FAA WJH Technical Center
00092823

Prototype Local Area Network (LAN) for NAS Facilites Information System-Phase II Design

Dorothy Buckanin
John Carr
Edwin Mack

October 1987

DOT/FAA/CT-TN86/44

Document is on file at the Technical Center Library, Atlantic City Airport, N.J. 08405

AVAILABLE IN ELECTRONIC FORMAT

U.S. Department of Transportation
Federal Aviation Administration
Technical Center
Atlantic City International Airport, N.J. 08405

FAA WJH Technical Center
Tech Center Library
Atlantic City, NJ 08405

technical note technical note

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for the contents or use thereof.

The United States Government does not endorse products or manufacturers. Trade or manufacturer's names appear herein solely because they are considered essential to the object of this report.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CT-TN86/44		

4. Title and Subtitle	5. Report Date
PROTOTYPE LOCAL AREA NETWORK (LAN) FOR NAS FACILITIES INFORMATION SYSTEM-PHASE II DESIGN	October 1987
	6. Performing Organization Code
7. Author(s) Dorothy Buckanin, Edwin Mack, and John Carr	8. Performing Organization Report No. DOT/FAA/CT-TN86/44
9. Performing Organization Name and Address Federal Aviation Administration Technical Center Atlantic City International Airport, New Jersey 08405	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic City International Airport, New Jersey 08405	13. Type of Report and Period Covered Technical Note
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Local area networks (LANs) are a rapidly evolving means of communication and resource sharing for personal computers within a small geographic area, such as one or more floors of a building. As more and more data systems are developed within the Federal Aviation Administration (FAA), the need for integrating these data systems with other resources (databases, wide-area networks, mainframe access) becomes increasingly necessary. The National Airspace System (NAS) Facilities Information System (NFIS) will serve as an information system for FAA Development and Logistics (ADL) management. The use of LAN technology will permit personal computers within NFIS to share peripherals, communicate with centrally located mainframes, and share common databases while maintaining the security of sensitive data.

Technical requirements for a LAN to support NFIS and ADL were defined, and a design was completed for a prototype LAN to meet those requirements. This document details the major design and selection criteria of the prototype LAN which will be installed and evaluated at the FAA Technical Center where major hardware and software issues will be addressed and evaluated against the design. For the reader's benefit, advantages and disadvantages of alternate LAN technologies are explained.

17. Key Words	18. Distribution Statement
NAS Facilities Information System Local Area Networks (LANs) File Server	Document is on file at the Technical Center Library, Atlantic City International Airport, New Jersey 08405

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	36	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

	Page
INTRODUCTION	1
Background	1
Objective	1
Design Upgrade	1
Updated NFIS Requirements	2
SYSTEM SELECTION CRITERIA	3
Functional Differences Between LANs and Multiuser Systems	3
LAN Software Considerations	5
LAN Cost Considerations	5
LAN Cost Benefits	6
THE PROTOTYPE LOCAL AREA NETWORK	9
Novell Capabilities Meeting NFIS Requirements	9
LAN Selection	10
Technical Center Prototype LAN	11
Workstations	11
Servers	13
Laser Printers	14
Preventing Data Loss Due to Power Fluctuations	17
Available LAN Software	18
Data Security	20
LAN Administration	21
Expandability of the S-Net and G-Net	21
Operational Testing	22
UPDATE AND CONCLUSIONS	23
BIBLIOGRAPHY	23
APPENDICES	
A - Prototype Network Costs	
B - Operational Testing	

LIST OF ILLUSTRATIONS

Figure		Page
1	Prototype NFIS LAN	12
2	Communications Servers	15
3	Asynchronous Communications Server	16

INTRODUCTION

BACKGROUND.

The National Airspace System (NAS) Facilities Information System (NFIS) is intended to support the Associate Administrator for Development and Logistics (ADL) in meeting the responsibilities of developing major improvements to the NAS. This plan calls for the development and implementation of a computer-based information system that will evolve through several phases into an efficient, cost-effective and comprehensive management instrument for ADL. Initially, the NFIS will consist of three independent subsystems: the Maintenance Management System (MMS); the Telecommunications Management System (TELMS); the Program Management System (PMS); and later, an Executive System.

The Executive System will contain data which support a wide range of general management and administrative functions and will provide linkages to data from other Federal Aviation Administration (FAA) information systems. It will also include aggregated and summary data from other NFIS subsystems. Phase I of the NFIS-E implementation will provide a basic set of capabilities, with priorities for implementation based on user requirements, data availability, and software complexity.

Access to the NFIS system will be through microcomputer workstations.

OBJECTIVE.

The objective of this effort is to select and prototype the communications network system suitable for NFIS microcomputers. The prototype will be located at the FAA Technical Center where its performance, quality, and reliability can be analyzed. In this testbed environment, the system can be used to answer procedural and operational questions for ADL networks to be installed in the FAA Headquarters and in the FAA Regions. When the performance evaluation has been completed on the prototype, a system will be designed and implemented for users of the NFIS at Headquarters, and guidelines for selection and installation of local area networks will be provided to ADL.

Two products, the work plan and the requirements analysis for the prototype network, were delivered in fiscal year 1985 under the prior program directive. Based on the written and verbal requirements provided by the Systems Engineering Service and related investigations, the selection and design of a prototype local area network (LAN) to support the NFIS microcomputer communications is contained herein.

DESIGN UPGRADE.

Initial design of the prototype LAN was completed in October 1985 and it was published as a Technical Note titled "Prototype Local Area Network (LAN) for NAS Facilities Information System." Due to additions and changes in requirements, the original design has been revised. The previous prototype design utilized the Nestar Plan Series LAN. The main reason for this selection was that it was one of the two LANS that could support multiuser Focus. The IBM Personal Computer (PC) Network also supports multiuser Focus; however, it has limited capabilities. Support of Focus was a prime requirement at the time of the original LAN selection.

Since that time, due to changes in LAN technology, the Novell series of LANS can now support multiuser Focus. Also, the requirement of the LAN supporting the Focus software has been deemphasized.

The Novell networks offer a number of advantages over the Nestar LAN. Some of these advantages are (1) a more powerful operating system (NetWare), (2) the ease of connecting to other networks that use NetWare, (3) the wide usage of the Novell NetWare operating system throughout the country, and (4) a larger selection of available application software.

UPDATED NFIS REQUIREMENTS.

FIRST REQUIREMENT. High-speed, user-friendly communication among the microcomputers at Headquarters.

SECOND REQUIREMENT. High-speed, user-friendly communication between the microcomputers within each region.

THIRD REQUIREMENT. Multiple, concurrent access to the NFIS modules and other databases resident on the file server.

FOURTH REQUIREMENT. Communications links between any authorized user and databases residing on mainframe computers. For FAA purposes, particular emphasis should be placed on Martin Marietta's IBM 3083 and the Technical Center's Data General MV8000.

FIFTH REQUIREMENT. The availability of a gateway to an X.25-wide area network.

On March 6, 1986, a contract was awarded to United States Telecom (Uninet, Inc.) to install a private nationwide data network for the FAA. Total cutover from the existing Public Data Network to the new Administration Data Transmission Network (ADTN) was expected 12 months after contract award.

SIXTH REQUIREMENT. Expandability and flexibility of the network to grow and support all users as new uses develop, as systems grow in size, and as reorganizations occur.

SEVENTH REQUIREMENT. Availability of a large number of LAN (multiuser) applications software products.

An earlier requirement that is currently in question is the necessity for multiuser Focus, a fourth generation database-oriented language, to run on the LAN. The NFIS Executive System is written in Focus; however, development of the Executive modules has been halted.

Multiuser Focus may be used on the system at some future time. Multiuser Focus running on a dedicated PC-AT microcomputer is cost beneficial because it provides Focus to each workstation in the system. The cost of the multiuser software package is $6800, while individual copies of Focus cost $1500 each. Use of more than five workstations on the LAN will pay for Focus, with an additional cost benefit for more users. Multiuser Focus can support up to 16 concurrent users. Because of questions concerning future development of the NFIS Executive System, multiuser Focus is not being installed on the prototype LAN at this time.

EIGHTH REQUIREMENT. Availability of file servers over 100 megabytes. The capability to support multiple file servers on any network which would provide for the growth of NFIS modules and shared database application.

NINTH REQUIREMENT. Adequate security mechanisms to ensure confidentiality of sensitive data and defined user privileges to prevent accidental or intentional destruction/modification of files or data.

TENTH REQUIREMENT. Quick and easy backup capability for file server.

Data is an important resource, and databases are costly to create or replace. Important shared databases reside on file servers. Recovery from damage or disaster should be as quick as possible.

Many maufacturers provide built-in tape backup facilities with their file server.

ELEVENTH REQUIREMENT. Clear, comprehensive documentation. Formal training for LAN supervisors is also highly desirable.

SYSTEM SELECTION CRITERIA

FUNCTIONAL DIFFERENCES BETWEEN LANS AND MULTIUSER SYSTEMS.

Two general types of systems are available which could meet the NFIS requirements: multiuser systems and LANs. A multiuser system has a vertical structure in which workstations are slaves to a central processing unit (CPU). A LAN has a generally horizontal structure in which the intelligence is distributed among all the workstations and servers.

A multiuser system is a time-shared system with a group of terminals and other devices sharing a main processor. A small multiuser system may contain a small number of terminals or PC workstations and a more powerful PC as the CPU. Multiuser systems have a significant range, the largest being a mainframe processor with hundreds of terminals and peripherals.

Conversely, in a LAN, independent computers are connected by a data link for file, resource-sharing and for communications tasks. The LAN utilizes a file server which contains the operating system software to control the network operation. Comparison of some of the advantages and disadvantages of these two types of systems are presented below:

1. There is more user independence on a LAN. Workstations can operate either standalone or on the network. Non-network computing activities, such as project and resource scheduling and spreadsheet analysis, can be accomplished without impacting the operation of the LAN. It is also generally easier to maintain more flexible computing hours on a LAN than on a multiuser system. Since larger computer systems usually require onsite operators and system managers, the cost often prohibits the support of operation during periods of limited use.

2. LANs can transfer data much more rapidly than the multiuser system which usually uses RS-232 interconnections which run at 9600 or 19200 baud (bits/second) maximum; LAN speeds typically begin at 500,000 bits/second and today's major

networks run at 2 to 10 megabits per second (Mbps). A LAN is therefore more efficient in handling large data transfers, such as large programs, data files, or text files.

3. Data security is essential in management data communication systems. Record and file locking are not available with many of the small multiuser operating systems (including Unix and System v). Many of the better LANs offer very good security techniques including passwords, access rights, encryption, etc.

4. Much of the popular software, such as Wordperfect, dBase III, R:Base 5000 and Lotus 1-2-3, is not available for mainframe and minicomputer systems.

5. The most advanced user-friendly computer interfaces (windows, popup menus, mouse and/or touch screen control, and on-line help) are available mostly on microcomputers. These user-friendly interfaces greatly reduce the amount of time necessary for employees to learn to use the system productively. Inexperienced personnel can quickly master applications using these user-friendly features.

6. Most LANs provide gateways to connect the users to mainframes. Most common gateways emulate an IBM 3274 cluster controller. It is used for communication with IBM mainframes using IBM's Systems Network Architecture (SNA) protocol. Some LANs also provide for bisynchronous communication with mainframe computers. Gateways are also available which allow any workstation on the LAN to communicate asynchronously with mainframe computers.

7. There is little standardization among multiuser operating systems.

8. A LAN is typically more expandable than a comparatively sized multiuser system. Also, LANs can be connected (bridged) to other LANs to incrementally increase the number of users as organizations grow.

9. One of the common multiuser operating systems, Unix, is complex and can be difficult for the inexperienced user to master. File security and real-time support are weak in Unix and System v ("Multiuser Operating Systems Provide a Low-Cost Alternative to LANs," J.D. Moseley, EDN, June 27, 1985), but there are improved versions of the Unix operating system which do provide good real-time capability.

10. If the CPU in a multiuser system is nonfunctioning, all system terminals are idle. If the file server in a LAN is nonfunctioning, local processing on the microcomputers can still continue.

11. Software cost trends favor LANs. The steady increase of software companies involved in LAN program development has created a competitive environment. This has tended to reduce the cost of new LAN application software. Upgrades are more frequent for major LAN applications; there is little incentive for vendors to upgrade mainframe software.

12. A small multiuser system usually is less costly than a comparatively sized LAN, sometimes by as much as a half. However, the life cycle cost of the system will be much greater if a normal system growth is experienced due to expansion limitations of the small multiuser systems.

13. A multiuser system can have an advantage over a LAN when sharing data. Access speed is faster when the shared data constantly resides in the central processor random access memory (RAM) of a multiuser system rather than on the disk of a LAN file server.

LAN SOFTWARE CONSIDERATIONS.

The local area networking industry is undergoing a period of realignment and standardization. The results will affect virtually every aspect of microcomputer networking. Critical aspects of standardization affect network software. The standards for microcomputer operating systems, for network operating systems, and for applications software will affect the reliability and the capability of a network. If software issues are not considered, the future growth and flexibility of the network could be seriously impaired.

Operating system compatibility is recognized as crucial for mainstream LANs. Most LAN manufacturers have announced support for MS-DOS 3.1 (operating system from Microsoft). The DOS 3.1 provides a large number of functions to application programs. The functions include routines for keyboard input, construction of file control blocks, date and time functions, and a variety of disk directory and file handling functions. The critical functions in a network environment deal with the disk directory and file handling. There must be some mechanism for synchronizing between users so that they do not damage or destroy each other's work. The DOS 3.1 supports record-locking to synchronize data usage.

Because of the nature of the new DOS, industry experts expect that many of the LAN companies will be forced to abandon their old software and create an entirely new network environment (Wilcox, 1985). Choosing a LAN that does not support DOS 3.1 and the Information Standards Organization (ISO) standard for interfaces can easily mean costly and excessive lifecycle maintenance costs to support an obsolete system.

As the environment changes, software houses that write network applications will see many of their current products for disk servers become obsolete. New software written for the standard will run on all LANs that support DOS 3.1. Due to this standard, a major increase in available LAN multiuser applications is expected. To support future growth, a network should definitely support DOS 3.1 or higher on the file server.

LAN COST CONSIDERATIONS.

LANs are priced by components. The major hardware components are file servers, interface cards for workstations, communication servers, and cabling. Application software is purchased separately. Appendix A gives a breakdown of network costs (August 1986).

The installation of cable can be the most expensive cost in a LAN. The cost to install cable may exceed the cost of the network devices. Generally older buildings will have higher installation costs. Newer buildings are designed to accommodate communications cabling as older ones are not.

When considering the addition of workstations to the network, the attachment cost should be low in comparison to the cost of the workstation. A significant cabling effort should not be required. The initial cable installation should include a reasonable amount of wiring for planned and probable expansion. Bus topologies are easier to expand than star topologies.

As with all computer systems, maintenance costs may dominate the total life cycle costs of the network. These costs should be carefully evaluated initially and then included in future budget plans. Cost benefit analysis is suggested to determine the feasibility of ordering spare components versus buying a maintenance contract.

LAN COST BENEFITS.

The cost benefits of local area networks accrue from two areas:

1. direct savings from equipment and services that do not have to be bought, and

2. productivity gains (cost of labor saved) from work that does not have to be done.

Additional nonquantifiable benefits accrue from increased data integrity.

DIRECT SAVINGS (SHARED HARDWARE). Local area networks provide for sharing many different items of computer hardware and software, as well as some telecommunications equipment and general office supplies. With networks, all users can share printers, disk storage, communications devices, files, databases, utilities, and application software. Multiple users can share one or more printers, including letter quality, and high-speed laser printers. Even though many users will require letter quality or graphics output on an occasional basis, it is not cost effective to purchase such special printers for each user. For example, the various rewrites of draft documents can be prepared using an inexpensive printer attached to a user's workstation. The finished document can be output on the high-quality, shared network printer.

Network users can take advantage of sharing large capacity disk drive storage contained in the network file server. This additional benefit of resource sharing will provide the capability of sharing databases, documents, files, and spreadsheets. Duplicate files will not be required on multiple PCs. The cost of upgrading individual PCs with larger disk drives is avoided.

Data, files, documents, etc., on the network can be backed up on a network device, such as a compact tape drive. Individual backup systems need not be purchased for each user. One shared backup device provides for a cost-effective use of expensive resources.

Many users can share data communications channels to mainframe computer systems and wide area networks. This eliminates the cost of additional transmission lines for most users, as well as the time element necessary for installation of those lines.

Through the use of special communications devices, network users can also utilize and share the resources of mini and mainframe computers and shared communications modems. These additional devices allow network users to communicate with send and receive files from other computer systems, thus eliminating the need to acquire these data through more manual and time-consuming methods. Sharing communications modems permits network users the flexibility to dial out of the network and connect to other networks, on or off premises mainframes, and commercial database services. The cost savings occur when individual modems are no longer required for each user's personal computer. The need to purchase special interface cards, such as the IRMA card (currently $750 each) for access to IBM mainframes, or other terminal emulation hardware and software is no longer required.

DIRECT SAVINGS (SHARED SOFTWARE). Many of the more popular software packages are available for use with the Novell network. Thus, multiple copies of software, such as dBase III Plus, WordPerfect, and R:Base 5000, would not be required. The cost savings for the network version for ten users can be 50 percent or more of the cost of ten single-user versions.

PRODUCTIVITY GAINS. The databases created with dBase III Plus can reside on the network which will permit access to the data to those who require it and allow the data to be shared among network users. This same procedure can be used for word processed documents. This rapid accessibility to shared databases will result in increased productivity for network users, eliminating the need to reproduce, transport, and load the data at individual workstations.

All data and files maintained on the network file server can be backed up on a regular basis on various media, including tape cartridge, nine-track tape drives, or other removable storage media, by the LAN Administrator, thus preventing the loss of data and the subsequent productivity loss required to replace these lost data. Automatic backup products are also available to allow selective backup of specific files, or files that have been updated. These backups can be set as automatic "appointments" that will function unattended. These backups can then be handled by a centralized organization. This will result in productivity savings, since backups can be tracked and filed. All users will know where to obtain the data when needed and not search for someone with the floppy disks or tape cartridges containing data needed due to a malfunction of the workstation or network. The actual backup procedure is cost-effective because it can be handled centrally, thus precluding the necessity of multiple users taking the time to perform the backup functions.

Data and files can be shared via the network's large capacity storage, rather than the manual method of sending floppy disks to personnel requiring specific data, i.e., the so-called "sneaker" LAN.

The electronic mail feature of Netware permits the transmission of documents, letters, memos, files, etc., to any or all users of the network. These items can be created with a word processor such as WordPerfect and then "mailed" to users. Mail can be forwarded to additional users, and items of mail can be sent "express" which will notify the recipient that mail has been received. Third party electronic mail packages, currently under evaluation, also provide for features such as "registered return receipt" mail.

Productivity increases result from the time saved by not having to manually reproduce and hand-carry mail to destinations. Direct savings are realized by the elimination of some paper, postage, and copying needs.

The benefit of resource sharing permits users located in different area of the organization to share the results of their independent work, thus increasing overall efficiency and productivity. There is no longer the need to create multiple copies of databases or files because users can share these data on the network.

These productivity gains will enable the Regions to efficiently manage the increased workload associated with the NAS Plan without unacceptable increases in staffing.

ADDITIONAL COST/BENEFITS OF NOVELL NETWORKS. Novell Advanced Netware can be used with a variety of popular IBM compatible PCs, thus providing flexibility in the microcomputer hardware configurations, permitting the use of existing computers, and reducing expenditures for special PCs or other hardware. The addition or deletion of workstations on the network can be performed without having a significant affect on network activity. The G-Net configuration permits connection of up to 128 workstations per file server. Workstations can be added or deleted to a G-Net or Arc-Net configuration with a minimum of costly cabling. This results in a cost saving over networks that require specific microprocessors or that require loss of system time and productivity when configuration changes are necessary.

The Novell Netware operating system can be installed on many different hardware configurations provided by other suppliers including equipment from Proteon, Arcnet, and 3Com. Existing networks can thus be integrated into the Novell network without the cost of replacing the existing network hardware. This capability will also provide an additional flexibility in that several different network configurations can be installed at a single location to (1) meet the performance requirements of the organizations using the network and (2) most cost effectively meet the unique organizational needs due to the physical layout of the users and general building architecture.

PRODUCTIVITY BENEFITS RESULTING FROM SHARED SOFTWARE AND SHARED DATA STORAGE MEDIA. The installation of network compatible software packages would be performed by experienced personnel, thus eliminating the time-consuming efforts of many naive computer users attempting to install and configure application software packages. In addition, a single point of contact can then be established for directing questions and problem resolution, rather than to a large number of users of varying knowledge and experience.

The use of a standard configuration of application software provides the benefit of standard training throughout the FAA, regardless of location; retraining of personnel moving from different offices, divisions, etc., is eliminated. Personnel can be moved on short- or long-term basis without the loss in productivity while learning new computer software. Standard application software will also permit the exchange of data, files, documents, etc., without confusion as to file formats and internal structure. Everyone will be speaking the same "language." Maintaining a standard application package will also result in the development of in-house expertise. It will eliminate some of the costs inherent with service contracts or the cost of using contractors to perform the functions of installation and problem resolution. Techniques developed by experienced users can be easily shared and distributed to all users throughout the Agency. This will again provide for a single point of contact for users to direct inquiries which can reduce the potential loss of productivity and possible damage to files through a lack of knowledge and experience.

Single-use software packages can run locally on a workstation while the workstation is logged into the network. Single-user WordPerfect has been tested. This situation will permit the network user the ability to utilize previously owned single-user software and still have the ability to access network files. These word processors installed as single-user versions will retrieve and save documents to the network drives. They will help to reduce any loss of productivity as new users become familiar with network functions and multiuser software. Existing

single-user software does not necessarily have to be scrapped in favor of multiuser software. This will reduce productivity losses of retraining personnel on new network packages. It should also be noted that many of these single-user packages have network versions available for modest upgrade prices.

OTHER NONQUANTIFIABLE BENEFITS. The use of the LAN with its shared resources can also result in quality improvements. Network updates to data can be performed in a timely manner. The network provides improved communications, and by sharing knowledge and information, it promotes efficiency and effectiveness in all areas.

THE PROTOTYPE LOCAL AREA NETWORK

NOVELL CAPABILITIES MEETING NFIS REQUIREMENTS.

The first requirement for NFIS is the communication among the microcomputers at Headquarters. Novell offers a variety of LAN topologies from which the network best suited for the building and workstations can be chosen. Any of these networks can be easily connected together utilizing bridge software and hardware available from Novell or other sources.

The second NFIS requirement is the communication among the microcomputers within each FAA region. Due to the distances between sector offices and each regional office, there is a need for remote communication capabilities. Novell offers communications servers which permit remote workstations to communicate with their LANs.

High-speed access to NFIS modules is part of the first two NFIS requirements. Novell LANs have special features, such as custom menus, which make them generally out perform other LANs. NFIS modules will be stored on high capacity file servers for fast access by the workstations.

Managers request a user-friendly system. The Novell menu-driven software is very user-friendly. At the user level the system can be turnkey with no requirement for user knowledge of networks or operating systems.

Another major requirement of NFIS is communications links between the workstations and management databases that reside on mainframe computers. Novell provides both synchronous and asynchronous gateways to mainframes.

A future requirement which should be currently considered is the availability of a gateway to the ADTN wide area network. Gateway Communications markets an X.25 gateway for Novell G-Net LANs.

It was discussed earlier in this report that a LAN must support DOS 3.1 because of its data integrity provisions. Novell NetWare supports DOS 3.1.

Since Information Builders, Incorporated, is coming out with a version of its multiuser Focus development and management system for the IBM PC Network, this software package should also operate on all Novell NetWare supported LANs.

Novell has by far the most extensive inventory of application software and provides a list of over 3000 programs that will run on its networks.

Novell offers a variety of file servers with capacities up to 183 megabytes. A network disk storage can be increased by the addition of other file servers. Many of these file servers offer built-in tape backup capability.

Novell documentation is rated as being excellent.

LAN SELECTION.

Novell offers five complete local area network systems (each includes hardware, software, and operation manuals). All five networks are supported by versions of the NetWare operating system. The five networks are S-Net, ProNet, Etherlink, Arc-net, and G-Net. They vary in topology, cabling requirements, and speed.

S-Net is a high-performance system. It utilizes the star topology and dual twisted-pair cable. It accommodates 24 nodes (workstations) per file server. Two servers will support 44 nodes. Speed decreases by about 10 percent for data transferred between servers.

ProNet utilizes a ring topology, similar to the IBM Token Ring network. Its cabling uses wire centers to permit flexibility, and hence, the system physically looks like a "string of stars." The cabling can be twisted pair, twinax, or fiber optics. The system runs at 10 Mbps.

The star configuration in the networks above is best suited to environments contained in a small geographic area where workstations are infrequently moved.

G-Net and Etherlink are both bus topologies. G-Net runs at 1.43 Mbps, and its end-to-end cable distance can be up to 7000 feet. Etherlink operates at a higher data rate of 10 Mbps, but this causes the maximum cable length to be a much shorter distance of 1600 feet.

The advantage of the bus topologies is that a single coax cable is daisy-chained between the workstations and servers. If cable layout is accomplished with reasonable planning, workstations can be easily added, deleted, and moved.

The Arc-net topology uses hubs to connect workstations and servers as in a star configuration, and then the hubs are interconnected to form a string of stars. Data rate is 2.5 Mbps. The maximum cable length is 20,000 feet. It is the most flexible LAN offered by Novell.

Aside from the above networks marketed by Novell, the NetWare operating system can run on a large number of the most popular networks and is extensively used throughout the country. Networks using Novell NetWare can be easily bridged together allowing them to function as a common network.

TECHNICAL CENTER PROTOTYPE LAN.

The LAN hardware selected for the prototype network at the Technical Center (figure 1) will be a combination of two LANs marketed by Novell; the S-Net and the G-Net. Both use versions of the Novell NetWare Operating System. These two were chosen because they represent two different popular LAN topologies and they can be evaluated against each other. They also can be interconnected by means of a bridge and evaluated as one larger LAN. Bridges may be needed in the Headquarters network if it appears that the Headquarters organizations would be better served by a group of smaller LANs rather than a single large one.

Each LAN will have a 109-megabyte file server and four personal computer workstations; there will be some flexibility in reconfiguring the workstations between the two types of LANs. The workstations will be a mix of IBM PC XTs and PC/370s. In addition there will be a SNA gateway to link the G-Net to the Martin Marietta (IBM 3083) mainframe in Washington, DC. Workstations on the S-Net will access the Martin Marietta IBM 3083 through the bridge.

The S-Net is a baseband system with a star topology, a 0.5 Mbps data rate, and dual twisted-pair cable. In the star topology, each workstation connects directly to the file server. Overall system speed is very fast and does not degrade appreciably as additional workstations become active. A maximum cable distance of 1500 feet is possible between the file server and the farthest workstation. The maximum number of workstations that can be connected to an S-Net file server is 24, but with the addition of multiple servers, the net size can be increased in multiples of 22. Novell recommends that no more than eight servers be on a single LAN, bringing the maximum LAN disk capacity to 2000 megabytes. In addition, each server is capable of handling up to five shared printers.

The G-Net is also a baseband system with a bus or linear topology; the cable is daisy-chained between each device on the LAN. Common coaxial cable is used for interconnection and runs at 1.43 Mbps. The maximum end-to-end cable distances can be 3500, 4000, or 7000 feet depending on the type of coax used; it can support up to 128 workstations per file server. Multiple file servers are permitted as in the S-Net above. It uses network interface cards from Gateway Communications, hence, the name G-Net. The operational speed tends to slow down when more than 12 workstations (approximately) use the net at the same time. This condition will be evaluated in respect to the FAA's management information requirements. Gateway Technology has also developed an X.25 gateway for G-Net.

WORKSTATIONS.

Workstations for the NFIS LAN are IBM PC microcomputers. In addition, the Novell LAN has been tested with 18 different types of IBM compatibles. Each workstation can be operated in a stand-alone mode or powered down without affecting the LAN operation. Each workstation will have a full-length network interface card residing on the PCs internal bus to allow it to be part of the prototype LAN. The card contains the intelligent devices that control the transmission of data, handle the network protocols on the LAN, and provide data buffering for the workstation.

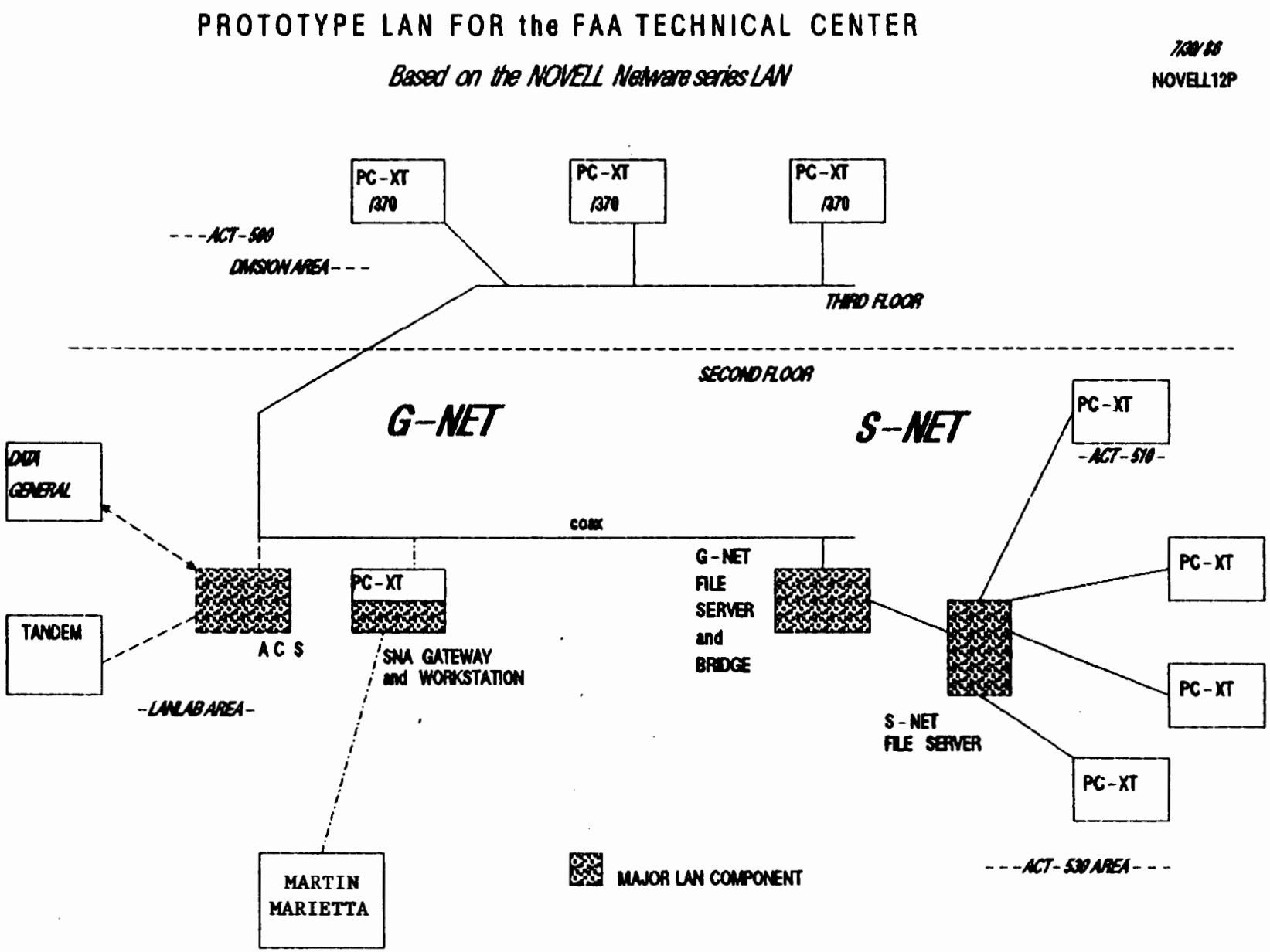

FIGURE 1. PROTOTYPE NFIS LAN

Novell states that the following microcomputers were tested and found to be functional as workstations:

IBM PC	Eagle PC Spirit XL
IBM PC XT	Eagle PC-2
IBM PC AT	ITT Extra
IBM PC 3270	TeleVideo 1605
IBM PC Portable	TeleVideo 1605H
Texas Instruments	Santa Clara Systems
Professional Computer	PC Terminal
Sperry Personal Computer	Leading Edge PC
All Compaq Models	AT&T Information
Columbia MPC-VP	Systems 6300
Corona PC	

Novell recommends that each workstation have a minimum of 192 kilobytes of memory for network usage. The DOS interface shell for DOS 2.0 and DOS 2.1 is approximately 24 kilobytes in size; the shell for DOS 3.0 is approximately 26 kilobytes.

SERVERS.

Servers fall into two categories: file servers and communications servers. A file server contains fixed disk storage which is shared by the workstations on the network. The disk contains the network operating system software (e.g., Novell's Advanced NetWare) which exercises control over the network. The multiuser software packages and any shared databases must also reside of the file server.

The S-Net file servers are available with 1 or 4 megabytes random access memory (RAM) and disk memory of 23, 47, 109, or 183 megabytes. They are available with or without tape backup. Disk storage can be expanded to 2 gigabytes. The RAM can be expanded to 8 megabytes. Each server can support up to five shared printers. The Motorola 68000 is the processor used in the S-Net server. The advanced NetWare operating system is supported. Each S-Net file server requires a network console, consisting of a terminal and keyboard.

The S-Net prototype LAN file server will include a 109-megabyte hard disk to provide quick shared access to the various databases and the multiuser applications software. The file server will contain 4 megabytes of internal RAM and will be equipped with a magnetic tape drive used to back up the data on the hard disk.

The G-Net will also contain a 109-megabyte file server equipped with a tape backup system. Such a backup capability is crucial for data recovery in the event of a failure on the file server hard disk.

The communications servers offered by Novell are the SNA Gateway for synchronous mainframe communications and an Asynchronous Communications Server (ACS) to handle various types of RS-232C links. An SNA gateway server will be connected to the G-Net LAN to allow authorized users to communicate with the Martin Marietta mainframe computer in Washington. The gateway emulates a remote IBM 3274 cluster controller and can access the mainframe to upload or download files and databases.

The gateway server will consist of an IBM PC-XT microcomputer with an emulator software package and a G-Net network interface card (the PC can be used as a workstation while operating as a server). Up to 16 workstations can simultaneously access the same mainframe through the gateway. The SNA gateway comes in 8, 16, and 32 concurrent user configurations. The Martin Marietta link will time-share the existing 9600 baud line from Martin Marietta's IBM 3083 mainframe in Washington, DC, to Martin Marietta's 3274 cluster controller at the Technical Center.

The same 3270 emulation would be required to communicate to the AMDAHL mainframe in Washington, DC, if such communication became necessary in the future. No plans have been made to acquire a leased line to the AMDAHL for this prototype system. The server configuration is shown in figure 2.

An ACS will soon be available from Novell and will be evaluated in the prototype LAN. The ACS provides up to 12 asynchronous ports to provide communications between a LAN and remote workstations, remote LANs, and/or mainframe computers. Remote workstations will have access to all of the LAN functions as if they were physically connected to the LAN. Each link can be a dial-up line with auto-dial and auto-answer at up to 9600 baud or a dedicated line with data rates up to 19.2 kilobaud.

Mainframe accesses are handled through the ACS using the NetWare ASCOM IV software. It is a very flexible package allowing menu, command, remote, or unattended operation. The ACS will allow all of the workstations on the S-Net and the G-Net to communicate asynchronously with the Data General MV 8000 mainframe and/or the Tandem computer at the Technical Center; or with other remote mainframe computers via phone lines. It will also allow remote workstations or dumb terminals to operate on the network.

The ACS will consist of one to three Wide Area Interface Modules (WNIMs) and associated software which will be installed on a PC microcomputer (figure 3). Each WNIM has four communications ports, each of which may be independently and dynamically configured.

LASER PRINTERS.

A laser printer can be connected to any file server in either an S-Net or a G-Net LAN. The printer would utilize one of the shared printer ports and would operate at a maximum data rate of 19.2 kilobytes per second. The printer could be shared by any workstation connected to the server network or to any other servers and workstations that are interconnected via a network bridge.

Laser printers print with dots, but with a much higher dot density than dot-matrix printers. They have the advantage of producing extremely high quality print with very quiet operation and very fast output printing (typically on the order of 7 to 12 pages per minute and by 1990 expected to be 13 to 30 pages per minute). Laser printers can do graphics and text with equal aplomb. Laser graphics are very good and have a 1:1 aspect ratio (unlike graphics produced by dot-matrix printers which tend to be distorted). Bit mapped graphics, particularly business charts, require not only special software drivers (supplied by the software developer) but also large internal memory to accommodate a graphic image prior to printing. A minimum internal memory size of about 500K is required for good graphics capability.

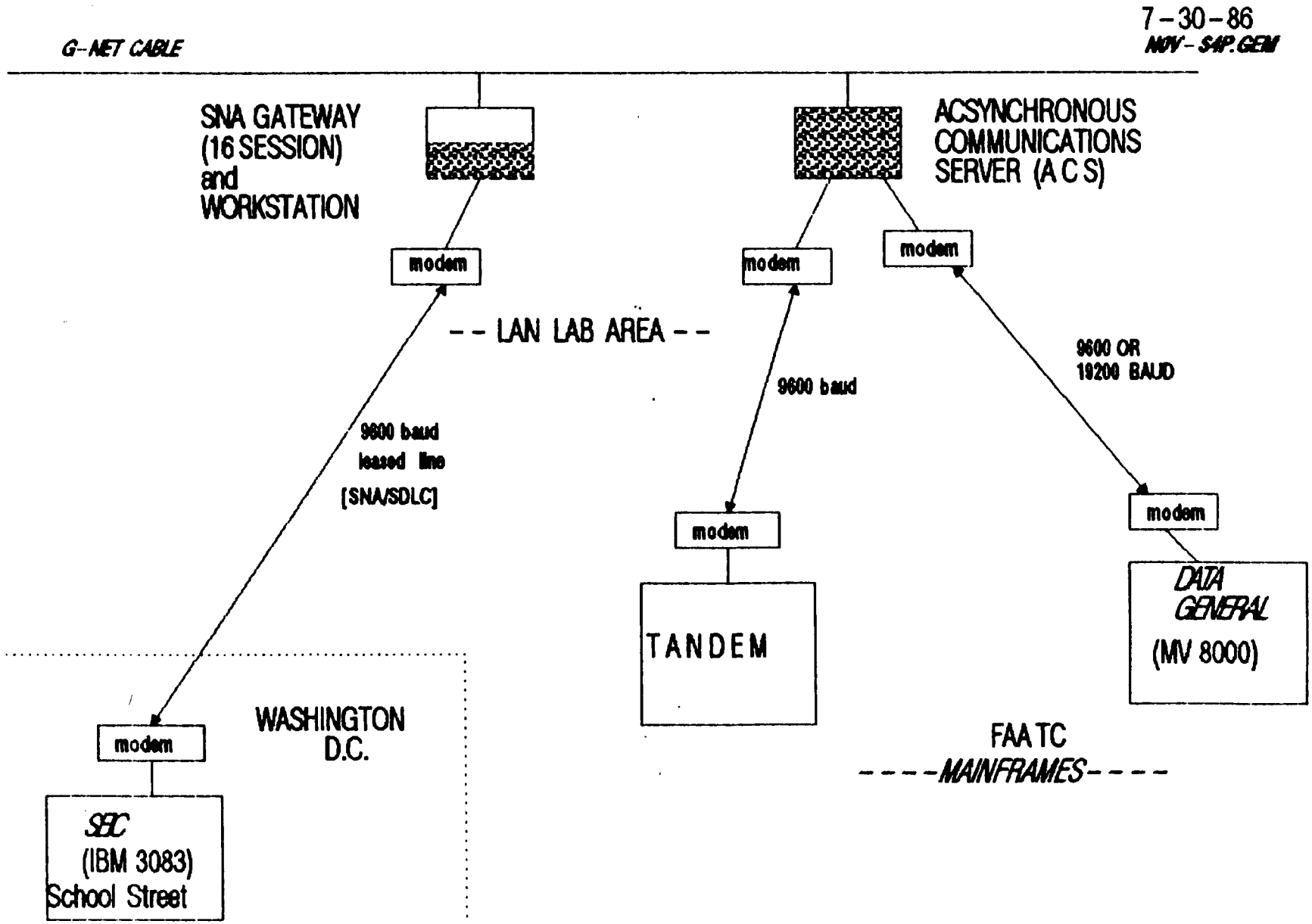

FIGURE 2. COMMUNICATIONS SERVERS

FAA WJH Technical Center
00092823

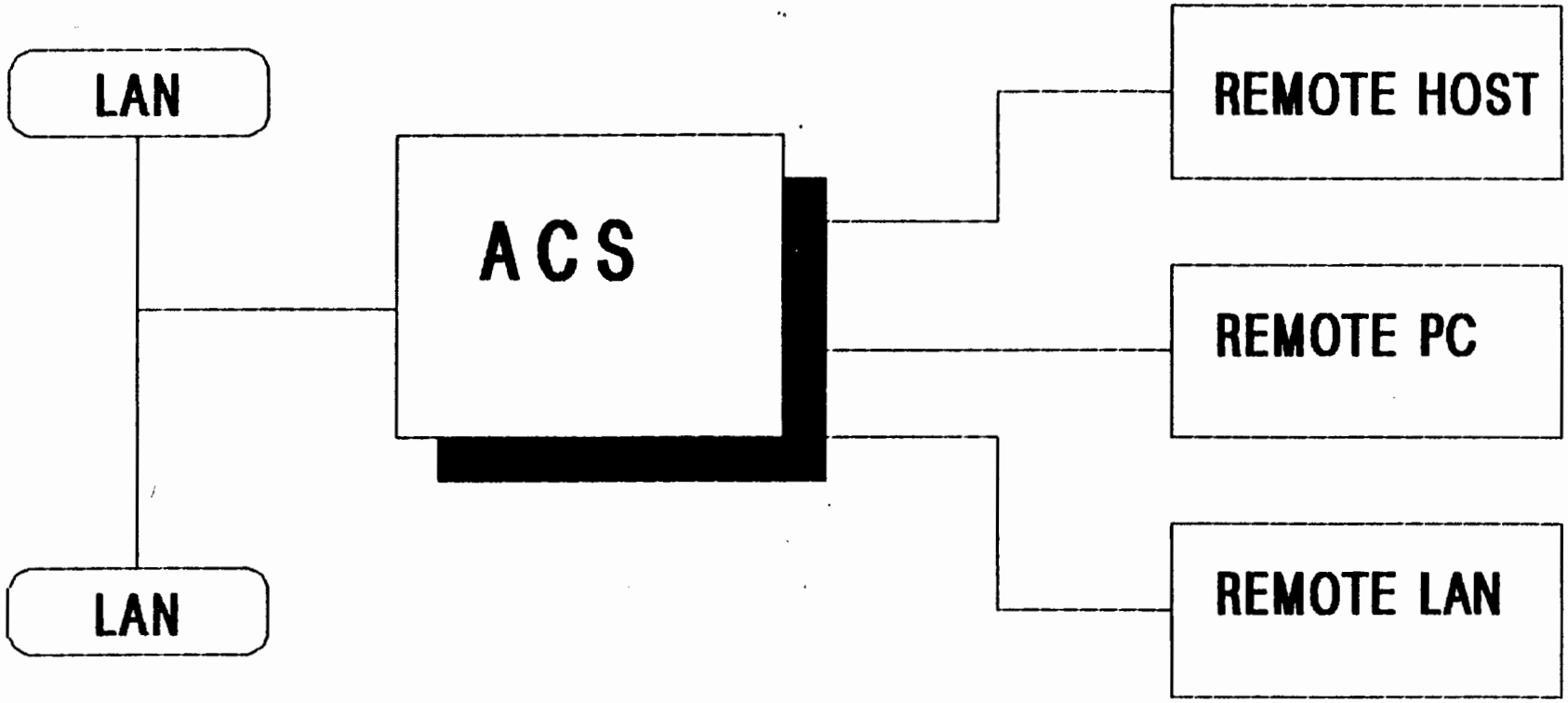

FIGURE 3. ASYNCHRONOUS COMMUNICATIONS SERVER

Prices of laser printers generally vary from about $7,500 to $2,000 for the cheaper models. More features are provided with the higher priced laser printers. These include better resolution, faster page speed, a greater number of different character fonts and variations of them (such as enhanced, compressed, and italic), and graphic effects such as halftones, histograms, and bar code generation.

Most of the laser printers on the market have the option of either a serial or a parallel interface, or both types of interfaces.

Since one of the primary benefits of a LAN is resource sharing and few, if any, users will have the need for a dedicated high volume printer, laser printers are a desirable resource to be shared on a LAN. Most users have an occasional need for graphics hardcopy and for high volume printing.

Laser printers are not part of the initial design for the prototype LAN. With the current rapid development of laser printers coupled with the competitively decreasing prices, a laser printer should be evaluated along with some of its graphics applications within the next 12 to 18 months.

PREVENTING DATA LOSS DUE TO POWER FLUCTUATIONS.

Data or files in microcomputer primary memory and/or on LAN server buffers are volatile until stored on disk or tape. Power-line fluctuations and outages, even momentary, will corrupt or destroy information. Unexpected power outages can cause a user to lose valuable time as well as data. Two good techniques are available to reduce or eliminate data loss due to power-line outages or fluctuations. The first is to use software packages which have a periodic automatic data "save" stored on a disk or tape. Then, the only information lost is that which was entered or modified since the last save. WordPerfect has a feature which saves on disk a user-selected, timed backup of the current document; creates a temporary file; and then updates the file during each save. The temporary file is eliminated when the document is saved as a normal WordPerfect operation. As an example, this document was saved every 10 minutes as it was written using WordPerfect.

The second technique is the use of some form of power-line conditioning. Microcomputers quite frequently use surge suppressor power outlet boxes to reduce or eliminate voltage surges or spikes. However, suppressors are passive devices and do nothing for dips or outages in the commercial alternating current (a.c.) power. An obvious solution is to run the microcomputer or LAN server on batteries during the dip or outage. This is done by using uninterruptible power sources (UPS) between the microcomputer and/or LAN server and the wall outlets. These devices contain a rechargeable battery and an inverter to convert the battery power into a.c. power for the microcomputer to use.

In one type, a standby UPS, the load (a microcomputer or LAN) is connected to commercial power by the UPS in normal operation. Sensing circuitry in the UPS detects a dip or outage occurring in the commercial a.c. power and switches the load over to the inverter output. The microcomputer thus continues to operate without interruption. The user, noting the power outage because the room suddenly is dark, now has several minutes to finish the important portion of his task, save the data on disk or tape, power-down the microcomputer normally, and then wait patiently for the lights to come back on. However, in some microcomputers (particularly some IBM PC-XTs), the power-fail circuitry in the microcomputer

itself is very sensitive; it will detect the 8 millisecond power switchover of a typical UPS and shut down the microcomputer, defeating the whole purpose of the UPS. The cure in this situation is to modify, adjust, or replace the microcomputer power supply or to use an on-line type of UPS.

An on-line, or floating, UPS continually powers its load (the microcomputer) from the battery/inverter combination, and the commercial a.c. power is converted to d.c. to keep the battery charged. When the commercial power fails, the load notices nothing, since it was getting its power from the battery all along. The floating UPS are more expensive because of the large d.c. converter needed to keep the battery charged while the inverter is operating.

The amount of time a UPS unit will power a microcomputer or server is dependent upon several factors, primarily the size of the UPS and the power requirements of the equipment. An IBM PC-XT with monitor and printer will run for approximately 7 minutes from a typical 200-watt UPS with a good battery. The typical battery is expected to last between 3 to 6 years. An audible alarm is usually provided to indicate when the UPS is operating from the battery and/or is approaching battery exhaustion.

UPS units are a necessity for LAN file servers where the commercial power is even remotely questionable. Many people will be depending upon a server for software and data storage. All critical workstations should also be UPS protected, along with any communications gateways or servers. The LAN operational integrity must be maintained at the beginning of an outage to allow the users to complete any communications, save their files or data, and then allow the system to power down.

The cost of a standby UPS unit for a typical workstation will range from $500 to $800, with the price of a floating UPS being approximately $800 to $1,500 for the same power capacity. Considering the number of man-hours that would be needed to recreate lost data due to dips or outages, UPS units are well worth their cost.

Power is a critical issue when changes are being made to a relational database. If the power ceases while the system is writing a pointer to the database file, the database can be fragmented (i.e., access is lost to part of the database). The data are not lost, but the mechanism is no longer available to find and access the data. Since larger databases will be shared on LAN file servers, it is vital that a suitable UPS unit protects the file server.

AVAILABLE LAN SOFTWARE.

The NetWare operating system supports DOS 3.1, and Novell is committed to maintaining compatibility with the IBM networks. This will assure that the majority of future applications software that will be developed for PC Network and Token Ring Network will run on any NetWare supported system.

Software provided by Novell includes EMS (electronic mail), NetWare B1-286 (allows multiuser business applications), NetWare RM (allows applications written in RM/Cobol), NetWare Micro Focus (allows applications written in Micro Focus II Cobol). Novell provides a list of more than 3000 programs that will run on its networks.

Some of the software packages available for use with NetWare are listed below:

Word Processing Packages

1. WordPerfect by SSI Software
2. Multimate Advantage by Multimate International
3. Multimate Professional Word Processor by Multimate International
4. Samna Word III by Samna
5. Samna+ by Samna
6. Office Writer by Office Solutions
7. Word Star 2000 by Micro Pro International
8. Microsoft Word by Microsoft Corporation

Databases Having NetWare Versions That Implement Record Locking

1. dBase III Plus by Ashton-Tate
2. R:Base 5000 by MicroRim
3. Revelation by COSMOS
4. Dataflex by DataAccess Corp.
5. MDBS III by Micro Database Systems
6. KnowledgeMan by Micro Database Systems
7. dbMan-Net by VersaSoft Corporation
8. Lan:Datastore by Software Connections
9. Informa by Unlimited Processing
10. Teamup by Unlimited Processing
11. B.O.S.S. by American Planning Corporation
12. METAFILE by MetaFile Information Systems Inc.
13. Q-PRO 4 by QNE
14. GOLDATAbase by Goldata Computer Services
15. The Sensible Solution by O'Hanlon Computer Systems
16. Micro-Adapt by Data Financial Systems

Major Accounting Packages With Multiuser NetWare Versions

1. EasyBusiness System Plus Series by Sorcim/IUS

2. Open Systems Accounting Software by Open Systems Inc.

3. RealWorld Software by RealWorld Corp.

4. Hard Disk Accounting Series by Great Plains Software

5. Solomon III by TLB

6. MBA Accounting Software by Micro Business Applications

7. Excalibur Plus series by Armos Systems Inc.

8. CYMA General Business by CYMA/McGraw Hill

9. Accounting Software by Libra Programming

10. Fastrak by Core Software Inc.

11. Integrated Accounting Software by Promark Ltd.

12. The Madallion Collection by Timberline Systems

13. The Big 8 Accounting by ModTech

Aside from multiuser software, many single-user packages that need file locking and print spooling can have these features automatically handled by NetWare.

DATA SECURITY.

Frequently LAN users need to restrict access to their data residing on the file server or need to restrict access to the LAN or portions of the LAN. The Novell NetWare operating system provides for excellent data security. Password protection is incorporated with access rights resulting in controlled access to shared programs and databases. Control is allowed down through file level. NetWare file directories are related in a hierarchical fashion to promote a logical and meaningful organization of data. This allows the development, as needed, of both file organization and file control hierarchies.

NetWare allows various access privileges that govern any users access to any file directory:

1. Read--Reading data from open files.

2. Write--Writing new data to an open file.

3. Create--Creating (and simultaneously opening) new files.

4. Parental Rights--Giving authorized directory users the right to create and delete subdirectories, and grant access rights to other users.

5. Search--Performing directory searches.

6. Modify--Marking files as shareable, non-shareable, read only, or read/write.

The system administrator will establish passwords and access privileges for each user, based on the user's job functions. Security can be assignable on a group level, e.g., for a project team effort. Short of stealing a password, there is no way to bypass the file server security.

LAN ADMINISTRATION.

A LAN Administrator will be required to manage the LAN at least as a part-time task, depending upon the size and complexity of the network. The LAN Administrator will be responsible for configuration control, for identifying and dealing with system malfunctions, and for planning and implementing enhancements to the LAN. This position will require a person with a fairly extensive software background, including a good working knowledge of the DOS operating system. The LAN Administrator will require some training on the selected LAN. Novell provides a 2-day course for LAN administrators at a cost of approximately $200 per person. At least two persons should complete this course for every site at which LANs are installed. Additional training courses are available for installing and maintaining LANs ($300 per student, 2 days) and for detailed basic knowledge of Novell products and systems ($200 per student, 2 days).

Failure of critical elements of the system should be detected automatically. Test procedures to check and verify important network functions should be developed. Statistics on utilization of each link or node, error rate, and retransmission rate should be gathered at a central location.

Both preventive and corrective hardware maintenance will be required. A spare supply of LAN interface cards (between 5 and 10 percent of the number in the system) should be maintained as spares. Test equipment such as oscilloscopes and logic analyzers will be needed.

A maintenance contract with the LAN supplier should be considered. If an in-house capability for maintenance can be developed, some of the possible advantages would be reduced costs, faster responses to problems, and better control over maintenance decisions.

As larger and more important databases are maintained on LAN file servers, regular and frequent backup of the file server to magnetic tape becomes an important duty of the LAN Administrator.

EXPANDABILITY OF THE S-NET AND G-NET.

As LAN operations become established, there arises a need to expand the capabilities of the system. Such items as additional workstations and file servers and an increased need to communicate outside of the network will be part of the growth of a LAN. Novell NetWare provides for multiple servers and internetworks (bridges between LANs). Printers, communications servers, and even bridges to other types of networks that utilize Novell NetWare, can be shared by any workstation on any connected networks. Each file server is assigned a name and any workstation can, when authorized, access files in any other file server in the system.

Additional servers for the S-Net can be added either in a daisy-chain or a ring configuration. The network capacity can be expanded to provide up to 2 gigabytes of disk storage. When two S-Net file servers are connected, two output ports of each server are utilized. Therefore the number of workstations on each server is reduced from 24 to 22. Each additional file server allows three more printers to be shared.

The G-Net file server, utilizing the NetWare/286 operating system, is specified to have a maximum capacity of 128 work stations and a maximum disk storage of 2 gigabytes. A maximum of 8 file servers can be interconnected on the network.

The G-Net can be connected to an S-Net LAN by a bridge. In the prototype LAN, the NetWare 286 operating system in the G-Net file server will handle the network bridging. The data rate between S-Net servers or between an S-Net server and a G-Net server is 0.6 Mbps. Bridging is the means of interconnecting one or more LANs. Novell's NetWare/286 file servers will also permit up to three additional LANs to be transparently bridged together. Where cable lengths do not permit access to a file server, a separate microcomputer can be used to bridge up to four LANs together.

When a LAN grows to a size where data transfers start to slow down, the LAN can be subdivided into smaller networks, partitioning it into areas of heavy work station-server transfers. Bridging, then, is used to provide the data transfers between the smaller LANs. Bridges can also be used as network extenders or repeaters where the maximum cable length of a single LAN will be exceeded.

OPERATIONAL TESTING.

Operational testing of the prototype LAN will include the following categories:

A. LAN Operation
B. Configuration Software
C. Database Testing
D. Mainframe Links
E. Wide Area Network Communication
F. Bridging
G. Maintenance
H. Training

Testing will not be limited to the specific categories indicated. The prototype LAN is intended as a testbed so that determinations can be made regarding LAN capabilities. The prototype will also provide a testbed for answering future questions about LAN compatibility with other software and hardware as it becomes available on the market. The results of these test will provide input to ADL for recommended LAN configurations. Appendix B gives a brief description of the operational testing.

UPDATE AND CONCLUSIONS

The technology of microcomputer local area networks (LANs) and micro-mainframe communications is evolving rapidly. Available products change from week to week. However, many of the basic selection and evaluation criteria have not changed; in particular, three main concepts are still vital to good network design. A network must provide for organizational growth and movement of personnel (expandability and flexibility). A network must be compatible with available software and the industry standards for software development. A network must provide for security to prevent the accidental or deliberate access, deletion, or modification of data. These concepts provide a foundation for evaluation of any network.

Standards in the microcommunications industry are now in the process of definition. These standards will not develop overnight, but over some much longer period of time. The communications marketplace cannot operate without standards; the major vendors recognize the need and are already working in that direction. Meanwhile many organizations have not waited for standards. These organizations have LANs already in operation and report increased productivity coupled with satisfaction among users.

The availability of software for Novell LANs is increasing steadily. Prices are volatile and are decreasing rapidly. All facts and issues in this report reflect the state of LAN technology in July 1986.

BIBLIOGRAPHY

Abrams, Marshall D., "Observations on Operating a Local Area Network," Computer, May 1985, pp. 51-65.

Austin, Sandy, "Image Makers," Business Computer Systems, June 1986, pp. 69-76.

Derfler, Jr., Frank J., "The Lay of the LANs," PC Magazine, February 5, 1985, pp. 116-122.

Glidewell, Ph.D., Richard, "Hardware Evaluations-Novell Network," Business Computer Systems, September 1985, pp. 115-118.

Gottman, Michael K.,"Strategies for Sharing Resources", PC World, February 1985, pp. 42-50.

Haugdahl, J. Scott, "Local Area Networks for the IBM PC," BYTE, December 1984.

Hills, David, "Myth or Fact: There is no Software Available for Networks."

IBM PC Network (pamphlet), International Business Machine, Corporation, March 1985.

IBM Personal Computer Seminar Proceedings, Volume 2, Number 5, September 1984, pp. 2-14.

Information Resources Management Plan: Volume I: Strategic Overview, DOT/FAA, Washington, DC, October 1985.

"LANs vs. Multiuser Systems," DataDecisions, 1985, Filing Sequence 760.

Lilly, Susan, "IBM's Network Expected to Set New LAN Standard," PC Week.

Local Area Network Benchmark Report, Novell Inc., Orem, Utah, April 1984.

Local Area Network Software Report, 1985, Novell Inc., Orem, Utah, April 1985.

"Local Area Networks, Tying Computers Together: The Productivity Connection," Creative Computing, Volume II, No. 10, October 1985.

Lockwood, Russ, "Local Area Networks," Creative Computing, October 1985, pp. 20-80.

Lytel, David, "Demand, New Players Boost LAN Market," Mini-Micro Systems, June 1985, pp. 97-106.

Moseley, J.D., "Multiuser Operating Systems Provide a Low-Cost Alternative to LANs," EDN, June 1985, pp. 87-92.

NetWare Product Seminar Companion: NetWare Asynchronous Communications Server, Novell Inc., Orem, Utah, 1986.

Novell NetWare Product Overview, Novell Inc., Orem, Utah, September 1985.

"PC-to Mainframe Communication," DataDecisions, 1985, Filing Sequence 750.

Sachs, Jonathan, "Six Leading LANs," PC World, February 1985, pp.108-165.

Sammons & Associates, "An Inside Look at IBM's LAN," PC Magazine, February 1985, pp. 136-143.

Wilcox, Art, "Untangling Networks," PC World, February 1985, pp. 232-241.

APPENDIX A
PROTOTYPE NETWORK COSTS

LANs are priced by components. The major components are file servers, interface cards for work stations, communication servers, and cabling. Application software is purchased separately. This appendix gives a breakdown of current (August 1986) network costs. Prices are provided for information and cost estimating purposes. These prices are extremely volatile. Novell Federal Systems Division and other vendors have General Services Administration (GSA) pricing for most components.

G-NET

Quantity	Item	Amount
1	Novell G-Net-Part Number 850-72109-002 Includes 109-megabyte NetWare Server with tape backup, Advanced Netware 286 Operating System, 3 G-Net interface cards, 2 20-foot cables, manuals and co-processor board.	$15,637.30
2	G-Net interface cards (IBM) with 20-foot cable. Unit price = $467.25 ea.	$934.50
1	SNA Gateway Part Number 883-93-001 (16 sessions)	$5,424.55
	TOTAL G-NET COST:	$21,996.35

S-NET

Quantity	Item	Amount
1	Novell S-Net Part Number 440-10109-004 Includes NetWare Server Number 68B with 4-megabyte RAM, NSD2 (109-megabyte) disk subsystem, 1 serial port and 6 network interface port cards, 4 network interface cards (NICs), 4 30-foot LAN cables, 1 10-foot console cable, Advanced NetWare Operating System, and systems manuals.	$14,057.55
2	S-Net Network interface cards, Part Number 810-86-001 unit price = $222.50	$445.00
1	S-Net Network intelligent cards (intelligent)-required for bridge, with 100-ohm cable.	$351.55
1	Alpha-numeric terminal, CIE Model ANT (required for system console)	$370.00
	TOTAL S-NET COST:	$15,224.10

NOVELL ASYNCHRONOUS COMMUNICATIONS CONTROLLER

Product release August 1986. Price is expected to be under $5,000.

CABLE/CONNECTORS

Quantity	Item	Amount
500 feet	Dual twisted pair (shielded)	$150.00
100 feet	15 conductor (plenum)	$200.00
200 feet	15 conductor (non-plenum)	$120.00
1500 feet	Coaxial cable (plenum)	$1,500.00
10	Connector, Amphenol, DE9S, unit price = $3.50	$35.00
20	Connector, Amphenol, DE9P, unit price = $2.25	$45.00
	Backshell, Amphenol, 17-1370, unit price = $1.80	$54.00
	TOTAL CONNECTOR/CABLE COST:	$2,104.00

TYPICAL WORKSTATION COSTS

Quantity	Item	Amount
8	IBM PC-XT (microcomputer) Includes 512-kilobyte memory, 20-megabyte fixed disk with disk adapters, 1 360-kilobyte floppy disk drive and asynchronous communications adapter, unit price = $1882; Princeton HX-RGB monitor, unit price = $449; color graphics monitor adapter, unit price = $159; MS DOS 2.1 and Basic interpreter, unit price = $59.00; AST, Six Pak Plus, multifunction card, unit price = $219.00	$21,664.00
10	UPS (uninterruptible power source), American Power Conversion, Corp. model 300 PC+, unit price = $550.00	$5,500.00
10	Surge Suppressors, Data Shield Model S-85, Mfr. PTI, unit price = $89.95	$899.50

APPENDIX B
OPERATIONAL TESTING

A. LAN OPERATION

Local area network operational testing will be used to:

A.1 Identify problems in installation and setup of:

1. G-Net medium performance bus topology LAN utilizing coaxial cable.
2. S-Net high performance star topology LAN utilizing dual twisted-pair wire.
3. Arc-net medium performance starburst (arbitrary tree) topology utilizing coaxial cable.
4. Bridging: covered in section F.
5. Mainframe links (SNA and asynchronous): covered in section D.
6. Wide Area Network Communications covered in section E.
7. Additional hardware and software links as required by future needs.
8. LAN hardware:
    a. Verify that it performs as it was designed.
    b. Check cabling lengths, types, ease of installation and setup.
    c. Proper functioning of mechanical components.
    d. Flexibility of each LAN topology to allow the relocation and addition of workstations.
    e. Verify that additional servers can be added and users can be repartitioned between them.
    f. Test the reliability of file servers.
    g. How well written the manuals are and how well they reflect the current versions of hardware and software.
9. Workstations:
    a. Verify that each workstation can function independently of network with LAN hardware installed.
    b. Insure that each workstation can access the file server and quickly transmit and receive the data as requested.

A.2 Identify the conditions under which LAN performance fails or server access rates begin to degrade significantly with regard to:

1. Increasing number of workstations.
2. The size of databases.
3. The installation of bridges.
4. The use of different types of applications.

A.3 Limitations of the network.

1. Determine areas of heavy LAN traffic.

A.4 Cost/performance parameters.

1. How network capabilities increase with:
   a. added file servers.
   b. increased disk storage.
   c. additional hardware and software.
   d. the training of key personnel.
2. Determination of benefit versus cost for various configurations.

A.5 Resource sharing capabilities.

1. Investigate sharing plotters, printers, and modems.
2. Verify that printers attached to the file server can be shared from network commands and from application packages, i.e., WordPerfect, dBase, etc.

A.6 User interface effectiveness.

1. Determine ease of use for users with limited computer experience.
2. Determine if all major services and functions can be menu driven.
3. Check ease of use of login scripts and mapping.

A.7 Workstation compatibility.

1. Test that available IBM compatibles and other microcomputers will function properly on the network.

A.8 Effectiveness of LAN security.

1. How difficult will it be for users at various skill levels to break network security.

A.9 Electronic Mail System (EMS).

1. Determine average length of time to learn the EMS, without formal training.
2. Determine the size of mailboxes and procedures for clearing obsolete data.
3. Determine server file sizes required for various numbers of users.

A.10 Tape Backup operation.

1. Impact that tape backup has on network performance.
2. Length of time and procedures required for backup.
3. Investigate techniques for automatic periodic tape backup for storing only updated data.

B. CONFIGURATION SOFTWARE

B.1 ADL Recommended Configuration Software

1. Install multi-user dBase III Plus.
2. Install multi-user R-Base 5000.
3. Install multi-user WordPerfect.
4. Evaluate multi-user software and compare similar packages for best performance.
5. Determine disk storage requirements for application software.

B.2 Single-User Software Packages

1. Determine which packages can be used on LAN.
2. Evaluate performance of single-user software on LAN.
3. The number of software packages evaluated will be contingent on available funding.

B.3 Software Security

1. Investigate security features required to safeguard applications software. Verify that security of servers and files is manageable, yet unbreakable.

B.4 Multi-User/Single-User Software Comparison

1. Determine ease-of-use and speed differences between individual PC versions and LAN versions of applications software (of the same revision number).

C. DATABASES

C.1 Install Databases

1. Load three databases from the Horizontal Separation Standards program onto the File Server.
2. Transfer various size files and databases throughout the network.
3. Test simultaneous or near-simultaneous access to the File Server.

C.2 Information Resource Management Plan (IRMP) Support

1. Answer operational questions (in this context, operational means operating to support FAA information and data management systems).

C.3 File Server Disk Capacities

1. Determine required capacities using databases with applications software.

D. MAINFRAME LINKS

D.1 Communication Between LAN and IBM 3083 Mainframe.

1. Establish link between LAN at Technical Center and SEIC mainframe in Washington, D.C.
2. Coordinate with SEIC at Technical Center for shared use of leased line and modem currently in place.
3. Prepare SNA Gateway on LAN for operation onlink.
4. Determine required software and hardware modifications to mainframe computer and communications devices (cluster controllers, input/output processors, modems, etc.).

D.2 Test Link Operation

1. Utilize software tools.
2. Process data locally.
3. Transmit data to Host Computer.
4. Run Host applications packages on the LAN.
5. Test PROFS operation via network.

D.3 SNA Gateway

1. Test SNA Gateway microcomputer to determine if there are any problems when it is simultaneously being used as a workstation on the LAN.

D.4 Asynchronous Communications

1. Test asynchronous communications between the LAN and the Data General MV8000 and the Tandem computer located at the Technical Center.
2. Use the Asynchronous Communications Controller (ACS) that has been ordered from Novell.
3. Connect ACS to MV8000 and Tandem computers using modems and dedicated lines.
4. Ascertain hardware and software changes required for MV8000 and Tandem operation with this configuration.

5. Determine problems and limitations in LAN user access to the databases on the MV8000 and the Tandem (data size and link speed limitations, control code and user queuing, etc.).

E. WIDE AREA NETWORK COMMUNICATIONS

E.1 Administration Data Transmission Network (ADTN)

1. Test asynchronous communications between the LAN and the SEIC IBM 3083 mainframe computer in Washington, D.C., over the ADTN Wide Area Communications Network.
2. Use the ACS for communication between the LAN and the ADTN.
3. Monitor data transmission rates.
4. Check data for proper sequencing and validity.

F. BRIDGING

F.1 Novell S-Net/G-Net Bridge

1. Establish a bridge between the S-Net and the G-Net.
2. Check the transparency of the bridge to the network.
3. Determine the additional load on the File Server when it is also functioning as a bridge.
4. Check how good the remote workstation feature of an external bridge LAN is (i.e., the capability of a remote PC to dial-in to the LAN).

F.2 S-Net, Multiple G-Net, Arc-net Bridges

1. Establish bridges between the S-Net, multiple G-Nets, and an Arc-net at the Technical Center.
2. Test operation of multiple bridged networks.
3. Verify that bridging works between each type of LAN, allowing quick and easy access to servers and gateways on other LANS.

G. MAINTENANCE

G.1 Maintenance Procedures

1. Establish maintenance procedures for the LAN.
2. Determine routine and preventive maintenance functions.
3. Ascertain frequency at which they must be performed.
4. Document the most common trouble areas.
5. Decide which maintenance functions can be handled in house and which should be contracted out.
6. Provide a list of test equipment needed to maintain the LAN.

H. TRAINING

H.1 Training Considerations

1. Ascertain which system administrator functions are automated.
2. Determine administrator functions which must be performed by human resources.
3. Decide on the amount of training required for the system administrator and users to efficiently utilize the network capabilities.