NLS
FLIGHT SIMULATION LABORATORY (FSL) DOCUMENTATION

FINAL REPORT

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NLS FLIGHT SIMULATION LABORATORY (FSL) DOCUMENTATION

1.0 INTRODUCTION

The Flight Simulation Laboratory (FSL) is located at the Marshall Space Flight Center in building 4476. The laboratory consists of a mix of both engine hardware components and component models (i.e., the engine control architecture implemented in the simulation laboratory).

The NLS Engine Avionics Flight Simulation Laboratory Documentation Task includes both a documentation system and a documentation data set in an electronics format which is used to represent various engine configurations including project redline procedures, updates and approval cycles.

2.0 FSL DOCUMENTATION/SYSTEM DESIGN

The FSL Electronics Documentation System Design consists of modification and utilization of the MSFC Integrated Engineering System (IES), translation of the existing FSL documentation to an electronic format, and generation of new drawings to represent the Engine Flight Simulation Laboratory design and implementation. Figure 2.0-1 shows the FSL Functional Block Diagram, which describes the engine simulation laboratory.

The intent of the electronic documentation is to provide ease of access, local print/plot capabilities, as well as the ability to correct and/or modify the stored data by network users who are authorized to access this information.

3.0 FSL DOCUMENTATION CONVERSION/TRANSLATION

The original Requirements Document, Design Document, and various Functional Block Diagrams for the FSL were scanned and stored as PostScript files for fast viewing. Every paragraph in the FSL Design Document was stored as a separate file in its individual native format. These items were entered into the IES database using the MSFC Integrated File Management System (IFM) and/or MSFC Document Management System (DM/Manager) Software Tools. This enables the authorized users to view the documentation from any terminal that is attached to the server network, while giving a controlled access to features and options; such as adding, deleting, changing and/or redlining of the documentation.

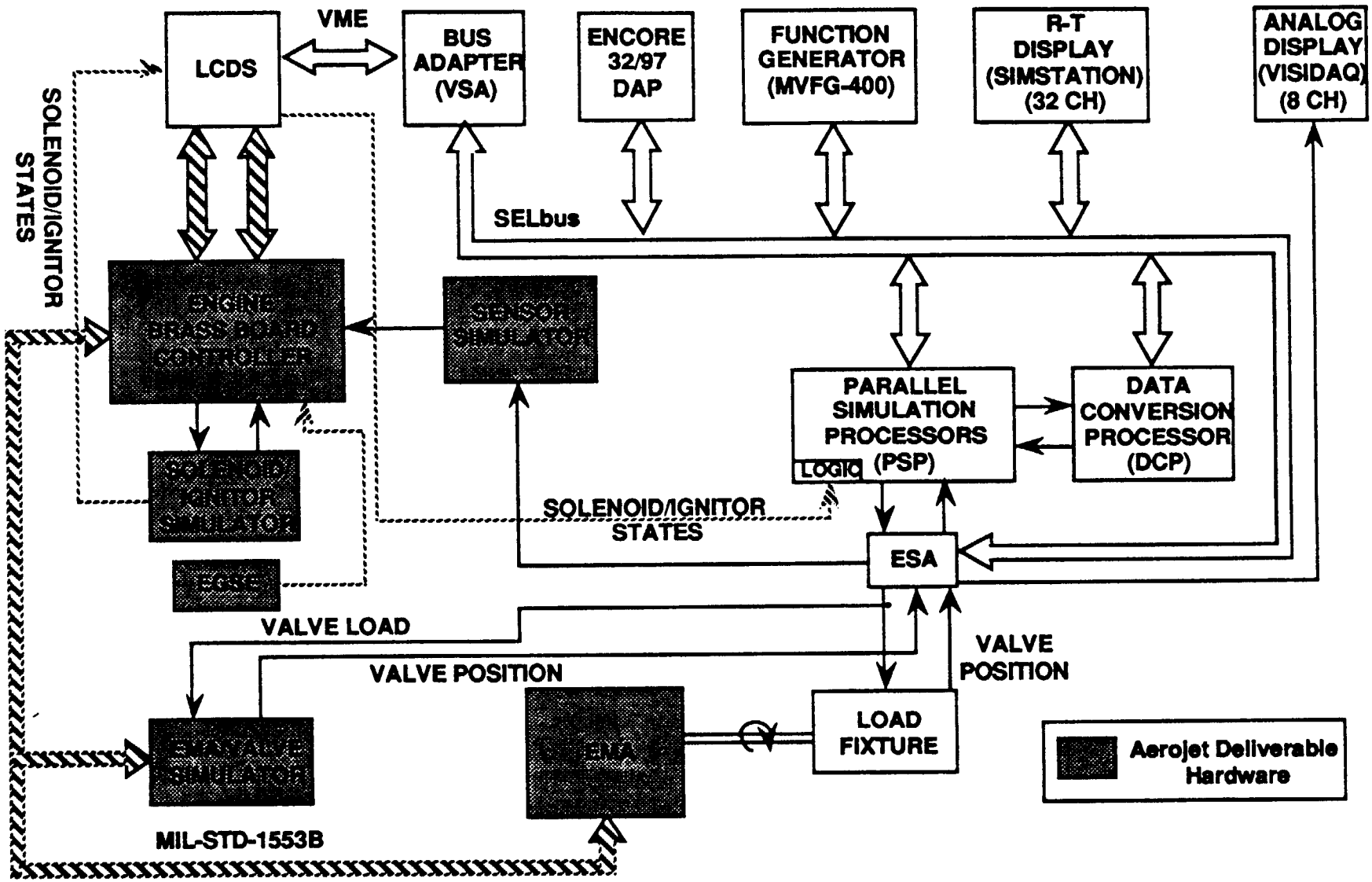

FIGURE 2.0-1. PRIMARY FSL TEST CONFIGURATION

3.1 FSL Documentation Tree

A tree diagram is provided for this documentation as a quick reference, which may be found very helpful by users not familiar with the FSL project or the methods of viewing the simulator design. This diagram depicts the different levels, and items of the documentation task. The diagram can be used as a guide to locate the information and/or to find the filenames/item numbers of the items of interest for use as the search criteria. Figure A-1 drawing 97M54311, Sheet 2, shows a top level representation of the FSL documentation tree diagram. See Appendix A for a drawing of the tree diagram. Figure A-1, drawing 97M54311, Sheet 1, shows the functional block diagram for the FSL. A complete tree diagram is included for future reference with each element shown as a separate diagram.

3.2 FSL Design Document

The FSL Design Document describes the laboratory design and operational modes for testing an engine controller, electromechanical actuation subsystem, sensor simulators and engine models. The purpose of this document is to describe an FSL design which can be used to exercise real-time simulation programs based on math models of liquid propellant rocket engines. The intent of the document was to show a configuration to evaluate the NLS STME engine but is easy to reconfigure to test any engine model and associated hardware-in-the-loop.

The FSL Design Document has been converted to an electronic format and placed on the IES electronic documentation system utilizing the MSFC Integrated File Management System (IFM). Figure 3.2-1 shows the laboratory primary test configuration as shown in the design document. This configuration can be viewed by selecting page 8 while viewing the electronic version of the document in IFM.

3.3 FSL Requirement Document

The Requirements Document was scanned and entered in the IFM system for future references and any activities relevant to the engine laboratory design. This document was originally generated with the requirement for developing an engine simulator based on the National Launch System (NLS) engine requirements generated from documents supplied by NASA and the Aerojet Company.

The Requirements Document does not represent a true final configuration of the laboratory and should not be used as a document to represent the design. Only the Design Document should be used when software and hardware capabilities are being investigated for developing the engine hardware-in-the-loop laboratory. A new requirements document should be generated when a laboratory configuration is being developed for a new engine configuration or avionics system.

3.4 FSL Documentation Search Capabilities

A search capability is included in the electronic documentation systems to ensure a fast access to the stored data. For example, to view the FSL test article grounding and isolation system, either the item description or the item number can be used as the search criteria.

3.5 FSL Hardware

The FSL hardware consists of a complement of simulation hardware and interfaces to accommodate a set of vehicle engine hardware components including sensors, controllers, solenoids, and actuators. Figure A-1 shows the FSL functional block diagram. Each block represents a part of the engine simulator or interface equipment and the engine controller. Each hardware item can be accessed by referencing the FSL tree diagram and the system hardware item number. For example, the real-time engine hardware can be accessed by looking at Figure A-1. The FSL functional diagram is protected and represents the NLS STME engine configuration. It can be checked-out from IFM and modified for a new engine configuration, by an Authorized User.

3.6 FSL Software

The FSL software consists of both applications and system software. The applications software also includes two engine models which were used to test the FSL capabilities. Utilizing the tree diagram, this software can be viewed in IFM under item 97M54311 (see Appendix A).

4.0 ELECTRONIC DOCUMENTATION SYSTEM DESIGN AND IMPLEMENTATION

The MSFC Integrated Engineering System (IES) has been enhanced and used to store and display the existing documentation (drawings, specifications, engine math models, and data sets used in the design of the FSL) to an Integrated File Management (IFM) system. Figure 2.0-1

shows the functional block diagram of the FSL which was used as a data entry to the MSFC IES and the File Management System for providing the on-line interactive operations nodes.

The IES electronic documentation system task includes modifications and enhancements of the existing MSFC Integrated Engineering System to ensure that the CAD/CAE facility is not degraded due to large transfers of image data and files on the local area network. Modifications include a new file server which is used as a database engine, a new network node concentrator for routing and high speed data communications between LANs in various buildings, enhanced plotting capabilities, and a complement of interactive network node devices. Table 4-1 lists the complement of hardware and software which was required to modify and enhance the integrated engineering system LAN communication network.

Item	Description	Part Number	Qty
1	Backbone Concentrator Node	FINF73000	1
2	BCN Red. System Resurce	FINF75010	1
3	BCN Red. Frash EPROM	FINF75015	1
4	BCN Power Supply	FINF75020	1
5	Quad Port Synchronous	FINF74280	1
6	Quad Port Ethernet	FINF74450	3
7	Multimode FDDI	FINF74930	2
8	XNS Protocol	FINF6400	1
9	Site Manager	FINF76804	1
10	Getting Started Documentation	FINF9401	2
11	Config System Vol 1 & 2	FINF9470	2
12	Operating Routers/Bridges	FINF9570	2
13	Ethernet Bridges	FINF508	1
14	Ethernet Bridges	FINF508	1

Table 4-1. LAN Hardware and Software

Table 4-2 shows the complements of hardware and software required to implement Task III of the program scope of work for the software design and implementation.

Item	Description	Part Number	Qty
1	Asterx Word and Graphicvs	SSBT32800	5
2	Asterx Filter Pack	SSBT33100	5
3	PEM Disk-2.1GB	FDSK379	1
	PEM Disk-2.1GB	FDSK379	1
	PEM Disk-2.1GB	FDSK379	1
	PEM Disk-2.1GB	FDSK379	1
4	Internal Disk Assembly	FDSK296	1
	Internal Disk Assembly	FDSK296	1
	Internal Disk Assembly	FDSK296	1
	Internal Disk Assembly	FDSK296	1
5	Fixed Disk-2.1GB	FDSK380	1
	Fixed Disk-2.1GB	FDSK380	1
	Fixed Disk-2.1GB	FDSK380	1
	Fixed Disk-2.1GB	FDSK380	1
	Fixed Disk-2.1GB	FDSK380	1
	Fixed Disk-2.1GB	FDSK380	1
6	DB Access Runtime	SNAV20600	6
7	X DMANDS Runtime	SRBT05400	6
8	Network File System (NFS)	SSAAZ08100	6
9	64MB Memory Expansion	FMEM101	1
	64MB Memory Expansion	FMEM101	1
	64MB Memory Expansion	FMEM101	1
	64MB Memory Expansion	FMEM101	1
	64MB Memory Expansion	FMEM101	1
	64MB Memory Expansion	FMEM101	1

Table 4-2. Software and Hardware Required for Task III

Table 4-3 shows the complement of hardware and software required to implement Task IV of the electronic documentation system including a database server, ORACLE database system and nodes for the interactive documentation system.

Item	Description	Part Number	Qty
1	SMP54SCO Interserve Multiprocessor	FDSK187	1
2	SMP Software	SSBY525AA-0000A	1
3	10GB Cartridge Tape Drive	FMTP149	1
4	Internal Disk-1GB	FDSK399	1
	Internal Disk-1GB	FDSK399	1
	Internal Disk-1GB	FDSK399	1
	Internal Disk-1GB	FDSK399	1
	Internal Disk-1GB	FDSK399	1
	Internal Disk-1GB	FDSK399	1
	Internal Disk-1GB	FDSK399	1
	Internal Disk-1GB	FDSK399	1
5	7.0M Office Cable	MCBLV52	5
6	Transceiver with Cable Tap	FINF261	5
7	ORACLE 64 Users Software	SNCC040AAK0000A	1
8	RIS Data Server	SN88AAC00	1
9	TD4/GLZ/32MB	TD4	1
	21 Inch Display	Display	1
	TD4/GLZ/32MB	TD4	1
	21 Inch Display	Display	1
	TD4/GLZ/32MB	TD4	1
	21 Inch Display	Display	1
	TD4/GLZ/32MB	TD4	1
	21 Inch Display	Display	1
	TD4/GLZ/32MB	TD4	1
	21 Inch Display	Display	1
10	TD5/GLZ/32MB	TD5	1
	20 Inch Display	Display	1
	TD5/GLZ/32MB	TD5	1
	20 Inch Display	Display	1
	TD5/GLZ/32MB	TD5	1
	20 Inch Display	Display	1
	TD5/GLZ/32MB	TD5	1
	20 Inch Display	Display	1

Table 4-3. Electronic Documentation System for Task IV

Table 4-4 shows the complement of hardware and software required to implement Task V, identified as the documentation system database storage subsystem.

Item	Description	Part Number	Qty
1	EXALT	SSBY537AA-0100A	13
2	DM/DB Access Runtime	SNBX385AB-0500A	13
3	7.0M Office Cable	MCBLV52	5
4	TD5/GLZ/32MB	TD5	1
	20 Inch Display	Display	1
	TD5/GLZ/32MB	TD5	1
	20 Inch Display	Display	1
	TD5/GLZ/32MB	TD5	1
	20 Inch Display	Display	1
	TD5/GLZ/32MB	TD5	1
	20 Inch Display	Display	1
5	Tranceiver with Cable Tap	FINF261	8

Table 4-4. Hardware and Software for Task IV

Table 4-5 shows the complement of hardware required to implement Task VI which is identified as a part of the network node development subsystem.

Item	Description	Part Number	Qty
1	Shinko 445	CHCS445	1
2	Disk Assembly	FDSK296	1
	Disk Assembly	FDSK273	1
	Disk Assembly	FDSK273	1
3	Internal Disk-2.1GB	FDSK380	1
	Internal Disk-2.1GB	FDSK380	1
4	TD4/GLZ/32MB	TD4	1
	20 Inch Display	Display	1
	TD4/GLZ/32MB	TD4	1
	20 Inch Display	Display	1
	TD4/GLZ/32MB	TD4	1
	20 Inch Display	Display	1
5	TD4/GLZ/32MB	TD4	1
	21 Inch Display	Display	1
	TD4/GLZ/32MB	TD4	1
	21 Inch Display	Display	1
	TD4/GLZ/32MB	TD4	1
	21 Inch Display	Display	1
6	EXALT	SSBY537-0100A	3
7	EXALT	SSBY537-0100A	2
8	DM/DB Access Runtime	SNBX386AB	3
9	DM/DB Access Runtime	SNBX386AB	2
10	DM/DB Access Runtime	SNBX386AB	2
11	TD5/GLZ/32MB	TD5	1
	21 Inch Display	Display	1
	Graphics Processor	GP	1
12	EXALT	SSBY537-0100A	2
13	7.0M Office Cable	MCBLV52	7
14	Tranceiver with Cable Tap	FINF261	7

Table 4-5. Hardware and Software Required for Task VI

Table 4-6 shows the hardware and software required to implement Task VII which includes plotting, software and interactive nodes.

Item	Description	Part Number	Qty
1	Shinko 745	FPLT793	1
2	Disk Assembly	FDSK296	1
3	Internal Disk-2.1GB	FDSK381	1
	Internal Disk-2.1GB	FDSK381	1
4	TD4/GLZ/32MB	TD4	1
	20 Inch Display	Display	1
	TD4/GLZ/32MB	TD4	1
	20 Inch Display	Display	1
	TD4/GLZ/32MB	TD4	1
	20 Inch Display	Display	1
5	EXALT	SSBY537AA-0100A	6
6	DM/DB Access Runtime	SNBX386AB	3
7	TD5/GLZ/32MB	TD5	1
	21 Inch Display	Display	1
	TD5/GLZ/32MB	TD5	1
	21 Inch Display	Display	1
	TD5/GLZ/32MB	TD5	1
	21 Inch Display	Display	1
8	DM/DB Access Runtime	SNBX386AB	3
9	7.0M Office Cable	MCBLV52	6
10	Tranceiver with Cable Tap	FINF261	6

Table 4-6. Hardware and Software for Task VII

Table 4-7 shows the miscellaneous complement of hardware and software required to complete the documentation and system design task.

Item	Description	Part Number	Qty
1	20 Meter Teflon Drop	MCBL790	25
2	Microsoft Office Software		1
3	Microsoft Office Software		1
4	Microsoft Office Software		1
5	Ethernet Adapter Card	FINF760	1
6	Sound Card for TD	FINF75200-0A	1
7	Sound Card for TD	FINF75200-0A	1
8	Sound Card for TD	FINF75200-0A	1
9	BIN/BCN V8 1 AN SUITE	41019VO80	1
10	Microsoft System MGMT		1
11	Microsoft SQL Server		1
12	Microsoft Systems MGMT		10
13	Microsoft Windows NT		2
14	Castle Rock, SNMP Net		1

Table 4-7. Miscellaneous Hardware and Software

4.1 Electronic Documentation System Local Area Network (LAN)

Figure A-2 shows the IES communication connectivity network with access paths to various laboratories and interactive network nodes. The FSL basic documentation system design consists of 25 nodes but can accommodate many additional nodes depending on the Integrated Engineering System complement of network node interactors. The communication network consists of a 1 GB backbone with TCP/IP routing and bridging. A symmetric multi-processor architecture utilizing three basic components consisting of link modules, processor modules and interconnects is used to develop the backbone concentrator node. Figure 4.1-1 shows the symmetric multi-processor architecture.

4.1.1 High Speed Router

The router backbone used for the IES node communications task consists of LAN connectivity for both Ethernet/802.3 and FDDI. Multi-protocols include both TCP/IP and Novel IPX.

The router architecture includes a symmetric multi-processor which distributes the processing power to each network interface module as shown in Figure 4.1.1-1. Each network interface module has its own dedicated processor module which performs all routing processing tasks. The routing information base and protocol is replicated on each processor module.

Network growth can be accommodated by simply adding network interface modules. No central processor is necessary for the routing task.

The backbone concentrator node supports 52 LAN/WAN interfaces and up to 13 FDDI communication channels. Expansion capabilities exist for additional FDDI or Quad Ethernet modules which can be integrated to allow additional LANs and nodes.

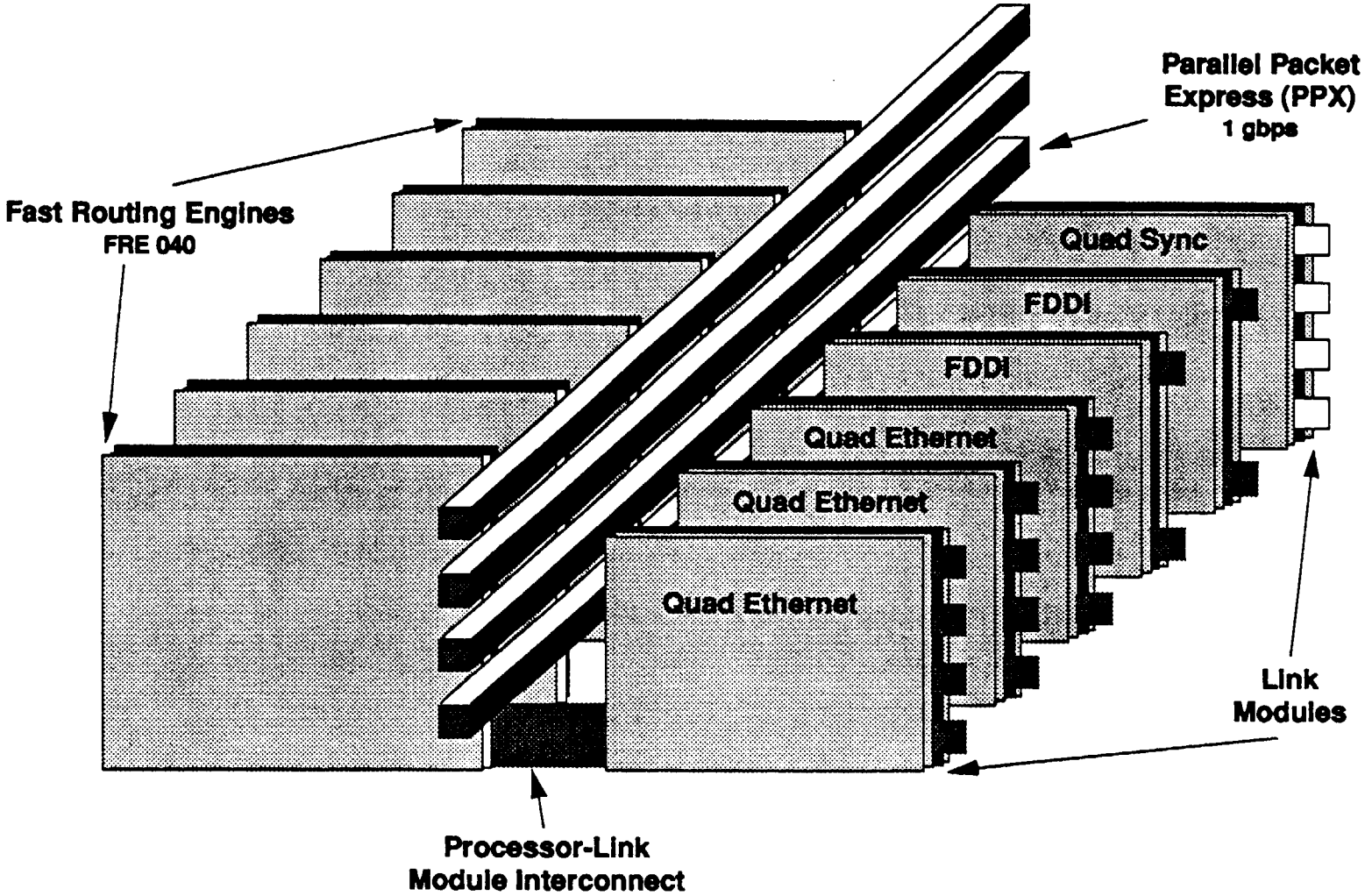

Figure 4.1-1. Backbone Concentrator Node Architecture

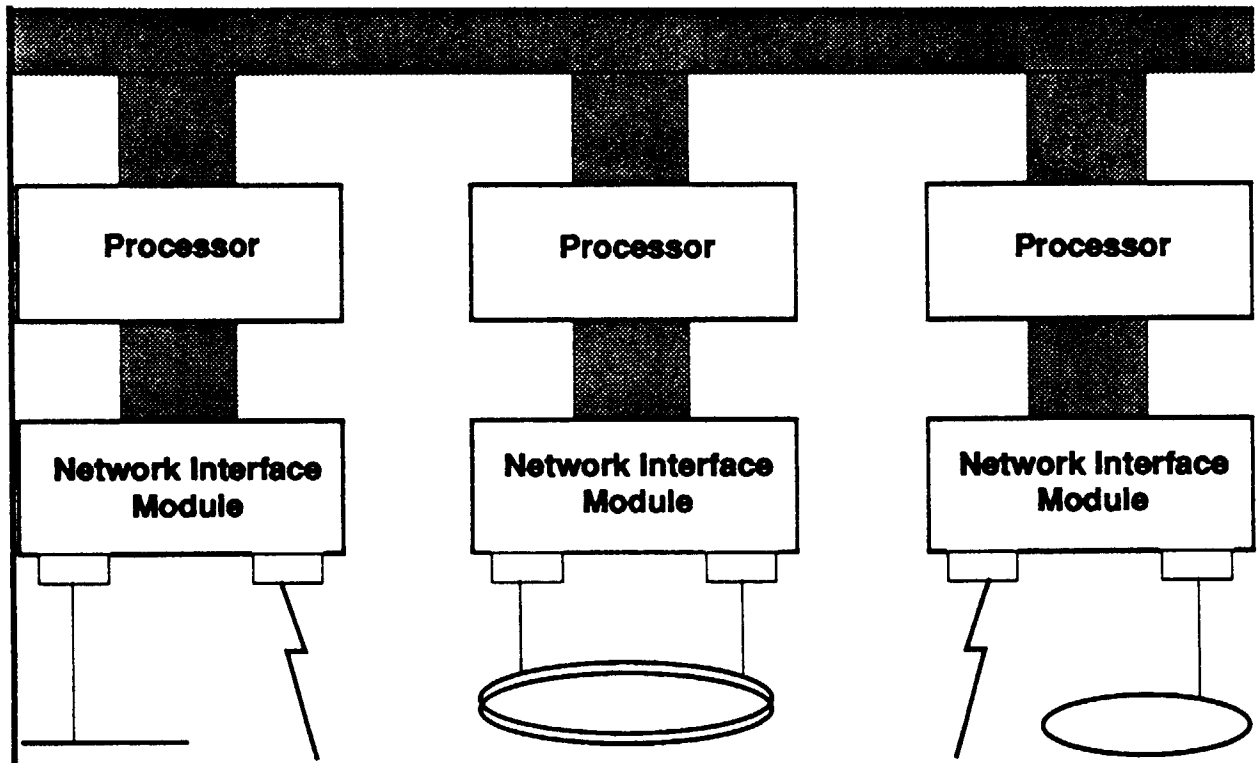

Figure 4.1.1-1. Symmetric Multiprocessor Architecture

4.1.2 Fiber Distributed Data Interface (FDDI)

The FDDI modules are used on the SMP database engine and the IAN backbone. See Figure 4.1-1 for a block diagram of the LAN and Backbone Concentrator Node (BCN). The FDDI is a 100 Mbps LAN that uses the fiber-optic media for data communications. This configuration uses 10 mbps Ethernet data communications for the SMP server but will be upgraded to 100 mbps when the FDDI module is installed in the BCN. The purpose of this upgrade is to increase the database communication throughput by a factor of ten. The two FDDI modules are shown in Figure 4.1-1 which shows the architecture for the backbone concentrator node.

4.1.3 Ethernet Communication Network

Three quad Ethernet interface modules are used for data communication between the laboratories. This interface supports IEEE 802.3 and version 1.0/2.0 Ethernet frame formats. The data communication for this module is 10 Mb and the transmission media is fiber cables between the various laboratories. The LAN protocol support includes both TCP/IP and Novel IPX. Figure 4.1-1 shows the backbone concentrator node architecture and the three quad Ethernet link modules.

4.1.4 Synchronous Communication Network

A quad synchronous communication network module is included in the backbone concentrator to perform the existing functionality required for building 4656 and off-site serial data communication task. This link serves to function up to T1 (64 Kbs) communication capabilities.

4.2 Electronic Documentation System Software

Electronic Documentation is a process of managing or controlling documents and drawings (i.e., a type of filing system). In a manual paper-based environment, a user will organize individual pieces of data into file folders and store those groups of folders and other data elements in a file cabinet.

A paperless Electronic Documentation System parallels a manual effort and provides a file cabinet, file folders, and the ability to store groups of files within the file folders. It also simplifies the task of managing distributed information in large scale engineering/management environments by enabling the diverse user population to locate, access and control data with

organized efficiency and at the same time provides the ability to create fluent links between various document formats, incompatible databases and different computing equipment attached to the IES network or to the bridged combinations of similar networks that obey the same protocol.

The FSL paperless Electronic Documentation was accomplished utilizing the Integrated File Management System (IFM) and the Document Management System (DM) software packages. These filing systems also track location, version, ownership and file integrity through a series of catalogs in a relational database system. The storage and file security is maintained on library check-in check-out basis by both systems. The following paragraphs describe the IFM and the DM System.

4.2.1 Integrated File Management System (IFM)

The Integrated File Management System (IFM) is a set of tools that provide the user an efficient method to store, retrieve, display, and manage files through a X-Windows based graphical user interface. Users have to connect to an X-Windows server from their local node (workstation, PC, Macintosh (tm), etc.) and from the X-Windows server, the menus and screens for the IFM will be displayed at the local node. In some situations, such as a project environment, the IFM follows a workflow in order to track and manage files in a secure and controlled environment. The workflow for the IFM may be setup by an authorized user anytime during or after completion of the project documentation. The IFM is not intended to impact the users core activities such as design, analysis, or document preparation. The IFM is a tool to provide the user the means to off-load and retrieve files from a local working area by transferring data between the local node and a central internal storage device. The IFM system viewer software package supports several different types of file formats which becomes very useful when used for fast viewing of the files stored in the remote storage device. However, only the authorized user(s) on the network can access, simultaneously, the items entered into the database by other users. The IFM system is compatible with both the PC based computers as well as the Macintosh computers. **However, extra care must be taken when using a Macintosh computer for entering data/files into the remote central storage device. A simple check procedure would ensure the integrity of the transferred data. To ensure good data was transferred by the Macintosh computer, they need to be retrieved back into the Macintosh hard disk and be examined. The retrieved file formats should match the format of the original files.**

4.2.2 Document Management System (DM)

The Document Management System (DM) is a set of tools that provide comprehensive file management on a network. The members of the DM family work together to provide simple file access, file viewing, non-destructive file redlining, data collection or capture, workflow control, and file security. The DM is a user-friendly windows based product that works in concert with the Intergraph/Network File Manager (I/NFM) to organize information about the work environment, its users, and its files, storing this information in any location that is accessible to the network. In some situations, such as a project environment, the DM can be setup by an authorized user to follow a workflow in order to track and manage files in a secure and controlled environment. The DM, like the IFM, is designed to provide the user the means to off-load and retrieve data stored at the central storage device from a local working area, rather than impacting the users core activities such as design, analysis, or document preparation. The DM system view/redline software package supports several different types of file formats which becomes very useful when used for fast viewing of the files stored in the remote storage device. However, only the authorized users on the network can access the files entered into the database by other users. The DM system is compatible only with the PC based computers, at the present time. However, the next version of DM will support the Macintosh computers also.

4.3 FSL Documentation System Database Server

The Electronics Documentation System database server for the IES was installed on a special server LAN and was implemented in Building 4487, room A183. The server was implemented with 4 Pentium microprocessors and is identified as ISMP05, IFMSMP1. See Figure A-2 in the Appendix A for a block diagram of the Integrated Engineering System network. The data communication system is a 10 Mb/s Ethernet LAN. However, this network is in the process of being upgraded to a separate FDDI module which has been installed in the backbone concentrator node LAN communication subsystem. This will increase the speed of the database engine to a 100 Mb/s communication link for passing data files to the different network nodes.

4.3.1 Documentation System File Servers

Figure A-2 in Appendix A shows the complement of servers for the IES and the distribution to the various buildings.

4.3.2 Database Server

The database server is located in Building 4487/A183 and is used for all database functions regardless of workstation node location. The Oracle relational database management system is installed on this server.

4.3.3 Documentation System Plotting/Printing

Both the Integrated File Management, IFM, and the Document Management, DM, systems provide the users the means to plot viewable item types to a selected plot queue. A viewable file is defined as a file of type: Postscript, TIFF, IGDS, BLKIM, tg4, etc., that can be viewed on screen by selecting either the View or the Redline buttons from the IFM menu screen or selecting the view/redline option from the DM windows. The plot option for the IFM is provided in the menu screen while in DM can be selected either by choosing the print button from the toolbar or selecting the Print option from under the File. In any case, a dialog box appears with simple instructions to follow for plotting files to the desired plot queue. The items stored in any other format (i.e., native formats) can be printed to a local printer. To print a non-viewable item to the local printer, the item must be either checked-out or copied-out to the local node using either the IFM or the DM System. This will place a copy of the file attached to that item on the local hard drive. The local file can then be opened and be printed to the local printer, using the original application software package.

4.3.4 Documentation Storage

Documentation files are stored on the five X-Window servers which are distributed on the IES network of LANs. In general, the files are stored on the X-Windows file server in the same building. Some files are also stored on the database engine.

4.4 FSL Electronic Documentation System Network Nodes

The FSL Electronic System Documentation Nodes consist of the Database Engine (Server), Archival Storage Units, Workstations and ancillary support computational resources, Plotters, PC's and clones and Apple Macintosh Personal Computers tied together into the IES network and optimized for using the shared resources and to create an efficient computing environment for engineers and managers for exchanging design information in real time, as well as tasks in the concurrent or integrated engineering environments in the areas of review and redlining of

documents, integrated document publishing and CAD document conferencing activities. The increasing number of nodes on the IES network is currently estimated at 300+.

The FSL Electronic Documentation can be accessed from any node on the IES network, provided that the user is authorized to access the database for the FSL project.

5.0 ELECTRONIC DOCUMENTATION SYSTEM VERIFICATION

The paperless FSL Electronic Documentation was tested from several locations using different types of computers such as: Macintosh, PC based processors, and MSFC's InterAct 3000 machines. The results were as expected. Every node on the network was capable of successfully accessing the database, transferring data files for storage on the remote device as well as retrieving data for viewing and redlining of documents. Both the DM and the IFM systems were QA'ed, corrected, and verified to perform as expected by the NLS Request For Proposal document, and as stated in the NLS Program Descope Design Document.

5.1 Software Comparison & Test Results

The results of the comparison of the functions and features of the DM System and the IFM System software packages revealed both advantages and disadvantages as outlined in the following list:

- Both the DM and the IFM Systems have all the required features and functions necessary for paperless electronic documentation.

- Both the DM and the IFM System software packages were QA'ed. Problems were found, corrected and verification tests were performed.

- Both the DM and the IFM Systems possess powerful and user friendly search functions, useful in finding, viewing, and/or modifying particular items stored in the central storage device.

- The IFM system menu screen structure seems to be easier to grasp for the first time user.

- Extra care must be taken when using a Macintosh computer for transferring data to the remote storage device with IFM. Depending on the file type, the data sent may not arrive

at the destination with proper format. Uncontrollable FTP default settings by IFM was detected.

- The DM system is windows based and therefore is easier to work with by a windows user.

- The DM system offers additional tools to the windows users for customizing their local display screen by using the options under Filter and/or View to tailoring the information displayed locally.

- The DM system places a copy of the file on the local hard drive every time an item is called for viewing or redlining. Consequently, any commands issued afterwards will be performed at the speed of the local processor.

- The current version of the DM system is not compatible with the Macintosh machines.

6.0 CONCLUSION

Demonstrations indicated that the engine Flight Simulation Laboratory documentation is available in paperless format and can be used in various engine simulation laboratory formats.

Test and demonstrations indicated that the LAN and router configuration can be enhanced to allow a 100 mb/s data transfer rate to all laboratories on the IES communication network.

Test and demonstrations also proved that the addition of the NLS FSL documentation task does not degrade the MSFC IES from the original design concept or CAD/CAM/CAE system.

The addition of the database engine made the IES function more useful with the increased number of users and a faster data transfer rate.

The Oracle relative database management system was installed giving a better standard for the database management system.

Twenty-five interactive NT Windows workstation nodes were added to the IES to ensure the system was not overloaded due to the additional data storage and retrieval requirements.

Both IFM and DM system were verified and QA'ed.

Data security was verified and proven to be acceptable.

Both Macintosh and PC nodes were proven to be acceptable.

Both the DM and the IFM systems were proven to possess powerful and user friendly features such as the Search function, useful in finding, viewing, and/or modifying items.

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10 January 1995

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Enclosed is the Contract NAS8-37925/SBA 4-89-1-0110 approved Final Technical Report.

If you have any questions, please contact the undersigned.

Sincerely,

Mary K. Cannon
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