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Kennedy Space Center Network
Documentation System

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ABSTRACT

The Kennedy Space Center Network Documentation System (KSC NDS) is being designed and implemented by NASA and the KSC contractor organizations to provide a means for network tracking, configuration, and control. Currently, a variety of host and client platforms are in use as a result of each organization having established its own network documentation system. The solution is to incorporate as many existing 'systems' as possible in the effort to consolidate and standardize KSC-wide documentation.

INTRODUCTION

The National Aeronautics and Space Administration (NASA) and KSC organizations perform the tasks necessary to prepare and launch space Shuttles. This life cycle begins immediately after an orbiter returns to earth and ends the moment it clears the launch tower. During that life cycle, there are literally tens of thousands of computers used to process information vital to a successful launch. Most of these computers are networked throughout KSC generating a logistics nightmare for the configuration control, tracking and planning of the wiring for all these networks.

HISTORY/PROBLEM STATEMENT

The interconnection of these computers was initially performed without a significant amount of planning or coordination. As a matter of fact, each organizations implemented required network topologies without the benefit of input from other organizations. When it was necessary to connect these networks, representatives from each network met to resolve how the interconnections were to take place. Documentation was not required, so each organization was left on their own as to how to represent what had happened. Often, because of time constraints, documentation was never done, even at the most rudimentary levels, if the network appeared to be working. After all, the network designers and installers were not documenters! If a request was made, the information that could be recalled was recorded as hand sketches at best.

The rapid evolution of large, complex networks at KSC added to the problem in that a wide variety of software and hardware components was selected to perform the design and installation. Each organization ended up

with different standard computer and network hardware to serve individual needs. Today, one can find almost every kind of network, configuration, and component imaginable. There are users that feel mainframes with terminals attached are best, while others are MAC supporters and still others use PC systems. In addition, it is possible to find various (IBM, Apollo, FDDI) token ring configurations, various ethernet configurations (e.g., thicknet, thinnet, 10 base T, etc.), and others.

KSC is a very large, sprawling complex located on the east coast of Florida. The north area includes the launch pads and the Shuttle refurbishment buildings. The next significant area is the Industrial Area that contains KSC NASA Headquarters and several supporting buildings. In addition, there are numerous peripheral buildings and trailers and a number of isolated facilities. Currently, connectivity among these facilities is through one of the several KSC networks.

SOLUTIONS

As a result, the approach in recent years has been to make use of existing network information, without regard to form, network topology, platform or location. Rather than require that each organization modify their documentation to meet some newly established standard, network documentation personnel have elected to design Graphical User Interface (GUI) frontends to access existing data. In some cases, this has been relatively easy. In others, the data either does not exist in electronic form or is in a form that is difficult to interface.

TOOLS

Many of the organizations recognized the need to capture key data along the way and implemented this using tools like Microsoft's EXCEL, Borland's dBASE and dBASE for Windows, Nantucket's Clipper, Microsoft's FoxPro and Word, and others. Doing this allowed at least basic data capture and storage. Others developed relational database applications utilizing Oracle or Informix. This has resulted in data existing in a variety of forms and in a variety of locations. Frontends designed today offer the user the capability to access data and have it presented in such a manner as to appear to come from a single source having a standard format. The user only cares that data can be found; it

doesn't make a difference where that data resides nor does it matter what form the data takes when stored. Furthermore, the user can expect similar information to appear the same when in fact this data may exist in multiple forms. As an example, cable run data may be maintained using a spreadsheet by one organization but be contained in a dBASE table by another. The information structure is clearly different but the content may be the same or very similar.

Since computer software technology is developing and changing rapidly, it is difficult to select a set of tools for performing the task. Development of GUI tools means that significant improvements are being made daily. Also, as each organization is currently using different computer platforms, tool selection becomes even more complex. Superior tools for one environment might, but probably do not, exist for another. For example, while Microsoft's Visual Basic is a strong development tool on a PC, there is nothing available for a UNIX environment. Macintosh support is minimal also. Intergraph Corporation provides a suite of integrated development tools that function on both PC and UNIX platforms. However, no MAC support is provided. What happens is that the developers must be proficient in using two or three visual design tools so that each frontend can be configured on each platform. Use of X-Windows does allow cross-platform operation, but at a significant degradation in performance.

NETWORKS

Each network evolved to provide a specific need in satisfying a requirement. At KSC, there are two functions to be satisfied. One has to do with the day-to-day administrative activity. These networks are known as institutional networks. The other is known as mission-critical activity. Mission-critical network data, configurations, location of cable runs, etc., are highly protected for obvious reasons. Only those personnel having a properly established need have detailed information concerning these networks. For that reason, the institutional networks represent the topic of this paper.

The institutional networks discussed here are the Shuttle Operations Data Network (SODN), the KSC Data Network (KDN), and the Payload Operations Network (PON). Two additional elements of the Kennedy

Institutional Networks (KIN) are the KSC Metropolitan Area Network (KMAN) and the fifth element, the KSC Wide Area Network (KWAN), that provides access to other NASA Centers and facilities through the Program Support Communications Network Interface (PSCNI) and the NASA Science Internet (NSI). An overview of these networks is shown in Figure 1. Each network is configured to meet the requirements that existed at the time the network was designed and installed. As such, there are significant differences in the structure and substance of each network. There are consistent properties also. Thinnet, thicknet, phonenet, twisted pair and other wiring schemes are used. While the predominate physical layer is Ethernet, there are others, including Token Ring, etc.

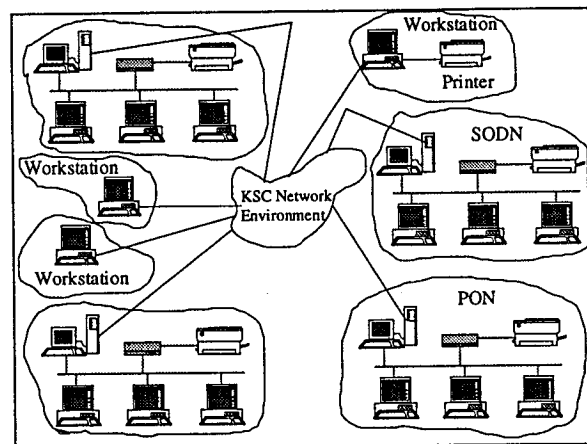


Figure 1. KSC Network Environment (KNE).

The KDN includes the Base Operations Network (BON) and the Document Imaging network. This network is not intended for use in any mission-critical operation. Various network and transport layer protocols are used including TCP/IP, AppleTalk Phase 2, Microsoft NetBEUI, etc.

The PON is also an institutional network and is not used for any mission-critical activity. This network provides administrative support for the processing of Space Shuttle and Expendable Vehicle payloads. About 30 facilities are provided network inter-connectivity by this network. Network and transport layer protocols used include TCP/IP, Intergraph XNS, DECnet 5, AppleTalk Phase 2 and Microsoft NetBEUI.

The SODN is a third institutional network and provides a wide variety of protocols. The routed network carries TCP/IP, AppleTalk, NetBIOS over TCP, XNS, and SPX/IPX, as well as many upper layer protocols. WAN and LAN intra-facility network connectivity support

Ethernet, Token-Ring, broadband, T-Carrier, Fiber Optic Inter Repeater Link (FOIRL), and Fiber Distributed Data Interface (FDDI) communications technologies.

High-speed backbones are used for data distribution. While a high-speed backbone is a critical distribution element, premises wiring is critical to local distribution. Current premises wiring designs utilize carefully chosen media so that future needs can be easily met. In addition, designs are such that additions and changes can be accommodated without significant impact to current operations.

The Kennedy Metropolitan Area Network (KMAN) is a logical network consisting of two physical networks. These systems, used in parallel, are configured to allow traffic load balancing, and prohibit physical loops through the use of Interior Gateway Router Protocol (IGRP), a proprietary routing protocol. While there are multiple physical connections to the KMAN, by each, to the major networks, these connections are all through the Kennedy Space Center Isolation (KSCISO) router. No host-level or server-level services are directly attached to the KMAN.

There are multiple physical connections to the Kennedy Metropolitan Area Network by each of the major networks and there is a working group responsible for its design and configuration.

The allowable routed protocols are:

- IP Suite
- Novell SPX/IPX
- DECnet Phase IV
- OSI ES/IS CLNP
- SNA
- XEROX XNS (not Ungerma Bass)
- AppleTalk Phase II

The KSC Wide Area Network (KWAN) is the link between the Hub routers on PON, KDN, and SODN and the KSC Isolation Router, the internal WAN interface. The external interface is the link between the KSC Isolation Router and the outside world (NSI and PSCNI). The router provides routing for IP, DECnet, XNS, IPX, and AppleTalk. The router also provides Access List security filtering by limiting access to KSC for only IP port 25 Simple Mail Transfer Protocol (SMTP) and IPX protocol. The IP access for other ports is by address access only. Area Mapping is employed for DECnet, XNS, AppleTalk, and Novell IPX. The three major networks interface through their own hubbing systems and are responsible for any further

filtering or security requirements that may apply to their network.

On the operational side, numerous Network Operating Systems (NOS's) have evolved from the centralized mainframe computing environments to a personal computer (PC) based distributed system. All NOS's have several common characteristics. These include:

- Initiate a network communications path
- Emulate the resident file servers file and data structure
- Send and receive errorless data across the network
- Terminate communications gracefully

Generally, NOS's can be divided into the following two different categories:

- Client/Server technology
- Peer-to-peer technology

There are advantages and disadvantages of both technologies. In most instances, the number of users and the application types determine which technology to select. Peer-to-peer networks typically require that the user application reside and function on the user's PC. Performance then becomes a function of the user's PC configuration. In this type network, peripherals can be shared. The client/server configuration splits an application into two parts and assigns the processing of each part to the resource best suited to handle it. The user workstation or 'client' is the front-end and manipulates data on the local level. The back-end or 'server' component of the application stores, retrieves, processes, and secures data. Many clients can share the features of a single server. Client/server architecture is designed to optimize network performance by attempting to minimize network traffic. In a client/server configuration, individual workstations communicate with each other through the server. In a peer-to-peer NOS, workstations can communicate directly. In addition, peer-to-peer NOS's support most of the functions of the client/server NOS. UNIX is also a NOS.

KSC has a variety of LANs as mentioned earlier. In addition, several networking NOS's exist also. The networks mentioned earlier utilize the following NOS's:

- KDN: Novell NetWare, Microsoft NT Advanced Server, AppleTalk
- PON: LAN Manager, AppleTalk
- SODN: LAN Manager, IBM LAN Server, Microsoft Network (MS-NET), Novell NetWare, AppleTalk

As the computing requirements and user needs grow, networking and NOS technology must keep changing and improving.

NDS APPLICATIONS

The KSC Network Documentation System makes use of all current technologies. The basic configuration consists of a Microsoft NT Advanced Server that supports several visual software development tools. These tools include:

- Microsoft Visual Basic
- Borland Paradox for Windows
- Borland dBASE for Windows
- Borland dBASE for DOS
- Borland Delphi Client/Server
- Microsoft SQL Server
- Microsoft C++
- Microsoft SMS
- Intergraph MicroStation
- Intergraph dbAccess and related products

The objective is to provide user friendly GUI access to wanted data. This can be accomplished a number of ways. Designers at KSC have elected to start with a single logon screen followed by a general purpose menu containing all available functions. Selective functions can be disabled as needed depending on the individual user and the allowed access for that user.

Shown in Figure 2 is one main menu containing typical user selections. The following functions can be performed as a result of the appropriate menu selection:

- IP Address Maintenance
- Available Network Resources
- Circuit Card Maintenance
- t-Carrier Maintenance
- Cable Labels
- Device Labels
- Network Drawings and Database
- Inventory
- Work Order Preparation
- Service Requests
- File Maintenance
- Network Configuration (Software, Hardware)

The menu shown in Figure 2 was created using Borland's Paradox for Windows product. Any of the other available GUI products could have been used, but Paradox represented the easiest platform for this application.

Each button is programmed to perform a predetermined function as required at design time. Pressing a button launches an application that performs a task described by the button's label. For example, when the user needs to make labels for a cable or group of cables, the "Cable

Labels" button would be selected by placing the mouse cursor over the button and pressing the left button.

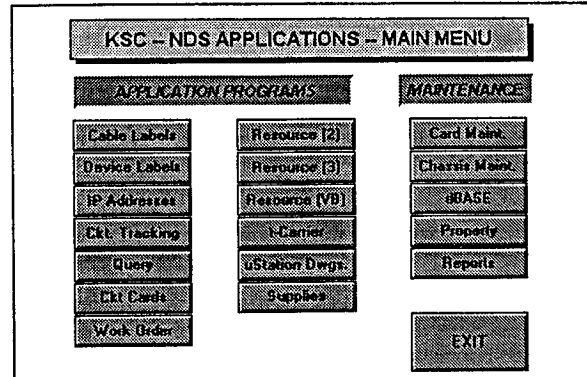


Figure 2. User's Main Menu.

CABLE LABEL APPLICATION

The code behind the "Cable Labels" button is shown in Figure 3. The amount of programming required to launch the application consists of one line that tells the computer to execute a program located in a pre-defined location. The program being launched could be anything. In this example, a Paradox form is loaded. (Paradox starts an application by loading a form within Paradox.) The Screen shown in Figure 4 is the "Cable Labels" data maintenance screen. The location of the files containing the cable label data could be of almost any type: in this case they are dBASE files. Furthermore, the location of the database could be on a workstation or server physically removed from the user. The only requirement is that the data files must be shared so that the user can access the data.

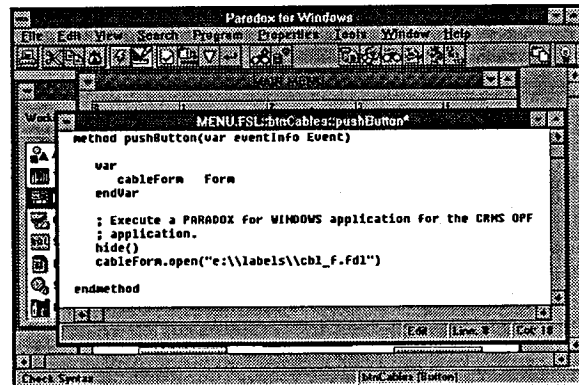


Figure 3. Code to Launch "Cable Labels" Module.

Normally, the user wants to add label information to the database and then print the labels. A number of parameters have been programmed into the application as shown. Any number of parameters could be established and programmed at design time. At KSC,

the screen used is somewhat general purpose so that most, if not all, the user's needs are satisfied by this single form. If desired, screen layouts could be easily modified to meet different needs.

Figure 4. A Cable Label Database Maintenance Screen.

While the function of most of the buttons is self explanatory, a more detailed description follows.

- **Add** -- Add a new cable label record to the database.
- **Delete** -- Delete the record currently shown.
- **Post** -- Post the newly entered record (write the record).
- **Output** -- Select the output type, either labels or a listing of all label records contained in the database.
- **Edit** -- Edit the record shown.
- **End Edit** -- Changes/additions to the current record are complete.
- **Sort** -- Shown in the inactive state but would sort the records in the database as wanted by the user.
- **Search** -- Search the database for the record or records based on data entered in one or more fields on the screen.
- **EXIT** -- Exit this application and return to the main menu.

An explanation will help to define the "NEAR END" and "FAR END" field titles shown in Figure 4. Either end of the cable can be termed the near end and by default, the other end is the far end. When labels are printed, the application is programmed to provide an even number of labels. Half will be printed so that they can be placed from the near end while the other half are placed from the halfway point of the cable to the far end. The user enters either the length of the cable in feet or the number of labels wanted. The application uses the length information to determine the number of labels to

print based on the requirement to place a label at least every 20 feet along the cable. If the user enters an odd number of labels, the application will round up to the next full integer. Figure 5 contains the label printout for the label shown in Figure 4.

Figure 5. The Cable Label Format.

Once the user has completed the session, pressing the EXIT button returns the user to the main menu. The newly created cable label information has been placed in a file within the prescribed database. Linkages to other files in the database are possible through the key cable ID field.

DEVICE LABEL APPLICATION

A similar requirement is to prepare labels to be placed on network equipment. The screen shown in Figure 6 shows one such way to accomplish the task. Note the similarities between the "Cable Labels" and the "Device Labels" screens. Colors, button sizes, button labels, field titles, etc., are similar in design to minimize the visual impact on the user.

Figure 6. The Device Label Maintenance Screen.

IP ADDRESS ASSIGNMENT APPLICATION

Another typical network documentation requirement is that of assigning and maintaining IP addresses. Most of the KSC networks support, and depend on, the TCP/IP link. The development team was given the requirement that IP addresses were to be assigned automatically and by more than one user at a time. This meant that a multiuser application had to be written to meet these requirements. In many cases, single devices can have multiple IP addresses. To accommodate this, a multi-file relational database was designed. One file contains information concerning devices and the other file contains the information about IP addresses for that device.

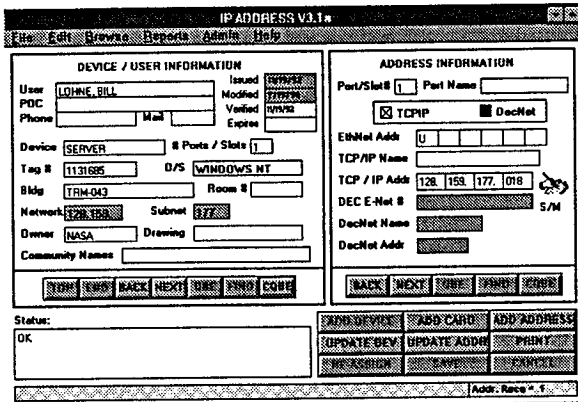


Figure 7. IP Address Maintenance Screen.

At KSC, the problem of maintaining and assigning IP addresses generally falls within each established network support group. Each organization is assigned a network including all subnets. As new networks are designed and installed, IP addresses are assigned, often manually, from the assigned block of addresses. The process of combining everyone's IP address data into a single, shared database is currently in process. Once completed, each network administrator will have access to the database through the screen shown in Figure 7.

This application was developed using Microsoft's Visual Basic development environment. The original database was dBASE, but it has since been converted to Microsoft SQL. A Microsoft NT server serves as the SQL server as well. This server is part of the NDS development lab, and as such is available to all KSC users for development and operational use.

The primary user's screen is shown in Figure 7. Note that the screen is split into two sections -- the DEVICE/USER INFORMATION section and the ADDRESS INFORMATION section. The DEVICE/USER part of the screen looks at data in the file containing device/user information while the

ADDRESS part of the screen is a view of the related device/user address data. The screen contains data fields as requested by a number of potential users. Thus the application is general purpose. Not all users would use every available field. Some fields are mandatory, so all users must complete those fields when entering new data.

Where a complete subnet is being assigned to a single user (network administrator who will then assign individual IP addresses), the user enters device/user information and then selects the S/M hand icon. This will automatically assign a block of addresses. This generally takes a minute or two while 255 records are written to the address file for a single entry in the device/user file.

Network and subnet constraints are initially entered into the Building Table shown in Figure 8. These parameters are decided at network design time, and the table is completed with the information from the design layout. Network and subnet design layouts include the location information by building and room as required. There are times when a network will appear in more than one location. Subnets could appear in more than one location also. Room data is not always available or needed.

BUILDING	NUMBER	FRS	RM	EAST	DM	FUNCTION	NETWORK SUB NETS
D-C	M7-355	4232		4234			128.217.011
D-C	M7-355	4232		4238		USER ROOM C	128.217.013
D-C	M7-355	4255		4255		USER ROOM B	128.217.013
D-C	M7-355	4255		4263		USER ROOM A	128.217.013
D-C	M7-355	4240		4254			128.217.011
D-C	M7-355	4256		4264			128.217.011
D-C	M7-355	4266		4939			128.217.011
D-C	M7-355	5200		5299			128.217.011
TRM-042							128.159.177
TRM-043						NETWORK GRDU	128.159.177

Figure 8. View of Table Controlling IP Address Restrictions.

The network and subnet values allowed for a given addition are controlled by the table shown in Figure 8. After the building and room have been selected, the IP Address screen appears with the "Network" and "Subnet" fields automatically filled with data from the table. When moving to the ADDRESS side of the screen, the TCP/IP Addr fields will contain the appropriate network and subnet data. The user will not be able to change these three octets.

The user can either enter a number in the last TCP/IP Addr block or click on the S/M hand icon. If a number is manually entered, it is compared against the IP Address database. If a duplicate is found, an error

screen appears showing details about that number. The user then can manually select a new number, or let the application automatically assign the next available number.

NETWORK DRAWINGS AND DATABASE

Another significant recent development concerns the marriage of detailed facility and network drawings to database information. This effort was performed by the Shuttle Processing Data Management System (SPDMS) engineers. SPDMS is part of the SODN organization's network.

The design for this documentation system includes electronic access to facility drawings that originate on the NASA DE VAX host computer. Facility drawings are prepared using Intergraph's MicroStation CAD/CAE drawing package. These facility drawings are copied to the master PC workstation that has been established as the authoritative source of cabling as-builts. This workstation is then used to provide the line contractors with a referenced facility drawing, seed file, and individual database tables of that facility. The line contractors can then document their additions, changes, etc. In addition to the CAD drawing, individual database records can be linked to any picture element within the drawing. This allows for database records to be displayed by simply selecting the element. For KSC-wide reference, the master PC workstation is used as a staging area for the completed drawings and data that can then be copied to the network directories on the NASA DE VAX host. In addition, through a series of conversions, the drawing can also be placed on the IBM host. Anyone capable of using an IBM host session on an OS/2 workstation can 'view' the network drawing.

The network configuration for this part of the documentation project is shown in Figure 9. Central to the operation of this system is the Master PC Workstation. This workstation not only uses Intergraph MicroStation for working with the drawings on a local level but also provides a means for tracking, configuration, and control of SPDMS network data. Detailed network design information is then added to the facility drawings to yield a complete network documentation package. A fixed format network drawing is brought up on the users screen. Clicking on a network element brings up the database file information concerning that element. A sample network drawing is shown in Figure 10. The left half of the figure shows the full floor of the facility being worked. The right half is a detail section of the left view. To determine more about any shown element, the user moves the arrow over the element of interest and double

clicks the left mouse button. A table containing detailed information about the selected element appears as shown in Figure 11.

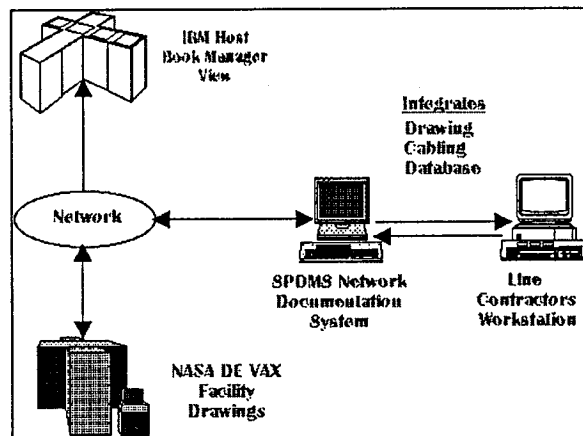


Figure 9. SPDMS NDS Network Configuration.

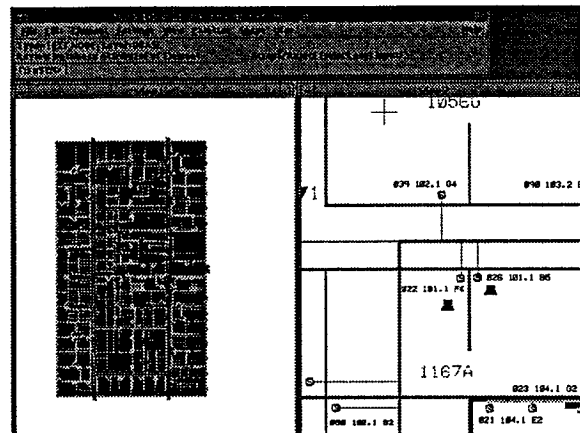


Figure 10. MicroStation Network Drawing.

At this point, we have shown several applications that are specific to a particular part of the total documentation picture. What is ultimately desired is to be able to electronically identify a single network element on a screen and from that view manipulate data concerning the complete 'circuit.' Thus, if a network problem occurs, an engineer can bring up a screen that allows him to pick a known element within the problem area and subsequently view the documentation and database information for the circuit from the user device to the host device. The preliminary design for this has been started. Typical of the engineer's initial screen is shown in Figure 12. This application was launched by the user having clicked on the **Ckt. Tracking** button of the main menu. As stated earlier, the form of this screen could vary to meet user needs while the function remains basically as shown. Each of the buttons shown

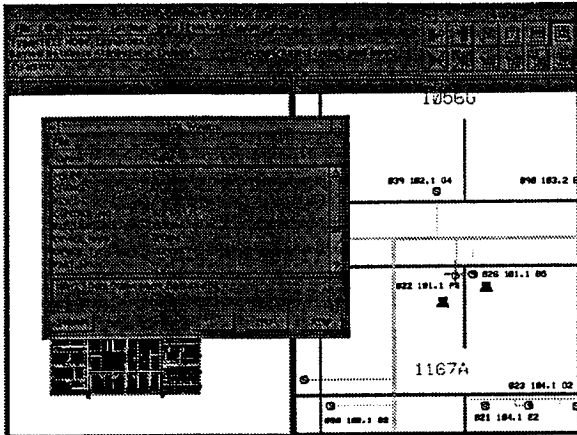


Figure 11. Figure 10 With Added Record From Database.

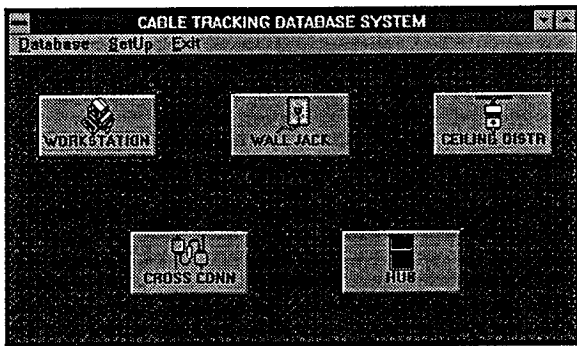


Figure 12. Cable Tracking Menu.

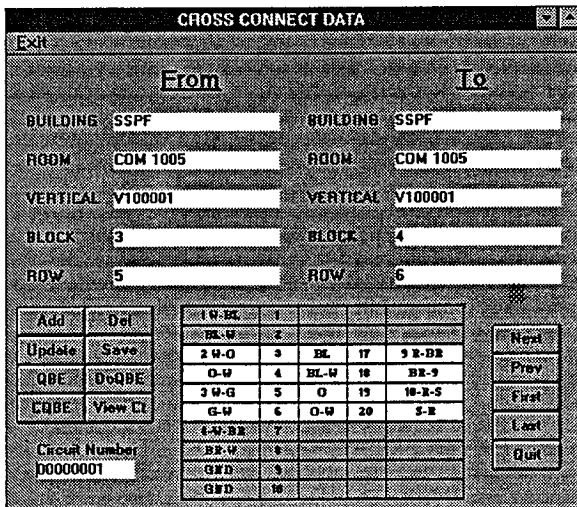


Figure 13. Typical Data View.

represent a part of a typical network path or circuit. Using the mouse to click on one of the buttons brings another screen in view. The new screen contains information from the database and shows the to and from data for the element selected. The information shown can be viewed or, if access privileges are

sufficient, data can be modified. A typical screen is shown in Figure 13. Note that the user has a number of available functions that can be performed by clicking on the appropriate button.

One of the nice features of this application is that the user, from any detail screen, can click on the View Ckt button and obtain a screen similar to that shown in Figure 14. This pictorial view shows the complete network circuit from end-to-end for the circuit selected. In addition, clicking on an element in this view brings up an overlaying table with the pertinent detail information about that part of the circuit. Of course, some end-to-end circuits will contain fewer elements than those shown in Figure 14. This application is being developed on a PC platform using Visual Basic. The drawing components are icons representing the elements shown and placed in the proper sequence.

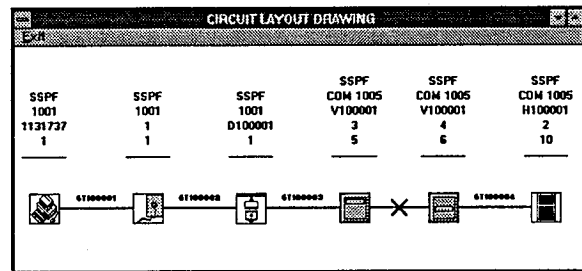


Figure 14. End-to-End Circuit Drawing.

INTERNET USE

Another aspect of the documentation effort that can't be covered in detail here is using the Internet and a viewer like Mosaic or Netscape to view and modify network data. Lockheed, Intergraph, and I-NET engineers have developed a preliminary system that uses a number of off-the-shelf products for developing what is currently called the FasTrack application. This application was designed to handle service requests where the required network resources are available. Use of standard desktop (Windows) components such as Microsoft Office, etc., allows development without having to procure specialized or expensive software. Intergraph's suite of new database products for the PC is used extensively. Workstation components needed to run this application add a small cost per workstation. Everything else needed is already installed on the workstation.

FasTrack data is contained in a database located physically on a UNIX server. Access to the database is controlled using Intergraph's Network File Manager (NFM) product. Full security is thus maintained by the setup parameters of NFM for the database. Using

Mosaic or Netscape to access the application lets all platforms that support Mosaic or Netscape view and, in some cases, modify the database. The initial user screen is shown in Figure 15. The menu shown is actually a Microsoft PowerPoint slide.

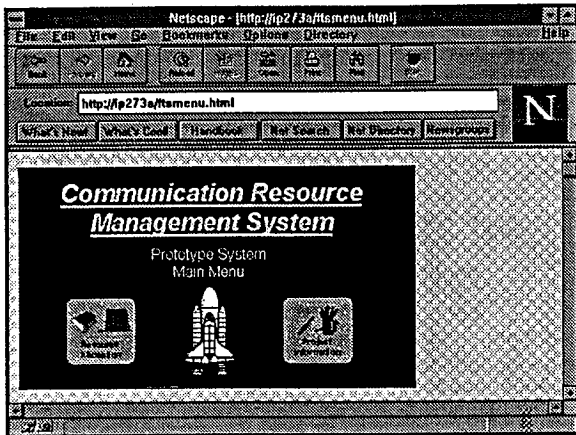


Figure 15. Netscape Screen for Access to the Database.

Future enhancements will extend current developments to function across multiple computer platforms with no apparent difference to the user. This will be accomplished within the constraints of the individual platforms in use.

SUMMARY

In summary, this paper touched on a few of the applications developed to process network documentation data. Several additional modules are available to the user that were not discussed here because of space limitations. Feasibility of designing GUI frontend modules to maintain existing network design data having various forms and locations has been demonstrated. As additional development is completed, the benefits of these efforts provide a consistent and standardized approach for working with network design data. Important to this effort is the concentration on design efforts that utilize existing computer hardware and software and minimize development time by using state-of-the-art visual design tools.