 8.15.80

USER COMMANDS :
FF  MP  MC  MD  MT  TX
A1  A2  A3

SYSTEM COMMANDS :
IC  TC  PC  DK  LD  FD
SIO  SMP  SMS  SMD  SMT
```

Scratch Diskette Directory Display

This display is generated by the AIDS executive in response to a "DK" command. It shows the name of the scratch diskette currently in drive number 1 and lists the contents of each of the 45 available files. The operator has a menu of commands to choose from:

LD = load a file and present the display in refreshed mode

SAVE = write the current overlay display into a selected file

INIT = initialize a new scratch diskette with selected name

DEL = delete a selected file

NAME = rename a selected file

Hard copy of typical HiMAT scratch diskette directory:

```
RESET                                                              08:18:02
HIMAT 8.15.80                                                      7.27.81
              PAGE 201   DIRECTORY FOR SCRATCH DISK HIMAT G. P. 1

FILE  PAGE  DESCRIPTION     FILE  PAGE  DESCRIPTION    FILE  PAGE  DESCRIPTION
  1     3   RATE GYROS       16     3   D/L ST.WDS      31     1   ENG PANEL
  2     3   ACCELS           17     1   DLSW'S          32     3   ENG FAILS
  3     3   PRESSURES        18     3   KEMPEL 3A       33     3   STC THR
  4     3   SURFACES         19     3   P.IN.DISCS      34     3   THR. TEST
  5     3   RADAR ALT        20     3   KEMPEL 3B       35     3   THR.CAL
  6     3   ATTITUDES        21     3   STRIPCHART      36     3   CAL NOZZLE
  7     3   KEMPEL 1         22     3   D/L TEST        37
  8     3   DUPACTS LC       23     3   ENG TEST        38     3   IPCS SENS
  9     3   LIMCY/B          24                         39     4   P MEM CHK
 10     3   SURF CALIB       25     3   PLA TEST        40     4   B MEM CHK
 11     3   DIV COMB         26                         41     3   POWER SUPS
 12     3   RAW U/L          27                         42     5   C FAIL 1
 13     3   KEMPEL 2         28                         43     3   C FAIL 2
 14     3   DL ACT FLS       29                         44     3   C FAIL 3
 15     3   DUP ACT FL       30     1   TRUTH           45     5   C FAIL 4


COMMAND LIST :  LD  SAVE  INIT  DEL  NAME
```

Tabular Data Display

This display is accessed by the user command "MP" and allows the user to define a display of up to 20 data items. For each item the user must specify item number, data type, hexadecimal address, description, and units. In addition, if the data type is either F1 or F2, the operator must also enter the zero and maximum scaling of the parameter in engineering units. Once created, the display may be saved on the scratch diskette if desired.

Hard copy of typical HiMAT page 3 display:

```
OPERATE          PAGE 3   USER-DEFINED DATA DISPLAY                  08:19:44
HIMAT 8.15.80                                                        7.27.81
ITEM  TYPE  ADDR   ZERO (EU)    MAX (EU)   DESCRIPTION      VALUE    UNITS
  1
  2    VG   6125                            PITCH          150.798   DEGREES
  3
  4    VG   6131                            ROLL           148.776   DEGREES
  5
  6    DG   61BA                            YAW            331.260   DEGREES
  7
  8    E0   6131                            90 D ROLL         ZERO
  9
 10    DV   629D                            SPECIAL OP      -0.020   VOLTS
 11
 12    E1   61DB                            UMB NOT SE         ONE
 13    E3   61DC                            LAN NOT SE         ONE
 14
 15    F2   6094      0.000      100.000    MIDV PR          0.098   DEG/SEC
 16    F2   6096      0.000      100.000    MIDV YR         -0.049   DEG/SEC
 17
 18    E0   61D7                            FAST ERECT        ZERO
 19
 20    E4   61D8                            PRI MODE          ZERO
      DISK : HIMAT G. P. 1     FILE NO.  6   FILE NAME : ATTITUDES
```

Block Memory Dump Data Display

This page format is accessed by command "MD" and allows the operator to display in hexadecimal format up to 304 bytes in a single block. The operator must specify the beginning and ending addresses of the block. The display may be saved on scratch diskette file if desired.

Hard copy of typical HiMAT block memory dump display:

```
OPERATE                                                            08:23:00
HIMAT 8.15.80                                                      7.27.81
                              PAGE 5   MEMORY DUMP

      61D7   40 00 00 00  33 08 00 C7  30 00 01 00  00 00 80 00
      61E7   92 04 00 00  88 A0 01 00  00 00 00 40  48 00 00 80
      61F7   80 4D 11 00  80 00 E0 80  40 00 06 08  1C 4D 80




          DISK : HIMAT G. P. 1    FILE NO. 42   FILE NAME : C FAIL 1
```

Free-Form Data Display

This display mode is accessed by the user command "FF" and allows the operator to create unstructured displays in any format desired. Separate commands are available to allow creating the static or background portion of the display, followed by the insertion of data items in any desired format at any location of the screen. Once created, the display may be saved on scratch diskette if desired.

Hard copy of typical HiMAT free-form data display:

```
OPERATE                                 PAGE 1                        08:21:12
HIMAT 8.15.80                                                          7.27.81
                                     ENGINE PANEL
. . . . . . . . .
.               .
  14.422 (PSI).
.               .
. COMPRESSOR    .                                   PLAD =    15.000 DEG
. DISCHARGE     .
. PRESSURE      .                                   PLAC =     0.000 DEG
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
.               .                 .                 .                       .
   10.000 (%)   .    0.000 (C)  .    99.996 (%)   .     0.000 (DEG)        .
.               .                 .                 .                       .
.    RPM        .    EXHAUST      .    EXHAUST      .    THROTTLE           .
.               .      GAS        .    NOZZLE       .    POSITION           .
.               .  TEMPERATURE    .     AREA        .                       .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
                          .           . CONTROL .  ENGINE   .  NOZZLE   .
                          .           .   MODE  . STABILITY .  CONTROL  .
                          . IGNITION  .  COMBAT .   HIGH    .  OVERRIDE .
                          .           .         .           .           .
                          .   ZERO    .   ZERO  .   ZERO    .   ZERO    .
      DISK : HIMAT G. P. 1     FILE NO. 31    FILE NAME : ENG PANEL
```

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16. Abstract

A microprocessor-based general purpose ground support equipment for electronic systems has been developed and placed in service at the NASA Dryden Flight Research Facility. The hardware and software are designed to permit diverse applications in support of aircraft flight systems and simulation facilities. This paper describes the implementation of the hardware and the structure of the software and describes the application of the system to an ongoing research aircraft project.

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