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.

The use of trade names or names of manufacturers in this report does not constitute an official endorsement of such products or manufacturers, either expressed or implied, by the National Aeronautics and Space Administration.

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
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, develop-
ment, 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.
Real-time data display:

Open-loop function generator:

Redundant sensor simulator:

Closed-loop simulation:

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.
Figure 3. Aircraft interrogation and display system.
Figure 4. AIDS I/O address map.
Figure 5. AIDS memory map.
<table>
<thead>
<tr>
<th>Level</th>
<th>Assignment</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trap</td>
<td>Not used</td>
<td>-----</td>
</tr>
<tr>
<td>A</td>
<td>Bus timeout</td>
<td>AIDS tally only</td>
</tr>
<tr>
<td>B</td>
<td>Not used</td>
<td>-----</td>
</tr>
<tr>
<td>C</td>
<td>Not used</td>
<td>-----</td>
</tr>
<tr>
<td>0</td>
<td>INTR pushbutton</td>
<td>User manual interrupt</td>
</tr>
<tr>
<td>1</td>
<td>Timer no. 0</td>
<td>RTMTX task wait timer</td>
</tr>
<tr>
<td>2</td>
<td>Disk controller</td>
<td>RTMTX diskette I/O</td>
</tr>
<tr>
<td>3</td>
<td>Timer no. 1</td>
<td>User clock</td>
</tr>
<tr>
<td>4</td>
<td>External interrupt</td>
<td>User sync</td>
</tr>
<tr>
<td>5</td>
<td>1 Hz interrupt</td>
<td>AIDS time of day clock</td>
</tr>
<tr>
<td>6</td>
<td>USART C receiver</td>
<td>RTMTX terminal handler</td>
</tr>
<tr>
<td>7</td>
<td>USART C transmitter</td>
<td>RTMTX terminal handler</td>
</tr>
</tbody>
</table>
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.

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Overlays

User main module

AIDS supervisor task module

Real-time multitasking executive

*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-sold 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 utility 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>
<thead>
<tr>
<th>Number</th>
<th>Code</th>
<th>Number of bytes</th>
<th>Number of bits</th>
<th>Data type</th>
<th>Sign?</th>
<th>Number of columns</th>
<th>Display format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H1</td>
<td>1</td>
<td>8</td>
<td>Any</td>
<td>---</td>
<td>2</td>
<td>HH</td>
</tr>
<tr>
<td>2</td>
<td>H2</td>
<td>2</td>
<td>16</td>
<td>Any</td>
<td>---</td>
<td>4</td>
<td>HHHH</td>
</tr>
<tr>
<td>3</td>
<td>H3</td>
<td>3</td>
<td>24</td>
<td>Any</td>
<td>---</td>
<td>6</td>
<td>HHHHHHHH</td>
</tr>
<tr>
<td>4</td>
<td>H4</td>
<td>4</td>
<td>32</td>
<td>Any</td>
<td>---</td>
<td>8</td>
<td>HHHHHHHHHH</td>
</tr>
<tr>
<td>5</td>
<td>B1</td>
<td>8</td>
<td>8</td>
<td>Any</td>
<td>---</td>
<td>8</td>
<td>BBBBBBBBBB</td>
</tr>
<tr>
<td>6</td>
<td>H2</td>
<td>2</td>
<td>16</td>
<td>Any</td>
<td>---</td>
<td>16</td>
<td>BBBBBBBBBBBBBBBBBBBBBBBB</td>
</tr>
<tr>
<td>7</td>
<td>F4</td>
<td>4</td>
<td>32</td>
<td>Floating point</td>
<td>Y</td>
<td>10</td>
<td>(-) JDDDDDDD.DDD</td>
</tr>
<tr>
<td>8</td>
<td>I1</td>
<td>1</td>
<td>8</td>
<td>Integer</td>
<td>N</td>
<td>4</td>
<td>DDD</td>
</tr>
<tr>
<td>9</td>
<td>I2</td>
<td>2</td>
<td>16</td>
<td>Integer</td>
<td>N</td>
<td>6</td>
<td>DDDDD</td>
</tr>
<tr>
<td>10</td>
<td>D1</td>
<td>1</td>
<td>8</td>
<td>Integer</td>
<td>Y</td>
<td>4</td>
<td>(-) DDD</td>
</tr>
<tr>
<td>11</td>
<td>D2</td>
<td>2</td>
<td>16</td>
<td>Integer</td>
<td>Y</td>
<td>6</td>
<td>(-) DDDDD</td>
</tr>
<tr>
<td>12</td>
<td>DD</td>
<td>2</td>
<td>12</td>
<td>DAC value</td>
<td>Y</td>
<td>6</td>
<td>HHHH</td>
</tr>
<tr>
<td>13</td>
<td>DH</td>
<td>2</td>
<td>12</td>
<td>DAC value</td>
<td>---</td>
<td>3</td>
<td>HHH</td>
</tr>
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<td>(-) JDD.DDD</td>
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<td>1</td>
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<td>O2</td>
<td>2</td>
<td>16</td>
<td>Any</td>
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<td>6</td>
<td>OOOOOOO</td>
</tr>
<tr>
<td>17</td>
<td>A1</td>
<td>1</td>
<td>---</td>
<td>ASCII string</td>
<td>---</td>
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<td>2</td>
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<td>---</td>
<td>2</td>
<td>AA</td>
</tr>
<tr>
<td>19</td>
<td>A3</td>
<td>3</td>
<td>---</td>
<td>ASCII string</td>
<td>---</td>
<td>3</td>
<td>AAA</td>
</tr>
<tr>
<td>20</td>
<td>A4</td>
<td>4</td>
<td>---</td>
<td>ASCII string</td>
<td>---</td>
<td>4</td>
<td>AAAA</td>
</tr>
<tr>
<td>21</td>
<td>A5</td>
<td>5</td>
<td>---</td>
<td>ASCII string</td>
<td>---</td>
<td>5</td>
<td>AAAAA</td>
</tr>
<tr>
<td>22</td>
<td>A6</td>
<td>6</td>
<td>---</td>
<td>ASCII string</td>
<td>---</td>
<td>6</td>
<td>AAAA AAA</td>
</tr>
<tr>
<td>23</td>
<td>A7</td>
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<td>---</td>
<td>ASCII string</td>
<td>---</td>
<td>7</td>
<td>AAAA AAAA</td>
</tr>
<tr>
<td>24</td>
<td>A8</td>
<td>8</td>
<td>---</td>
<td>ASCII string</td>
<td>---</td>
<td>8</td>
<td>AAAAAA AAAAAA</td>
</tr>
<tr>
<td>25</td>
<td>A9</td>
<td>9</td>
<td>---</td>
<td>ASCII string</td>
<td>---</td>
<td>9</td>
<td>AAAA AAAA AAAAAA</td>
</tr>
<tr>
<td>26</td>
<td>AA</td>
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<td>---</td>
<td>ASCII string</td>
<td>---</td>
<td>10</td>
<td>AAAA AAAA AAAA AAAA</td>
</tr>
<tr>
<td>27</td>
<td>AB</td>
<td>11</td>
<td>---</td>
<td>ASCII string</td>
<td>---</td>
<td>11</td>
<td>AAAA AAAA AAAA AAAA AAAA AAAA AAAA AAAA</td>
</tr>
<tr>
<td>28</td>
<td>AC</td>
<td>12</td>
<td>---</td>
<td>ASCII string</td>
<td>---</td>
<td>12</td>
<td>AAAA AAAA AAAA AAAA AAAA AAAA AAAA AAAA</td>
</tr>
<tr>
<td>29</td>
<td>AD</td>
<td>13</td>
<td>---</td>
<td>ASCII string</td>
<td>---</td>
<td>13</td>
<td>AAAA AAAA AAAA AAAA AAAA AAAA AAAA AAAA</td>
</tr>
<tr>
<td>30</td>
<td>AE</td>
<td>14</td>
<td>---</td>
<td>ASCII string</td>
<td>---</td>
<td>14</td>
<td>AAAA AAAA AAAA AAAA AAAA AAAA AAAA AAAA</td>
</tr>
<tr>
<td>31</td>
<td>AF</td>
<td>15</td>
<td>---</td>
<td>ASCII string</td>
<td>---</td>
<td>15</td>
<td>AAAA AAAA AAAA AAAA AAAA AAAA AAAA AAAA</td>
</tr>
<tr>
<td>32</td>
<td>E0</td>
<td>1</td>
<td>1</td>
<td>Event bit 0</td>
<td>---</td>
<td>4</td>
<td>&quot;ONE&quot; or &quot;ZERO&quot;</td>
</tr>
<tr>
<td>33</td>
<td>E1</td>
<td>1</td>
<td>1</td>
<td>Event bit 1</td>
<td>---</td>
<td>4</td>
<td>&quot;ONE&quot; or &quot;ZERO&quot;</td>
</tr>
<tr>
<td>34</td>
<td>E2</td>
<td>1</td>
<td>1</td>
<td>Event bit 2</td>
<td>---</td>
<td>4</td>
<td>&quot;ONE&quot; or &quot;ZERO&quot;</td>
</tr>
<tr>
<td>35</td>
<td>E3</td>
<td>1</td>
<td>1</td>
<td>Event bit 3</td>
<td>---</td>
<td>4</td>
<td>&quot;ONE&quot; or &quot;ZERO&quot;</td>
</tr>
<tr>
<td>36</td>
<td>E4</td>
<td>1</td>
<td>1</td>
<td>Event bit 4</td>
<td>---</td>
<td>4</td>
<td>&quot;ONE&quot; or &quot;ZERO&quot;</td>
</tr>
<tr>
<td>37</td>
<td>E5</td>
<td>1</td>
<td>1</td>
<td>Event bit 5</td>
<td>---</td>
<td>4</td>
<td>&quot;ONE&quot; or &quot;ZERO&quot;</td>
</tr>
<tr>
<td>38</td>
<td>E6</td>
<td>1</td>
<td>1</td>
<td>Event bit 6</td>
<td>---</td>
<td>4</td>
<td>&quot;ONE&quot; or &quot;ZERO&quot;</td>
</tr>
<tr>
<td>39</td>
<td>E7</td>
<td>1</td>
<td>1</td>
<td>Event bit 7</td>
<td>---</td>
<td>4</td>
<td>&quot;ONE&quot; or &quot;ZERO&quot;</td>
</tr>
<tr>
<td>40</td>
<td>F1</td>
<td>1</td>
<td>8</td>
<td>Fixed point</td>
<td>Y</td>
<td>10</td>
<td>(-) JDDDDDDD.DDD</td>
</tr>
<tr>
<td>41</td>
<td>F2</td>
<td>2</td>
<td>16</td>
<td>Fixed point</td>
<td>Y</td>
<td>10</td>
<td>(-) JDDDDDDD.DDD</td>
</tr>
<tr>
<td>42</td>
<td>DG</td>
<td>2</td>
<td>16</td>
<td>Directional gyro</td>
<td>Y</td>
<td>10</td>
<td>(-) JDDDDDDD.DDD</td>
</tr>
<tr>
<td>43</td>
<td>VG</td>
<td>2</td>
<td>16</td>
<td>Vertical gyro</td>
<td>Y</td>
<td>10</td>
<td>(-) JDDDDDDD.DDD</td>
</tr>
</tbody>
</table>

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 discrete 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

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Centronics Data Computer Corp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>306C</td>
</tr>
<tr>
<td>Interface</td>
<td>Standard Centronics parallel TTL interface</td>
</tr>
<tr>
<td>Characteristics</td>
<td>5 x 7 dot matrix, tractor feed, 80/132 character/line, 120 character/second print rate, two-channel vertical forms unit</td>
</tr>
</tbody>
</table>
APPENDIX B.—AIDS REAL-TIME MULTITASKING EXECUTIVE LISTINGS

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

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.
LOC OBJ LINE SOURCE STATEMENT

0037 1203 D 52 DB TB3
0038 12 53 ; DISK SERVICES TASKS (6)
0039 1204 D 54 PUBLIC RQBUF,RQAB
003A 1205 D 56 EXTRN RQPDIR,RQPATR,RQPDEL,RQPFMT,RQPAB,RQPARK
003B 1206 D 57 EXTRN RQDIRX,RQATRX,RQDELX,RQFMTX,RQBLX,RQAMX

003C 4445253 0A TASK4: DB 'DIRSVC' ; DIRECTORY SERVICES
003D 5643
003E 0000 E 61 DM RQPDIR
0040 3001 D 62 DM STK4
0041 3000 D 63 DM 48
0042 0000 E 64 DB 130
0043 6200 D 66 DM TB4
0044 41545452 0B TASK5: DB 'ATTRIB' ; ATTRIBUTES
0045 4942
0046 0000 E 69 DM RQPATR
0047 0040 D 70 DM STK5
0048 0000 E 71 DM 64
0049 0000 E 72 DB 131
004A 0000 E 73 DM RQDIRX
004B 3003 D 74 DM TB5
004C 44464C45 0F TASK6: DB 'DELETE'
004D 5445
004E 0000 E 77 DM RQPDEL
004F 0040 D 78 DM STK6
0050 0000 E 79 DM 64
0051 0000 E 80 DB 132
0052 0000 E 81 DM RQDELX
0053 4003 D 82 DM TB6
0054 46454144 0E TASK7: DB 'FORMAT'
0055 4154
0056 0000 E 85 DM RQPFMT
0057 0040 D 86 DM STK7
0058 0000 E 87 DM 64
0059 0000 E 88 DB 133
005A 0000 E 89 DM RQFMTX
005B 6203 D 90 DM TB7
005C 4446524D 0F TASK7: DB 'FORMAT'
005D 4154
005E 0000 E 95 DM RQPDEL
005F 3002 D 96 DM STK8
0060 0000 E 94 DM 64
0061 0000 E 95 DB 134
0062 0000 E 96 DM RQPLD
0063 7603 D 98 DM TB8
0064 52454E41 09 TASK9: DB 'RENAME'
0065 4945
0066 0000 E 97 DM RQPLD
0067 0000 E 98 DB 134
0068 0000 E 99 DM RQBLX
0069 6203 D 9A DM TB9
006A 4945
LOC | OBJ | LINE | SOURCE STATEMENT
---|---|---|---
0054 0000 E 101 DW ROPRM
0056 6402 D 102 DW STKP
0058 4000 103 DW 64
005A 87 104 DB 135
005B 0000 E 105 DW RQRNM
005D B503 D 106 DW TB9
107
108 ; BOOTSTRAP LOADER TASK
109
110 PUBLIC ROPOOL
111 EXTRN ROBOOT
112
006F 424F4F54 113 TASKI0: DB 'BOOT'
0063 2020
0065 0000 E 114 DW ROBOOT
0067 A022 D 115 DW STK10
0060 4000 116 DW 64
0064 FE 117 DB 254
006C 0000 118 DW 0
00AE 9E03 D 119 DW TB10
120
121 ; INITIAL EXCHANGE TABLE
122
0080 0F00 D 123 IET: DW ROL2EX
0082 7000 D 124 DW CMTLIX
0084 0000 E 125 DW RQINPX
0086 0000 E 126 DW RQOUTX
0088 0000 E 127 DW RQNPAE
008A 0000 E 128 DW RQBOOT
008C 0000 E 129 DW RQALRM
008E 0000 E 130 DW RQLEX
00C0 0000 E 131 DW RQLEX
00C2 8200 D 132 DW UREADX
00C4 0000 D 133 DW UWRITE
00C6 0000 E 134 DW RQDSKX
00C8 0000 E 135 DW RQDIRX
00CA 0000 D 136 DW RQAXRX
00CC 0000 E 137 DW RQDELX
00CE 0000 E 138 DW RQMTX
00D0 0000 E 139 DW RQLEX
00D2 0000 E 140 DW RQRNM
141
142 ; TABLES FOR DISK CONTROLLER TASK
143
144 PUBLIC ROCTST, RQNDEV, RQCT, RQDSK4
145
0D04 02 146 ROCTST: DB 2 ; CONTROLLER SPECIFICATION TABLE
0D05 70 147 DD 70H ; I/O ADDRESS
0D06 02 148 DB 2 ; INTERRUPT LEVEL 2
0D07 0F00 D 149 DW ROL2EX
0D09 7600 D 150 DW CMTLIX
151
0D0B 02 152 RQNDEV: DB 2 ; NUMBER OF DRIVES
153
0D0C 4630 154 RQCT: DB 'FO'; DEVICE CONFIGURATION TABLE

28
LOC OBJ LINE SOURCE STATEMENT

008E 00 155 DB 0:0:0
008F 00
008E 00
008E 4531 156 DB 'F1'
008E 00 157 DB 0:0:1
008E 00
008E 01
008E 6 01 159 RQDRC4: DB 1 ; DRIVE CHARACTERISTICS TABLE
008E 7 0 160 DB 70H ; 20A BOARD I/O ADDRESS
008E 6 0 161 DB 0 ; CONTROLLER CHIP 0
008E 8 0 162 DB 8 ; TRACK STEP TIME = 8 MS
008E 8 0 163 DB 8 ; HEAD SETTLING TIME = 8 MS
008E 49 164 DB 49H ; INDEX COUNT = 4 ; LOAD TIME = 35 MS
165
166 ; BUFFER ALLOCATION BLOCK
167
008E 0000 168 RGBAB: DW 0:0 ; STATIC MODE
008E 0000
008F 02 169 DB 2 ; MAXIMUM OF 2 FILES CONCURRENTLY OPEN
169
170 DB BARRAM
171
172 DBSEG
173
174 DS 15 ; EXCHANGE AREA
175
176 DS 15
177 DS 15
178 DS 15
179 DS 15
180 DS 15
181 DS 15
182 DS 10
183 DS 10
184 DS 10
185
186 DS 80 ; STACK AREA
187 DS 36
188 DS 48
189 DS 48
190 DS 64
191 DS 64
192 DS 64
193 DS 64
194 DS 64
195 DS 64
196
197 DS 20 ; TASK DESCRIPTOR AREA
198 DS 20
199 DS 20
200 DS 20
201 DS 20
202 DS 20
203 DS 20
204 DS 20

29
LOC OBJ LINE SOURCE STATEMENT

03BA 205 TB9: DS 20
03F E 206 TB10: DS 20
 029
0392 20B RQPPO: DS 256 J BOOITAP LOOATER BUFFER
0492 209 RQBBU: DS 700 J DIKSV BUFFER
076E 210 BABRAM: DS 800 J BAG BUFFER
 211
 212 END

PUBLIC SYMBOLS
CNTLIX D 007B RQDBB C 00EC RQCSSB C 0000 RQCSST C 0004 RQDSUB D 04B2 RQDCST C 000C RQDSBC C 00EC
RQLD E 0090 RQLEKEX D 001E RQLEKEX D 002B RQLEKEX D 003E RQLEKEX D 004B RQLEKEX D 005A
RQLC E 0069 RQGNEV C 003B RQPPO D 0382 RQGNEV C 003B RQGNEV C 003B
EXTERNAL SYMBOLS
RQALRM E 0000 RQATRX E 0000 RQBOOT E 0000 RQBUG E 0000 RQDELX E 0000 RQDIRX E 0000 RQDSKX E 0000
RQFMX E 0000 RQDHDA E 0000 RQIIPX E 0000 RQLEKEX E 0000 RQLEKEX E 0000 RQLEKEX E 0000 RQLEKEX E 0000
RQPATR E 0000 RQPSUEL E 0000 RQPAFIR E 0000 RQPSKEX E 0000 RQPSKEX E 0000 RQPSKEX E 0000
RQRMNX E 0000 RQTHDI E 0000 RQTHKE E 0000
USER SYMBOLS
BABRAM D 076E CNTLIX D 007B IET C 0080 IET C 0080 IET C 0080 IET C 0080 IET C 0080 IET C 0080 IET C 0080
RQBOOT E 0000 RQCSSB C 0000 RQCSST C 0004 RQDSUB D 04B2 RQDCST C 000C RQDSBC C 00EC
RQDIRX E 0000 RQDSBH E 0000 RQDSBH E 0000 RQDSBH E 0000 RQDSBH E 0000 RQDSBH E 0000 RQDSBH E 0000
RQFMX E 0000 RQDHDA E 0000 RQIIPX E 0000 RQLEKEX E 0000 RQLEKEX E 0000 RQLEKEX E 0000 RQLEKEX E 0000
RQLEKEX D 001E RQLEKEX D 002B RQLEKEX D 003E RQLEKEX D 004B RQLEKEX D 005A
RQLEKEX D 0069 RQGNEV C 003B RQGNEV C 003B RQGNEV C 003B RQGNEV C 003B
RQPSUEL E 0000 RQPSUEL E 0000 RQPSUEL E 0000 RQPSUEL E 0000 RQPSUEL E 0000 RQPSUEL E 0000 RQPSUEL E 0000
RQTHDI E 0000 RQTHKE E 0000 RQTHKE E 0000 RQTHKE E 0000 RQTHKE E 0000 RQTHKE E 0000 RQTHKE E 0000
STK5 D 016A STK6 D 016A STK7 D 016A STK8 D 016A STK9 D 016A STK10 D 016A TASK1 C 0017 TASK2 C 0017
STK2 C 0017 STK3 C 0017 STK4 C 0017 STK5 C 0017 STK6 C 0017 STK7 C 0017 STK8 C 0017 STK9 C 0017
STK10 D 023A STK11 D 023A STK12 D 023A STK13 D 023A STK14 D 023A STK15 D 023A TASK1 C 0017 TASK2 C 0017
TASK3 C 0017 TASK4 C 0017 TASK5 C 0017 TASK6 C 0017 TASK7 C 0017 TASK8 C 0017 TASK9 C 0017 TASK10 C 0017
TASK11 C 0017 TASK12 C 0017 TASK13 C 0017 TASK14 C 0017 TASK15 C 0017 TASK16 C 0017 TASK17 C 0017
TASK18 C 0017 TASK19 C 0017 TASK20 C 0017 TASK21 C 0017 TASK22 C 0017 TASK23 C 0017 TASK24 C 0017
TD1 D 032E TD2 D 032E TD3 D 032E TD4 D 032E TD5 D 032E TD6 D 032E TD7 D 032E TD8 D 032E
TD9 D 032E TD10 D 032E TD11 D 032E TD12 D 032E TD13 D 032E TD14 D 032E TD15 D 032E TD16 D 032E
TD17 D 032E TD18 D 032E TD19 D 032E TD20 D 032E TD21 D 032E TD22 D 032E TD23 D 032E TD24 D 032E
TD25 D 032E TD26 D 032E TD27 D 032E TD28 D 032E TD29 D 032E TD30 D 032E TD31 D 032E TD32 D 032E
TD33 D 032E TD34 D 032E TD35 D 032E TD36 D 032E TD37 D 032E TD38 D 032E TD39 D 032E TD40 D 032E
TD41 D 032E TD42 D 032E TD43 D 032E TD44 D 032E TD45 D 032E TD46 D 032E TD47 D 032E TD48 D 032E
TD49 D 032E TD50 D 032E TD51 D 032E TD52 D 032E TD53 D 032E TD54 D 032E TD55 D 032E TD56 D 032E
TD57 D 032E TD58 D 032E TD59 D 032E TD60 D 032E TD61 D 032E TD62 D 032E TD63 D 032E TD64 D 032E
TD65 D 032E TD66 D 032E TD67 D 032E TD68 D 032E TD69 D 032E TD70 D 032E TD71 D 032E TD72 D 032E
TD73 D 032E TD74 D 032E TD75 D 032E TD76 D 032E TD77 D 032E TD78 D 032E TD79 D 032E TD80 D 032E
TD81 D 032E TD82 D 032E TD83 D 032E TD84 D 032E TD85 D 032E TD86 D 032E TD87 D 032E TD88 D 032E
TD89 D 032E TD90 D 032E TD91 D 032E TD92 D 032E TD93 D 032E TD94 D 032E TD95 D 032E TD96 D 032E
TD97 D 032E TD98 D 032E TD99 D 032E TD100 D 032E TD101 D 032E TD102 D 032E TD103 D 032E TD104 D 032E
TD105 D 032E TD106 D 032E TD107 D 032E TD108 D 032E TD109 D 032E TD110 D 032E TD111 D 032E TD112 D 032E
TD113 D 032E TD114 D 032E TD115 D 032E TD116 D 032E TD117 D 032E TD118 D 032E TD119 D 032E TD120 D 032E
TD121 D 032E TD122 D 032E TD123 D 032E TD124 D 032E TD125 D 032E TD126 D 032E TD127 D 032E TD128 D 032E
ASSEMBLY COMPLETE, NO ERRORS

30
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:DI0830.LIB, &
   :F1:DFSRTR.LIB, &
   :F1:THI830.LIB, &
   :F1:TH0830.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(ODC00H) &
   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.HEXW1
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:DI0830.LIB, &
** :F1:DFSUNR.LIB, &
** :F1:THIO830.LIB, &
** :F1:THIO830.LIB, &
** :F1:RMX830.LIB, &
** :F1:BOT830.LIB, &
** :F1:PLMB0.LIB &
** TO &
** :F1:RQ830.LIB &
** MAP &
** PRINT (:F1:ROMLNC.LST)

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

SEGMENT INFORMATION:
START STOP LENGTH REL NAME

3EF6H B CODE
1275H B DATA
4OH 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 0026H 3H 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:
:FI:BOT830.LIB(VECRST)
:FI:RMX830.LIB(START)
:FI:RMX830.LIB(SUSPND)
:FI:RMX830.LIB(RESUME)
:FI:RMX830.LIB(DL TASK)
:FI:RMX830.LIB(DLEXCH)
:FI:CONFIG.OBJ(CONFIG)
:FI:BOT830.LIB(IN830P)
:FI:BOT830.LIB(RDBOOT)
:FI:BOT830.LIB(FILNAM)
:FI:BOT830.LIB(RDSECT)
:FI:DFSDIR.LIB(SEEK)
:FI:DFSDIR.LIB(DIRECTORY)
:FI:DFSDIR.LIB(ATTRIB)
:FI:DFSDIR.LIB(DELETE)
:FI:DFSDIR.LIB(RENAME)
:FI:DFSDIR.LIB(LOAD)
:FI:DFSDIR.LIB(FORMAT)
:FI:DFSDIR.LIB(FORMAT201)

32
:FI:DFSDIR.LIB(FMTTABLE)
:FI:DIQ830.LIB(DISKIO)
:FI:DIQ830.LIB(HAN204)
:FI:DFSUNR.LIB(NOFORMAT202)
:FI:DFSUNR.LIB(NOFORMAT204)
:FI:DFSUNR.LIB(NOFORMAT206)
:FI:DFSUNR.LIB(DRIVETIMEOUTVAL)
:FI:DFSUNR.LIB(MINISTARTUP)
:FI:THIG30.LIB(THDINI)
:FI:THIG30.LIB(ECHO)
:FI:THIG30.LIB(STDINF)
:FI:THIG30.LIB(PRINF)
:FI:THIG30.LIB(SCANBAUDRATE)
:FI:THIG30.LIB(LNEDIT)
:FI:THIG30.LIB(THDINO)
:FI:THIG30.LIB(CONTROL)
:FI:THIG30.LIB(USART8030)
:FI:THIG30.LIB(CNTRLTABLE)
:FI:THIG30.LIB(MERGER)
:FI:RMX830.LIB(SYNCH)
:FI:RMX830.LIB(RYLYST)
:FI:RMX830.LIB(DLYLST)
:FI:RMX830.LIB(DBMAN)
:FI:RMX830.LIB(SL)
:FI:RMX830.LIB(RMVSL)
:FI:RMX830.LIB(ENTSLL)
:FI:RMX830.LIB(TB8030)
:FI:BOTUNR.LIB(THRATE)
:FI:BOTUNR.LIB(RESETV)
:FI:BOTUNR.LIB(NODBGR)
:FI:BOTUNR.LIB(FILUNR)
:FI:PLMB0.LIB(@P0001)
:FI:PLMB0.LIB(@P0014)
:FI:PLMB0.LIB(@P0018)
:FI:PLMB0.LIB(@P0025)
:FI:PLMB0.LIB(@P0029)
:FI:PLMB0.LIB(@P0034)
:FI:PLMB0.LIB(@P0086)
:FI:PLMB0.LIB(@P0091)
:FI:PLMB0.LIB(@P0094)
:FI:PLMB0.LIB(@P0096)
:FI:PLMB0.LIB(@P0098)
:FI:PLMB0.LIB(@P0101)
:FI:PLMB0.LIB(@P0103)
Locator Listing

This listing is generated by the object locator 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(0DCC00H) &
** 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 R?GSTRT
00C1H PUB R?GSUSP
00EFH PUB R?RESM
011DH PUB R?DTSK
0166H PUB R?DXCH
0271H PUB R?BAD
0185H PUB R?CRTB
0259H PUB R?CST
0261H PUB R?RCT
0268H PUB R?DRDC4
0260H PUB R?RDEV
044EH PUB R?INTDI
03FFH PUB R?INTEI
037FH PUB R?INTINI
03E7H PUB R?LMASK
0463H PUB R?DLVL
0448H PUB R?ELVL
0285H PUB R?ENDI
0469H PUB R?SETTV
02F3H PUB R?UPFRI
0483H PUB R?BOOT
0615H PUB R?STATSTR
061EH PUB R?DSECT
0674H PUB R?SEEK
0A8AH PUB R?DETBLK
1095H PUB R?LSMAP
0A80H PUB R?MAPDBP
1590H PUB R?FILEOPENCHECK
188AH PUB R????DEL
1CE1H PUB R?POFN
1071H PUB R?BTDIR
1382H PUB R?ADJEOF
199FH PUB R?RTFCB
160BH PUB R?VALIDATEREQUEST
1282H PUB R?PBREAD
149CH PUB R?FILENAMECHECK
123BH PUB R?DPTTSK
107EH PUB R?RLSDIR
0E2BH PUB R?DIRGET
0C02H PUB R?IFREKB
1283H PUB R?DBSAVE
0A0DH PUB R?ABS10
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35
3BAEH PUB R?ENTDLY
3CA5H PUB R?STPDLY
3D99H PUB R?OBJJINI
3B6EH PUB RQCJTSK
3D75H PUB RQCXCH
3C55H PUB R?SETUP
3B68H PUB R?ENTSUS
3DC2H PUB R?RMVSUS
30CCH 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 R?RATE
3E79H PUB R?RST5HD
3E7CH PUB R?FILE
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 @P0029
3EB6H PUB @P0029
3EB8H PUB @P0030
3ED5H PUB @P0034
3ED7H PUB @P0035
3EE9H PUB @P0036
3EECH PUB @P0087
3EECH 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
3C00H PUB RORSTV
3C68H PUB CNTL1X
E122H PUB RQDRUF
DC70H PUB RQLOEX
DC7FH PUB RQL2EX
DC8EH PUB RQL3EX
DC9DH PUB RQL4EX
DCACH PUB RQL5EX
DCB8H PUB RQLAEX
DCCA9H PUB RQLBEX
DCD9H PUB RQLCEX
E022H PUB RQPOOL
DCF2H PUB UREADX
DCFCH PUB UWRITX
E753H PUB R?ADRXCX
E751H PUB R?INITM
E73FH PUB R?SIMVEC
E769H PUB R?RESPEX
E75FH PUB R?BOTLX
E755H PUB R?GLOLX
E775H PUB R?SLPMSG
E77EH PUB R?NAME
E76EH PUB R?CLSKIL
E7E8H PUB R?FREEBUXCH
E7DCH PUB R?RNPNX
E7F0H PUB R?FBLORG
E8EFH PUB R?FCBLISTLOCK
E903H PUB R?BITMAPLOCK
E7FCH PUB R?RETURNBUFCH
E808H PUB R?DISFSTKSTD
E89FH PUB R?DIRECTLOCK
E87AH PUB R?ABS1OM
E99DH PUB R?ROATRX
E9C0H PUB R?QDELX
E9E1H PUB R?QNMX
EA09H PUB R?QLDX
EA48H PUB R?QMTX
EA7BH PUB R?ENTX1
EA7CH PUB R?QDSKX
EA7AH PUB R?QETQ04
EA95H PUB R?QNPX
EA9FH PUB R?QWAKE
EAA9H PUB R?Q6EX
EAB0H PUB R?QBUG
EAC2H PUB R?LINES
EACH PUB R?LINLESS
EAD8H PUB R?CHARSS
EAE0H PUB R?CHARINPEXC
EAEAH PUB R?ECHOEXC
EDE0H PUB R?QALARMS
ED77H PUB R?QCNTRL
ED81H PUB R?QOUTX
ED88H PUB R?QALRM
ED95H PUB R?Q7EX
EE08H PUB R???QLR
EE0BH PUB R?QACV
EE24H PUB R???QDLH
EE36H PUB R?QLEX
EE60H PUB R???QELR
EEAH PUB R???QLR
EE6CH PUB R???QLR

MEMORY MAP OF MODULE ROM
READ FROM FILE :FI:ROM.OBJ
WRITTEN TO FILE :FI: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 3H 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
D000H EE74H 1275H B DATA
EE75H F68FH 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 8.15.00

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

SYSTEM COMMANDS :
IC TC PC DK LD FD
SIO SMP SMS SHD 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:

<table>
<thead>
<tr>
<th>FILE</th>
<th>PAGE</th>
<th>DESCRIPTION</th>
<th>FILE</th>
<th>PAGE</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>RATE GYROS</td>
<td>16</td>
<td>3</td>
<td>D/L ST. ADV</td>
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<td>2</td>
<td>3</td>
<td>ACCELS</td>
<td>17</td>
<td>1</td>
<td>D/L SW'S</td>
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<td>3</td>
<td>2</td>
<td>PRESSURES</td>
<td>18</td>
<td>3</td>
<td>KEMPEL 3A</td>
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<td>4</td>
<td>3</td>
<td>SURFACES</td>
<td>19</td>
<td>3</td>
<td>P. IN DISCS</td>
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<tr>
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<td>3</td>
<td>RANGE ALT</td>
<td>20</td>
<td>3</td>
<td>KEMPEL 3B</td>
</tr>
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<td>6</td>
<td>3</td>
<td>ATTITUDES</td>
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<td>2</td>
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<td>3</td>
<td>ENG TEST</td>
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<td>TRUTH</td>
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</table>

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:

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<th>USER-DEFINED DATA DISPLAY</th>
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<td></td>
<td>8:15:08</td>
<td>HIMAT 8:15:08</td>
<td>7.27.81</td>
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<th>UNITS</th>
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<td>6108</td>
<td>PRI MODE</td>
<td>ZERO</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>OPERATE</th>
<th>HIMAT 8.15.80</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAGE 5</td>
<td>MEMORY DUMP</td>
</tr>
</tbody>
</table>

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

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 PRESSURE
     PLAD = 15.000 DEG
     PLAC = 0.000 DEG

     10.000 (%) 0.000 (C) 99.996 (%) 0.000 (DEG)
RPM EXHAUST EXHAUST THROTTLE
GAS NOZZLE POSITION

     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
```

REFERENCES


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.