111-04
328
P-17

NASA Technical Memorandum 109072

# Description of the Experimental Avionics Systems Integration Laboratory (EASILY)


Bruce K. E. Outlaw
*Langley Research Center, Hampton, Virginia*





January 1994



National Aeronautics and
Space Administration
Langley Research Center
Hampton, Virginia 23681-0001

# SUMMARY

The Experimental Avionics Systems Integration Laboratory (EASILY) is a comprehensive facility used for development, integration, and preflight validation of hardware and software systems for the Terminal Area Productivity (TAP) Program's Transport Systems Research Vehicle (TSRV) experimental transport aircraft. This report describes the history, capabilities, and subsystems of EASILY. A functional description of the many subsystems is provided to give potential users the necessary knowledge of the capabilities of this facility.

# INTRODUCTION AND PURPOSE

The Experimental Avionics Systems Integration Laboratory (EASILY) is a special-purpose test facility of the Flight Management Division, Terminal Area Productivity Program Office (TAPPO), Experimental Flight Systems Section (EFSS). The Experimental Avionics Systems Integration Laboratory supports ground-based development and preflight validation of hardware and software systems for the NASA B-737 transport research aircraft. More specifically, EASILY serves the following purposes:

1. Development, integration, and validation of hardware and software for new research projects prior to installation on the NASA B-737 Transport Systems Research Vehicle (TSRV) aircraft.

2. Test bed for maintenance, testing, and operational support of existing experimental systems.

The EASILY staff presently consists of the following positions:

1. EASILY Manager: Responsible for overall planning and coordination of EASILY activities.

2. Computer Systems Engineer: As systems manager, maintains configuration control for software and hardware.

3. Lead Electronics Technician: Maintains, modifies, calibrates, and supports EASILY systems. This position also requires the generation and maintenance of CAD-based documentation.

4. Engineering Co-op Technician: Assists Lead Technician in daily facility operations.

## HISTORY

The Experimental Avionics System Integration Laboratory (EASILY) facility was established in 1976 to meet a need for high level integrated tests of the TSRV experimental avionics. This need resulted from the extensive Microwave Landing System (MLS) flight testing which was going on at the time. The National Aeronautics and Space Administration (NASA), in cooperation with the Federal Aviation Administration (FAA), was involved in an international competition for a world standard implementation of a new landing system. This new system would replace the current Instrument Landing System (ILS) whose capability was being strained by increased air terminal traffic and the need for improved safety. The United States entry was the MLS.

The establishment of EASILY allowed use of actual flight hardware and software for ground-based testing using a computer-based simulation of the TSRV aircraft in real-time. Initially an analog computer system was used to implement a simplified linear aircraft model. Later, a digital simulation link was established with Analysis and Computation Division (ACD) via underground telephone lines. Around the same time period, a limited digital simulation was implemented in an EASILY-located PDP-11 computer. Since this time, EASILY has expanded and developed to the point of having a high speed, high performance, full nonlinear simulation available from either the ACD via a fiber-optic link or from a dedicated EASILY Simulation VAX computer.

## CURRENT CAPABILITIES

The EASILY is a 2,400 square foot facility consisting of six computer systems and associated avionics subsystems that duplicate the hardware of the TSRV aircraft. The lab-resident computer systems permit rapid assessment of flight hardware and software problems. EASILY provides a comprehensive interface for real-time nonlinear aircraft flight simulation. Flight simulation is available using either of two simulation sources. The "official" means for testing TSRV experimental systems and software is by our direct interface with the simulation facilities of the Analysis and Simulation Branch (ASB) of the ACD. Implemented in a CONVEX mainframe computer at ACD, the real-time 737 simulation interfaces with EASILY via a high speed, high performance, fiber-optic digital bus known as CAMAC (Computer-Automated Measurement and Control).

Until recently, ACD was the only simulation source for EASILY. For simulation testing of flight projects in the development and integration stages, a totally EASILY-resident simulation is available that is functionally equivalent to the ACD simulation. This simulation software is implemented in a VAX 4000 computer dedicated for this purpose only.

The CAMAC system operates at an effective data rate of 24-megabits per second. The data signals from ACD are transmitted over a fiber-optic link in digital form to EASILY, then converted within the CAMAC system to the various formats to match the TSRV experimental system. Signals to ACD are likewise converted in the CAMAC to digital form. The following table lists the signal formats and the number of signals currently used:

| Signal Type | Quantity | Input/Output |
|---|---|---|
| Synchro | 4 | Input |
| Discrete | 5 | Input |
| Discrete | 36 | Output |
| Analog | 5 | Output |
| Analog | 41 | Input |
| Digital (ARINC 429) | 71 | Input |
| Digital (Pulse-pair) | 2 | Input |

Several spare signal channels exist for each signal type and additional modules can be added if necessary.

Of interest to pilots and researchers who fly the simulation in the laboratory is the amount of time delay between an input at the control stick and the desired action at the pilot displays. This time duration is defined as transport delay. For EASILY, this delay is approximately 90 milliseconds.

## FUNCTIONAL DESCRIPTION OF SUBSYSTEMS

### EASILY-ACD Interface:

The ACD real-time simulation software is installed in ACD's CONVEX C3850 mainframe computer system located in Building 1268. The CONVEX computer communicates with the EASILY facility over a fiber-optic link using a high performance digital data acquisition network known as CAMAC. EASILY is just one of 22 remote sites that make up ACD's real-time simulation system.

The basic elements that make up the CAMAC network are: (1) the Serial Highway Driver; (2) the Network Switch; and (3) the CAMAC crates. The Serial Highway Driver and the Network Switch are located at ACD and serve as interface units between the mainframe computer and the CAMAC serial highway. The Serial Highway Driver is the highway "master" and directs all communications between the mainframe computer and the CAMAC crates, which are located at each simulation site.

A CAMAC network consists of a CAMAC highway path from the network switch to the simulation site (e.g., EASILY) and then the return path to the switch. At the network switch, the electrical signals are converted to light signals by a fiber-optic transmitter/receiver called a FOUPA (Fiber-Optic, Universal Port Adapter) for transmission over a fiber-optic link to EASILY and other remotely located simulation sites. The fiber-optic link consists of two components: (1) a pair of FOUPA modules, one at the network switch and one at the simulation site to convert signals from electrical to light and vice-versa and (2) a transmission line made up of light conducting fibers.

Located at EASILY, and the other remote simulation sites is the CAMAC crate. EASILY has two crates, each being a powered card cage that houses the various modules required for the signal/data interface. Each crate contains various types of modules. There are modules such as Digital-to-Analog Converters (DACs), Digital-to-Synchro, and Digital-to-Discrete modules for converting incoming digital signals from ACD to the formats required. There are modules such as Analog-to-Digital Converters (ADCs) and Discrete-to-Digital modules which convert signals from EASILY into digital form for transmission back to ACD. There are also other specialized modules which provide functions such as timing synchronization between EASILY and ACD and supplies a means for transferring data between the CAMAC network and EASILY minicomputers.

## Computer Systems:

The Experimental Avionics Systems Integration Laboratory (EASILY) has a total of six computer systems. Two of the computers, the Flight Management Computer and the Display Computer, duplicate the TSRV experimental system functions. One computer, the Display Graphics Computer, is being evaluated for future use as a high-performance graphics generator to drive eight high-resolution cockpit displays. The three remaining EASILY computers are used to support facility operations. They are: The Software Development Computer, the Systems Development Computer, and the Simulation Computer.

For the experimental system, the Flight Management Computer is a VAX 4000-200 computer which performs the flight management computations and executes the flight control system algorithms. The Display Computer is also a VAX 4000 computer and serves as a host for the Sperry display processors that drive the eight cockpit color CRT displays. The Display Graphics Computer is a Silicon Graphics Reality 2

Onyx computer which is currently being evaluated as a future display host and graphics engine to drive eight high-resolution color displays in the experimental system.

The three facility support computers are all VAX 4000-200 computers. The Software Development Computer is connected to the Ethernet for use either locally or remotely for development of software programs tested in EASILY for eventual flight on the TSRV aircraft. This computer also serves as a means for supporting hard disk backups of all TAPPO/EFSS Macintosh computers. Incremental backups are done on a weekly basis for a total of 10 Macintosh computers. VAX computer backups are also done weekly. The System Development Computer is used for initial installation and checkout of various system software, such as new operating system releases. This computer provides an independent test base for evaluation of system type packages without disrupting normal facility operations. The simulation computer contains EASILY Flight Module Test software which is the full nonlinear 737 aircraft simulation package.

The VAX 4000-200 computers have a computation speed of 5.5 MIPS (million instructions per second). They are powerful computers which give EASILY extensive flexibility and expansion capability. A summary of the present capability utilized is as follows:

| COMPUTER | SPARE CPU CAPACITY | % MEMORY USED | RAM MEMORY SIZE |
|---|---|---|---|
| FLIGHT MANAGEMENT | 80% | 10% | 16M |
| DISPLAY | 85% | 8% | 16M |
| SIMULATION | 75% | 15% | 16M |

Due to the vast amount of CPU capacity remaining of the Flight Management Computer, an effort is underway to combine the Flight Management and Display computer's functions into a single VAX computer.

**Experimental Stations:**

EASILY contains six experimental stations that house the various system components. They are as follows:

(1) RFDIU Station
(2) DIF Station
(3) ACD Simulation Station
(4) Flight Management/Flight Control Computer Station

(5) Research Flight Station

(6) Data Acquisition Station

The RFDIU (Research Flight Deck Interface Unit) Station contains a flight-ready RFDIU, its associated Digital Autonomous Terminal Access Communications (DATAC) unit, and a patch panel for access to signals between the RFDIU and the CAMAC system. Details of this signal interface are shown in the EASILY Wiring Diagram book listed in the reference section of this paper.

The DIF (DATAC Interface) Station serves the same function for the DIF unit as the RFDI Station does for the RFDIU.

The ACD Simulation Station contains the ACD/EASILY fiber-optics connection, the CAMAC system, the EVIU (EASILY VME Interface Unit), the EVIU Monitor Panel, and a patch panel. The EVIU has special modules that perform certain types of signal conversions that the CAMAC system does not do. The EVIU modules provide ARINC 429 digital output signals that duplicate the format of the TSRV Air Data Inertial Reference System (ADIRS) unit. Also provided are DME pulse pair signal formats. The EVIU uses a Motorola 68010 CPU chip and a VME-type backplane to handle its activities.

In the Flight Management/Flight Controls Computer Station are kept removable hard disk drives and DATAC interface units for the Flight Management End Display computers. The removable drives allow convenient portability of software between computers. This station also contains a CVIU (CDU VME Interface Unit) which drives the navigation Control Display Unit (CDU), and the display system Bus Interface Unit (BIU). The BIU performs the DMA to serial digital bus conversion required for the display system graphics generator.

Simulated flying in EASILY is done at the Research Flight Station. The heart of this station is the Control Console Panel (CCP) which contains an array of switches that simulate the TSRV aircraft discrete signals that are not handled by ACD. Using this panel, various ILS, sensor, navigation, basic airplane, and interlock signal states can be manually set by the station operator to obtain a particular flight configuration. For example, the necessary signal conditions can be set to perform ILS approaches and MLS approaches. Basic airplane conditions such as landing gear position, aileron trim, rudder trim, flaps handle positioning and throttle handle position can be set at the CCP. The Research Flight Station also contains a special panel for changing simulation modes (IC, Run, and Hold) and reading/clearing sensor failure messages. The layout of the Research Flight Station is intentionally different from the TSRV research cockpit to allow easier maintenance and accessibility of system components. Two panels reside in this station that are used for diagnostic purposes. One panel has the capability of setting up display system conditions for troubleshooting components of the display system. The other panel is used to test the navigation CDUs. The navigation system components of the TSRV research cockpit, the Mode Control Panel, and two CDUs are mounted in the Research Flight Station and provide selection of flight modes and computer configuration when performing simulated flights.

**Data Acquisition:**

The Data Acquisition Station contains two 8-channel strip chart recorders and various instrumentation components, which allow testing of the corresponding aircraft components and recording of quick-look data for analysis purposes. In addition to the eight analog channels, the strip chart recorders can each record six discrete signals. By means of a special software program in the VAX computers, any group of 16 signals from a total of 200 signals can be selected for recording. A DATAC unit is also part of this station and interfaces the instrumentation components to the experimental system DATAC bus.

## DOCUMENTATION

EASILY documentation for the hardware and software exists in various forms. An EASILY Equipment Log book is maintained to provide hardware configuration control. Experimental equipment transferred between the TSRV aircraft and EASILY is recorded here. Also, following the same procedure as done for the TSRV aircraft, EASILY Work Request forms are used to document modifications to EASILY systems. These forms are maintained in a dedicated notebook.

Wiring documentation for EASILY is maintained in a CAD-based drawing system that resides in a personal computer. The drawings are kept in the EASILY Wiring Diagrams book with copies distributed to appropriate section personnel. This document contains wiring diagrams, schematics, and block diagrams for EASILY systems. It serves as a supplement to the TSRV Wiring Diagrams book that is used on the aircraft, and thus uses the same format.

For the EASILY software, full manual sets are kept and updated for the operating systems that reside in the computers. Weekly backups of computer software are done and stored both in the EASILY facility and the Building 1244 annex.

## REFERENCES

1. Grove, Randall D.: Real-Time Simulation User's Guide, NASA Langley Control Scientific Computing Complex Document R-1C, January 1993.

2. Test Facilities and Experimenter's Guide, Terminal Configured Vehicle Program, NASA Langley Research Center, October 1977.

3. Crawford, Daniel J.; and Cleveland II, Jeff I.: The New Langley Research Center Advanced Real-Time Simulation (ARTS) System, AIAA-86-2680. Presented at the AIAA/AHS/ASEE Aircraft System Design and Technology Meeting, Dayton, Ohio, October 20-22, 1986.

4. Cleary, Robert T.: An Ultra-High-Speed CAMAC Interface to a Large Flight Simulator System, Kinetic Systems Corporation Technical Note TN-104, Presented at the Aero-Space Engineering Conference, February 11-13, 1986.

5. Cleary, Robert T.: CAMAC, a Ideal High-Performance Data Acquisition Standard, Kinetic Systems Corporation Technical Note TN-113, December 1989.

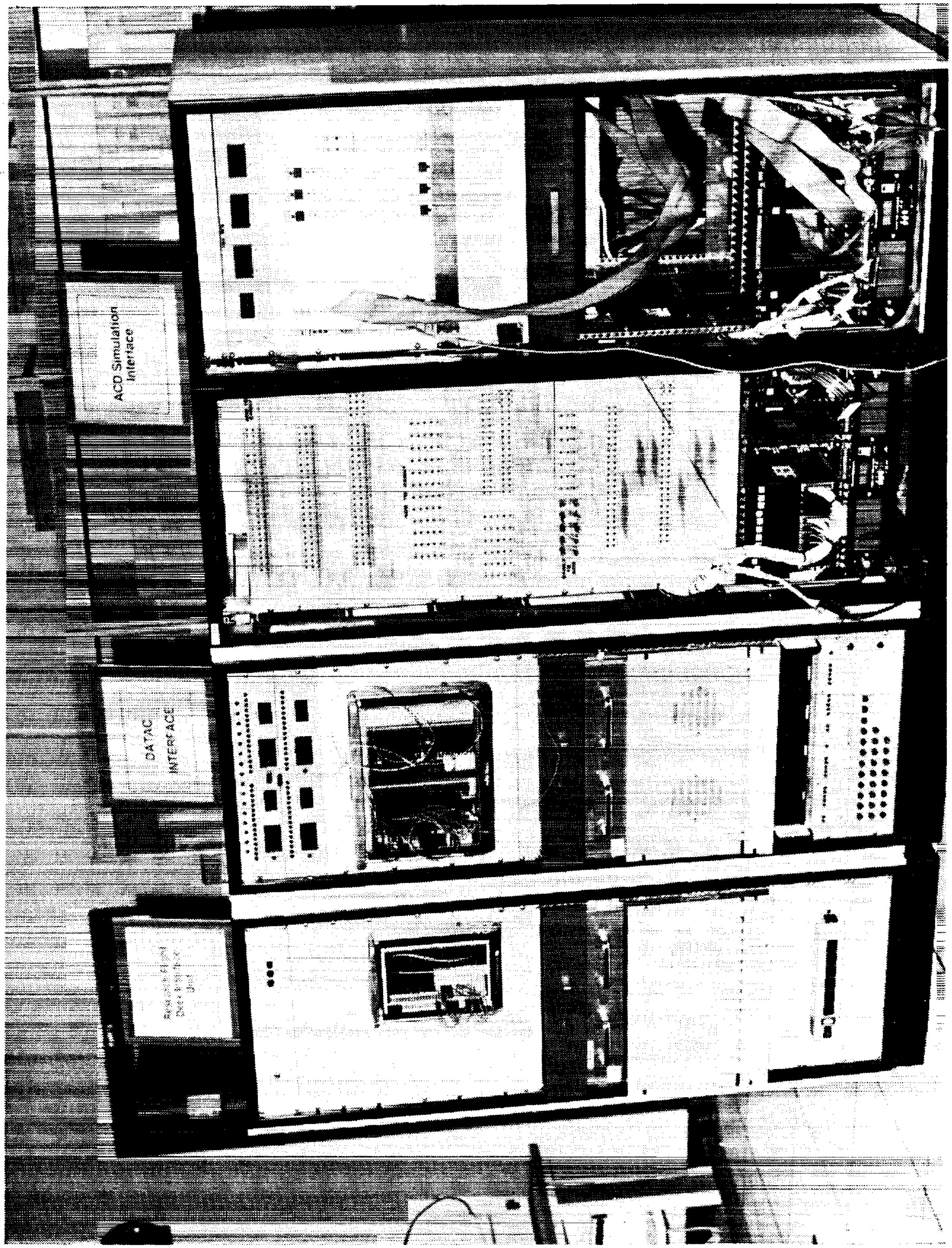


Figure 1 RFDIU, DIF, and ACD Simulation Stations


Figure 2 Flight Management/Flight Control Computer Station and VAX Computers

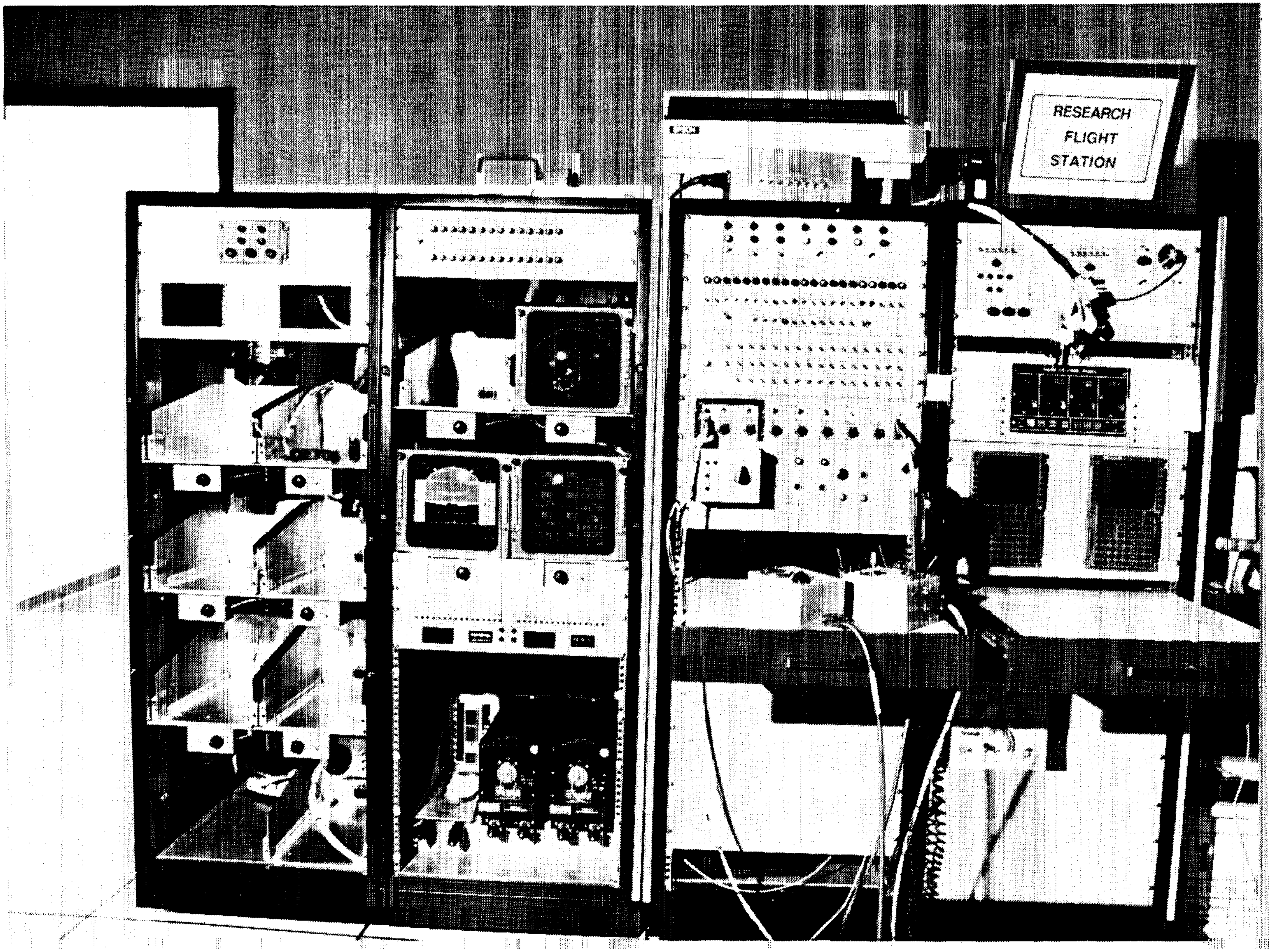


**Figure 3 Research Flight Station**

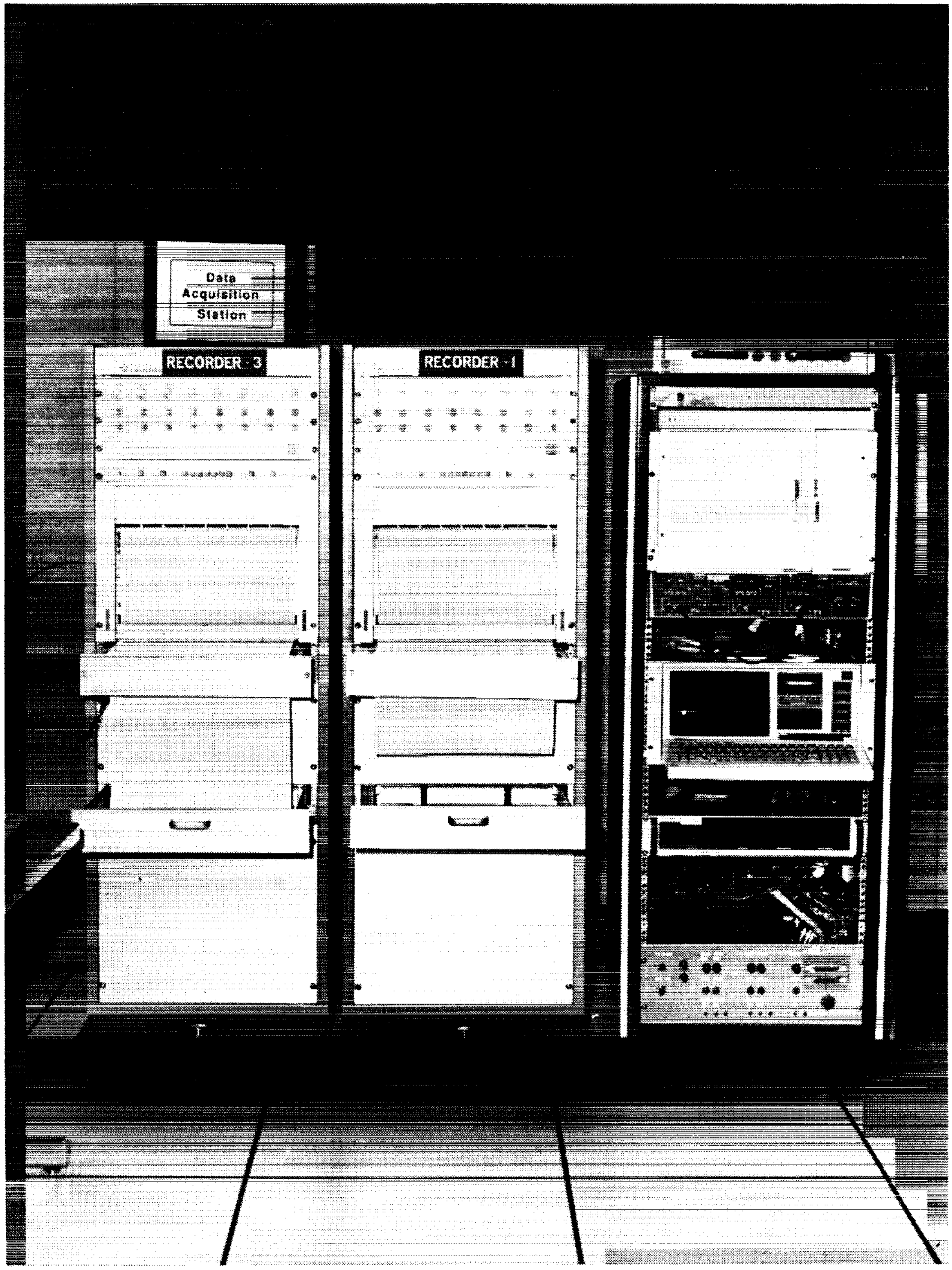


Figure 4 Data Acquisition Station

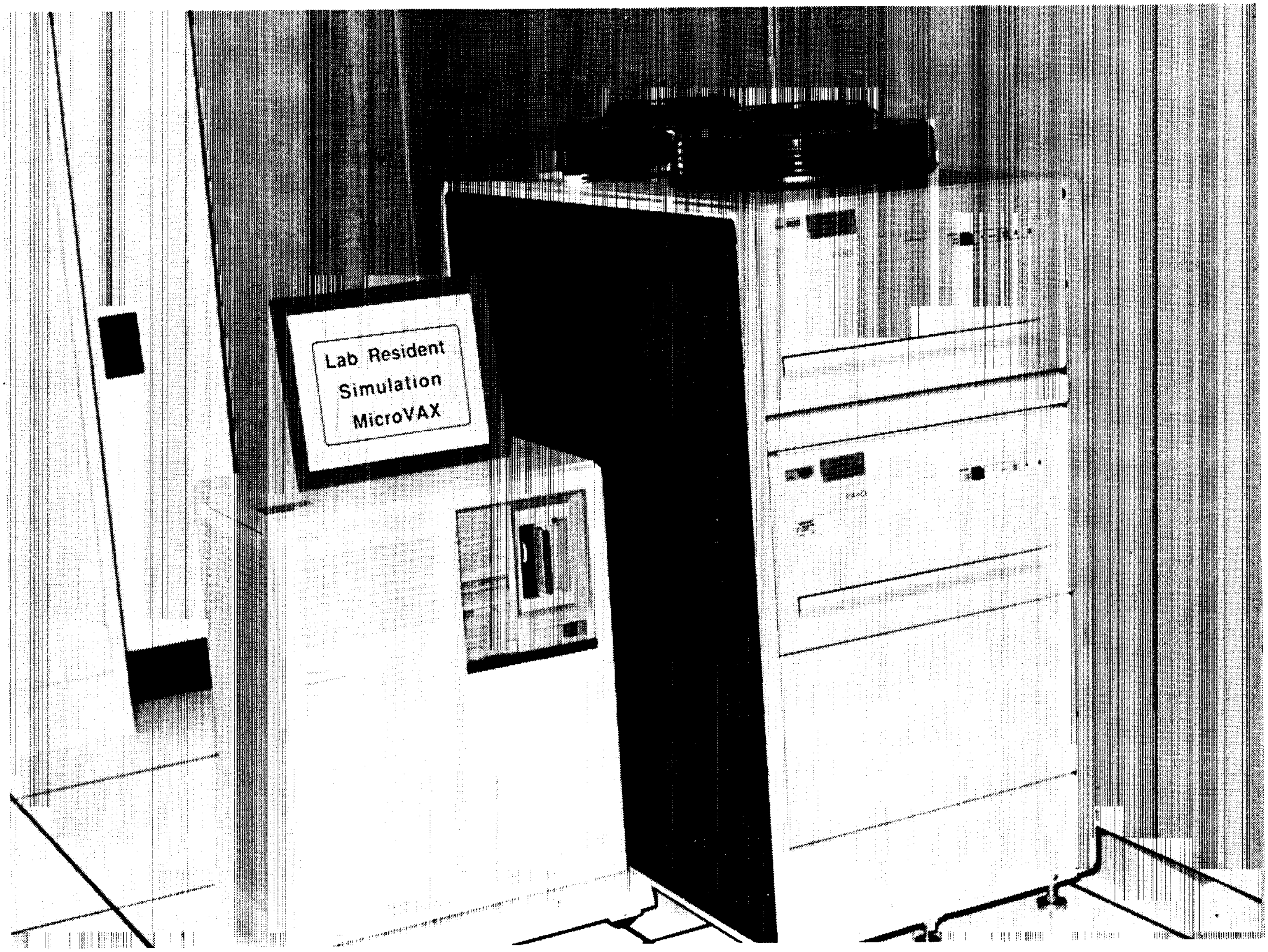


Figure 5 Simulation Computer System

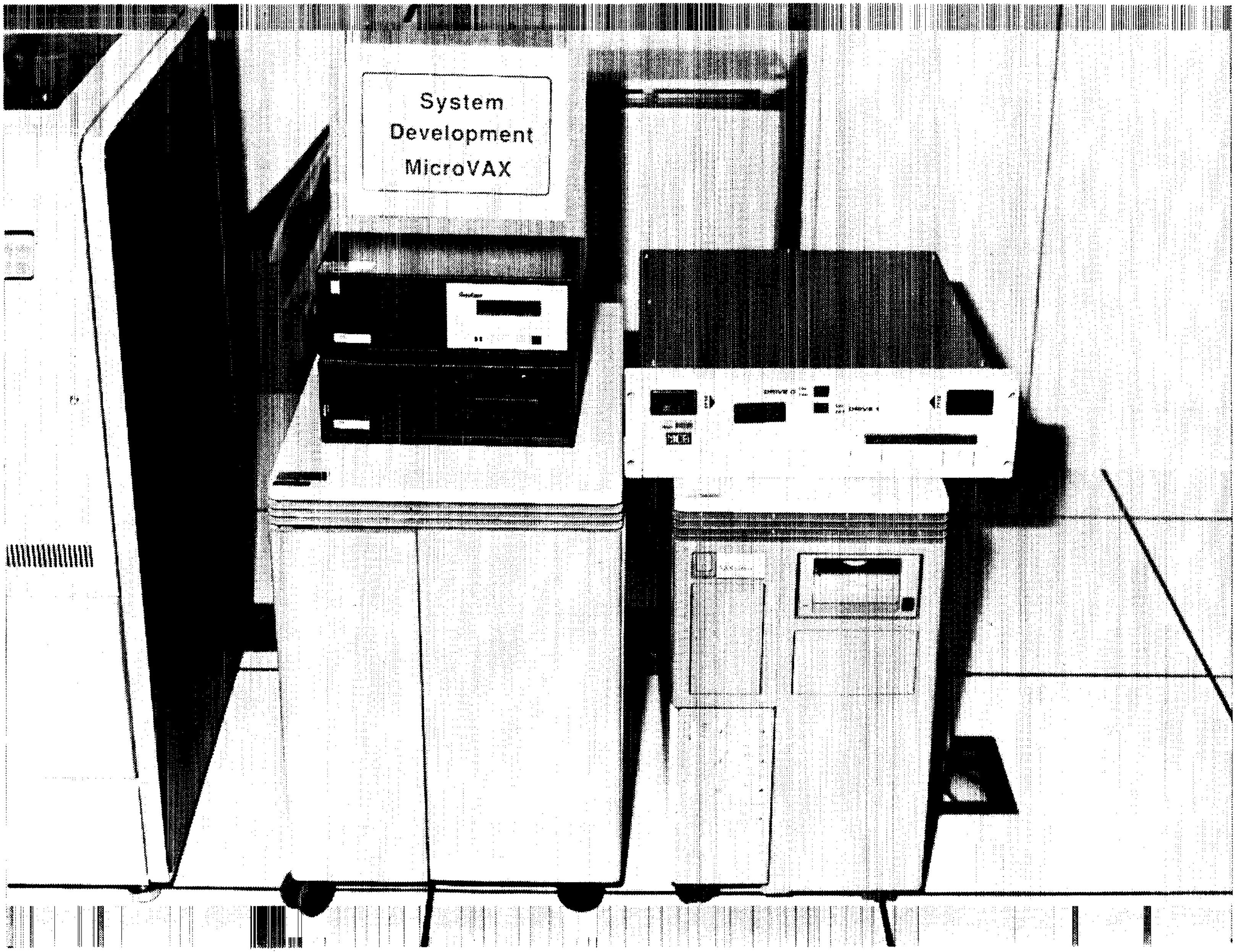


Figure 6 System Development Computer System


Figure 7 Software Development Compu

# REPORT DOCUMENTATION PAGE

*Form Approved*
*OMB No. 0704-0188*



| 1. AGENCY USE ONLY (*Leave blank*) | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED |
|---|---|---|
| | January 1994 | Technical Memorandum |

| | |
|---|---|
| 4. TITLE AND SUBTITLE<br>Description of the Experimental Avionics Systems Integration Laboratory (EASILY) | 5. FUNDING NUMBERS<br>505-64-13-11 |
| 6. AUTHOR(S)<br>Bruce K. E. Outlaw | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>National Aeronautics and Space Administration<br>Langley Research Center<br>Hampton, VA 23681-0001 | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)<br>National Aeronautics and Space Administration<br>Washington, DC 20546 | 10. SPONSORING / MONITORING AGENCY REPORT NUMBER<br>NASA TM-109072 |
| 11. SUPPLEMENTARY NOTES | |
| 12a. DISTRIBUTION / AVAILABILITY STATEMENT<br>Unclassified - Unlimited<br>Subject Category 09 | 12b. DISTRIBUTION CODE |

13. ABSTRACT (*Maximum 200 words*)

The Experimental Avionics Systems Integration Laboratory (EASILY) is a comprehensive facility used for development, integration, and preflight validation of hardware and software systems for the Terminal Area Productivity (TAP) Program's Transport Systems Research Vehicle (TSRV) experimental transport aircraft. This report describes the history, capabilities, and subsystems of EASILY. A functional description of the many subsystems is provided to give potential users the necessary knowledge of the capabilities of this facility.

| | |
|---|---|
| 14. SUBJECT TERMS<br>Simulation — Test Bed<br>Hardware/software Validation<br>System Integration | 15. NUMBER OF PAGES<br>16 |
| | 16. PRICE CODE<br>A03 |

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| Unclassified | Unclassified | | |

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102