123 Air Control Squadron Mobile Network

By

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I have discussed almost every part of this project with friends and coworkers and their invariably penetrating questions and objections very often forced me to revise and clarify processes discussed herein, and thus greatly increased the adequacy of the final product.

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Abstract

123rd Air Control Squadron Mobile Network

By Bukari J. Miles

The 123rd Air Control Squadron mission is to operate as a control and surveillance positioning for the Ohio, Indiana, and Kentucky air space areas. The organization has been tasked to design and implement a network that will be mobile, cost efficient, and able to interface with multiple resources. The AN/TYQ-23 Operations Module is the system currently in use. However, there are many shortfalls to this module such as extremely high maintenance cost, inefficient training scenarios, high mobilization cost, and ineffective diagnostics. The purpose for the 123 ACS mobile networks is to support the efficient transfer of command and control, intelligence, logistics and administrative data between fixed sites and deployed locations, functional areas at each deployed location, and CONUS gateway locations.

There are two elements of the 123 ACS mobile networks: Transmission and Data. Transmission provides a seamless radio communications interoperability between deployed air elements and based operations via satellite. The Data network is a scalable network providing video, data, and switched message services to users. Its primary purpose is to manage the video portion of the air traffic control missions. The implementation of a mobile network we allow us to allocate control of aircraft more effectively with less loss of time and better integrity.

Product Description and Intended Uses

This report documents the activities and results of a 2 year test of traffic detection technologies using the data and analysis evidence collected by the 123rd ACS Ohio ANG. The 123rd has been tasked to design and implement a network that will be mobile, cost efficient, and able to interface with multiple resources. The predecessor to the new mobile network is the AN/TYQ-23 Operations Module. The AN/TYQ-23 …..Because its technology was created in the late 1960s to early 1970s and it does not allow smooth integration to newer equipment this module has created many shortfalls.

Over the past decade the increasing air traffic along with higher demands has created a need for the integration of tactical equipment with commercial off-the-shelf equipment to keep up with growing technologies. The 123 ACS mobile networks are used as a surveillance position for the Ohio, Indiana, and Kentucky air space areas.

The purpose of 123 ACS mobile networks is to support the efficient transfer of command and control, intelligence, logistics and administrative data between:

- Fixed sites and deployed locations
- Deployed locations
- Functional areas at each deployed location
- CONUS gateway locations and deployed locations

To provide a smooth transmission from tactical to commercial off-the-shelf (COTS) dependency the system must be flexible, expandable, scaleable, and rapidly deployable to meet the needs of the Air Force today. The 123rd has developed an organizational network capable of handling these administration needs. With the completion of the design and implementation of the mobile network a successful testing phase will precede the process duplication of other units.

There are two elements of the 123 ACS mobile networks: Transmission and Data. We separate the design of these networks to allow maintenance simplification and easier mobilization of the different pieces. The immediate purpose for the system is to provide an alternate air control solutions system. The transmission network provides a seamless interoperability between deployed air elements and based operations via satellite. The Data provides a nodal infrastructure for voice, data, and message traffic user services. This report will focus primarily on the network portion of design with an occasional reference to the transmission portion to give a better understanding on some of the principals used.

Description of the Solution

The mobile network a.k.a. as BMOC is a scalable network providing telephone, video, data, and switched message services to users. This network may be connected to other nodes as external WANs. In terms relative to Air Force Operation, each user node might support a Flight or Staff section. There are two components to the BMOC infrastructure: Air Surveillance and Control System (ASAC) and AccessNet. By utilizing these two technologies in tandem the 123 ACS will be able to save money, improve training, increase response time efficiency, and expand its air surveillance area.

The ASAC was developed by Digicomp Research Corporation and procured by the 123 ACS. Its primary purpose is to manage the video portion of the air traffic control missions for the Ohio, Kentucky, and Indiana airspaces. The AccessNets' primary responsibility is to act as a digital radio communications switching network.

Lower Maintenance Cost

As stated before, the predecessor to the ASAC network was quite out of date and ridiculously more expensive to maintain. One of the strengths of ASAC and AccessNet is its integration of commercially available hardware and software and the range control system. The COTS components are assembled in a highly modular arrangement that allows easy replacement of bad components for future growth needs.

Mobile Surveillance

The BMOC network is designed to enable the user to do anything in the field that can be done at a home station (based on the bandwidth from the satellite) such as email, file transfer, broadcast messaging, and remote login. The key to bringing these capabilities to the field is that every component, piece of software, and protocol used to communicate between assemblages in the system (hosts and routers) is a commercially proven resource. The only major innovation is the range control system designed by Digicomp Research laboratories which has adapted these resources for deployment to a field environment.

Larger Surveillance Area

Air Force regulation maintains that each trainee has to be accompanied by a trainer at all times during any equipment operation. The BMOC systems are mobile and can be moved to any site area and even displayed on a large screen to allow trainees the ability to view missions without the hands on training. Also more than four air traffic controllers (Total of 8 missions) are capable of training at the same time.

Mobile and Efficient Backup System

The older equipment (AN/TYQ-23) utilized an external proprietary SCII hard drive which could only be interfaced by the Operations module or a specially manufacture test fixture. The AccessNet backup system utilizes 80GB hard drive and a 9.4GB automatic DVR backup which can be accessed from the node or from an external PC connected via LAN.

Recording Quality and Administration

The Stancil Recorder allows the administrator to configure channel settings, user rights access, monitor events, and run reports. The users' area of importance centers around the ability to view the storage activity by clicking on the stores activity needed. The older Operations Module performed some of the same operations as the AccessNet but not quite as efficient. In the older system the maintainer would have to decipher through some 30 to 200 pages of thermal print paper to find a problem. The recorder allows the user and administrator to see the status of channels and calls.

Streamline Communications

The AccessNet application allows operators and maintainers to remotely control radios (different types), control antenna, and different switching matrixes for remote control. By utilizing the AccessNet software there is no longer a need to have different interfaces for separate types of control radios. The AccessNet software acts as a switching interface to combine signals. This truly allows and almost entirely erases is the non-communicative hardware differences between organizations. You could say that it acts sort of like Windows software in that it either already has the necessary driver interface resources or accepts one through a commercial input.

User Profile

There are three categories of users for the ASAC and AccessNet models: Operators, Maintainers, and Digicomp Researchers

Operators

Operators are the principal users for ASAC and AccessNet systems. They are responsible for the daily tracking and control of aircraft, establishing communications with aircraft, providing continuous surveillance, assisting in airspace rescue operations, establishing and maintaining data links, gathering and forwarding intelligence products, providing classification of airborne objects, and providing threat warnings to forward, lateral and subordinate users. The operators are expected to know the ASAC and AccessNet side of the network and will be given instruction by the administrator on accessing the task they need to be concerned with.

Administrators

Administrators are responsible for overall maintenance of both the ASAC and the AccessNet systems. They are also responsible for organizing any performance oriented course that trains operators in the essential core task required of their position. Since the ASAC is a couple of years older technology than the AccessNet the administrators are expected to know their way around the technology tree that houses all files pertinent to the ASAC. However, the AccessNet system and software were design from a combination of corporations and so the learning curve for hardware on this system is based on time availability. The software execution is an on-the-job training and class presentation for the main technicians (see time line in MS Project: Miles, Bailey, Williams) with a projected field training date with General Dynamics around June 2005.

Digicomp Researchers

Digicomp researchers are not responsible for the system but are responsible for software and hardware help desk assistance. The current contract has been renewed for another 7 years to allow Digicomp to remotely login and assess any major system faults. This is mainly due to new engineering designs that are being implemented. Digicomp researches are 100% knowledgeable about the maintenance of the ASAC but are not involved in the type of remote system missions the 123rd incorporates.

Design Protocols

To promote interaction between sites and increase the effectiveness of air control surveillance the 123 ACS will design a mobile network that will make use of the Information Engineering Technology network representation. The old operations Module and tactical radio options were not designed to interface with commercial equipment. The main communication links resided within a tactical community. The new ASAC and AccessNet design will create a more state-of-the-art communications module. With the use of commercial equipment and a focus to design based on future needs more signaling interfaces will drive the network setup.

During the discussion of this project other areas of the IET program will be referred to; however, my experience with this system will mainly be involved with the system design portion.

The following section will explain in some detail the hardware and software components of both the ASAC and the AccessNet systems.

ASAC

This section contains an overview of the ASAC to include the hardware connectivity and software utilization and interaction. The equipment shown in figure 1.1 below consist of a US Robotics Courier 56K modem, Cyclades TS400 console server, Asante FriendlyNet GX5-424W Switch, MPS800 multi-protocol server, two Sun Enterprise 250 servers, Motorola Codex Mode 4, GPS antenna, server switch, Espirit 500 terminal, and a uninterruptible power supply (UPS).

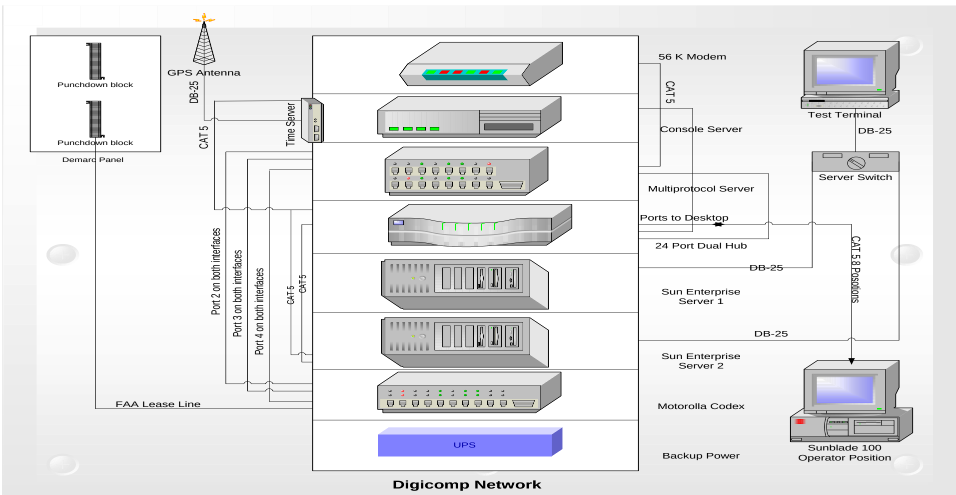

Figure 1.1 ASAC Network

The hardware environment of the ASAC uses UNIX and transmission control protocol/internet protocol (TCP/IP) for connectivity. The platform is a central set of multiprocessor Sun SPARC servers and remote user stations. A set of communication processors host the interface-specific hardware that communicates with each of the ASAC data sources. The following is a brief description of each network hardware resource.

US Robotics Courier 56K Modem

The 56K modem supports most communication protocols, operating systems, and phone systems. Its major advantages are global usage, integrated multilayered security, remote operation, reliability, and carrier loss redials. The intended use for our system is to allow Digicomp Corporation help desk to update software, and support for major maintenance issues.

Figure 1.2 Modem

Cyclades TS400 Console Server

The Cyclades TS400 Console Server is a Linux based, 1U rack-mountable advanced 4 port console server designed for remote data centre and branch server management. For our purposes the TS400 is a time server that provides network time synchronization. It is configured to receive time via GPS antenna. When the time server is turned on it automatically seeks the GPS signal for synchronization using STRATUM 1 timing.

Figure 1.3 Console Server

Asante FriendlyNet GX5-424W Switch

The Asante switch has a total of 28 possible connections (24 port switches and 4 gigabit ports). It provides a means of single-point connection for external interfaces. The switch also provides connectivity between the classified or unclassified IP backbone network and exterior data networks. We use this hub to add or remove nodes from the network by connecting to the free ports. Connections to this switch are all CAT 5 and the architecture is a star topology.

Figure 1.4 Switch

MPS800 Multi-Protocol Communications Server

The MPS800 is a WAN/LAN data communication server. It provides one 10/100 Ethernet port and eight high speed WAN serial ports. The network uses the MPS800 to interface the TPS-75 radar as a way to communicate with processor host interface software designed specifically for interface with tactical equipment. The MPS800 has complete WAN protocol support capabilities that allow it to network with tactical equipment. The administrator can dynamically configure parameters to meet the user's needs. The MPS800 also serves to isolate the external hardware from the rest of the system hardware both keeping it off the main nodes and making it more secure.

Figure 1.5 MPS 800

Sun Enterprise 250 Servers

The Enterprise 250 (E250) is a workgroup server that accommodates up to two 300- or 400-MHz UltraSPARC-II processors for extra-high performance, six hot-plug Ultra SCSI disks, fast Ethernet and protocol conversion between different types of networks or applications. The servers provide a messaging system enabling users to exchange information with others in the network as well as outside the network. The E250 is the network administrator's primary interface to the other hardware devices. It is used to administer a domain of devices and performs the configuration, auditing, and management of utilities.

Figure 1.6 Enterprise 250 Server

Motorola Codex Mode 4

The Motorola Codex modem is used as an interface manager to the TPS-75 for conditioning of the Mode 4 signal. Mode 4 operates as the net link. Mode 4 was designed to be independent of ground infrastructure. It permits any number of Users to simultaneously share the link, enabling both air/air and air/ground communications across many aircraft types and ground platforms.

Global Positioning Satellite (GPS) Antenna

The AccessNet system uses a reference from a GPS (stratum 1) as its timing source. During normal operation, the GPS receiver, through the GPS antenna, locks on and tracks the C/A signal transmitted by the GPS satellites that are circling the globe. The C/A signal is used to disciple the primary GPS oscillator (crystal) that in turn provides a reference to the main GPS bus and also is used to disciple the secondary GPS oscillator (Rubidium). In the typical configuration, the GPS provides timing but there are other options available for timing.

Figure 1.7 GPS Antenna

IEEE Switch Box

The IEEE switch box is used to change connection between each server and erases having to physically change server connection.

Figure 1.8 Server Switch Box

AccessNet

This section contains an overview of the AccessNet to include the hardware connectivity and software utilization and interaction. The equipment shown in figure 2.1 below consists of two T1/E1 fiber optic multiplexers, RJ45 patch panel, DB9 patch panel, two Carrier channel banks, remote control unit (RCU), TEN-4 Stancil Recorder/Reproducer 5U, AccessNet switch, 3 UHF radios, VHF radio, 8 operator console positions, and 3 uninterruptible power supply (UPS).

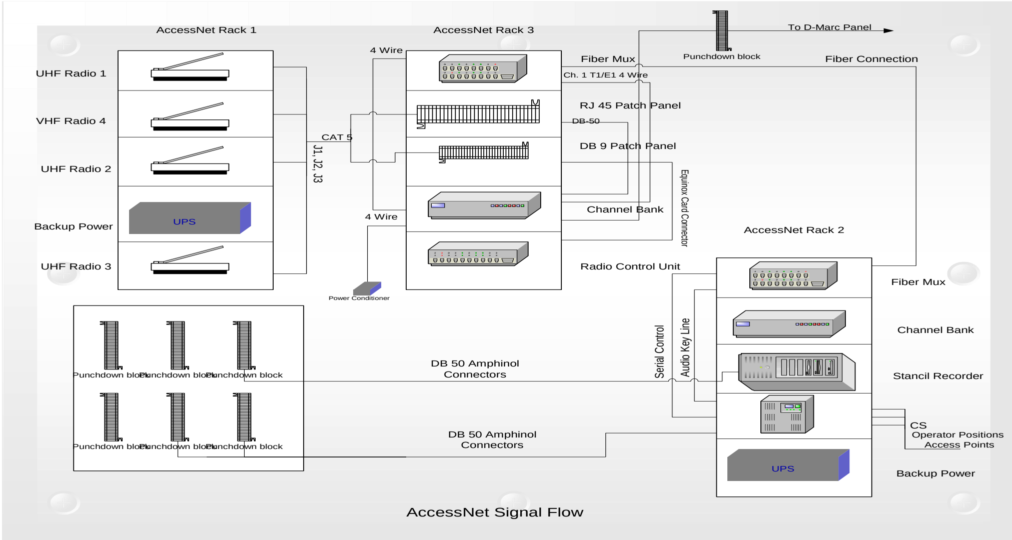

Figure 2.1 AccessNet Signal Flow

T1/E1 fiber optic multiplexers

The TC8300 is a 1 to 4 channel T1/E1 Fiber Optic Multiplexer. It converts the optical signal to an electrical signal understandable by other electronic interfaces. It is responsible for diagnostics of the signal, handling the audio key line for actuating the radios, and handling serial control of each operator radio position.

TC8300P T1/E1 Fiber Optic Multiplexer (Shown with ST Fiber Connectors)

Figure 2.2 Fiber Optic Multiplexer

RJ45 Patch Panel

The RJ45 patch panel provides a quick and easy way to route and reroute system configurations for troubleshooting. The patch panel has 2 major purposes. The first is to provide a physical conversion from a tactical radio to a CAT5 wire. The second is to separate the converted radio signals and send them across an Amphenol DB50 connector to a demarcation panel.

Figure 2.3 RJ45 Patch Panel

DB9 Patch Panel

The DB9 patch panel further breaks out the radio signal by routing the signal received from the RJ45 patch panel down to the radio control unit. This process allows the operator interface serial control of individual radios as aforementioned in the description of the T1/E1 fiber multiplexer.

Figure 2.4 DB9 Patch Panel

Remote Control Unit

The remote control unit permits the use of a single serial control connection between sites. That connection is based on a multiplexed serial control protocol. As radio commands are sent between sites they contain and address the ID of a specific radio. Upon receipt of the command, the RCU parses the command and then routes the command to the particular addressed radio. This is how the radios are networked together.

Carrier Channel Bank

The channel bank provides a dual purpose for the AccessNet system. First it provides analog interfaces for radio control. The channel bank connector facilitates 24 pair (6 positions) E&M access points for T1 connectivity. Second it provides a termination for separation of the T1 connections for 2-wire to 4-wire conversion.

Figure 2.5 Carrier Channel Bank

TEN-4 Stancil Recorder/Reproducer 5U

The Stancil Recorder is a voice logging recorder used to record each individual operator position depending on the decided configuration of each radio channel. In the past all radio positions in the older Operations Module were recorded on reel-to-reel technology. The Stancil recorder uses an 80 GB hard drive for immediate storage with automatic real-time backup of 9.4 GB DVD RAM (Approximately 15,000 channel hours) Its is designed to operate 24 hours per day with recording of regular LAN lines. Anytime radio or LAN line calls are initiated recording starts automatically.

Of all of the equipment for the AccessNet system the Stancil recorder is more or less the heart of the network. The terrorist actions of 911 have forced the FAA and other government agencies to strengthen air traffic control security. The recorder is the central interface for the operators. It makes it easier to find calls recorded more efficiently with better integrity.

Figure 2.6 TEN-4 Stancil Recorder/Reproducer 5U

AccessNet Switch Node

The AccessNet switch node contains the hardware required for real-time voice and data switching and coordination and control of the external interfaces. The switch node is a regular computer with extra components such as T1/DSP cards, MAC cards, serial port cards, and a multichassis interconnect card. There are 8 system console connections on the switch node.

Operator Interface Position

The AccessNet operator position is a General Dynamics proprietary hardware that the operators use to communicate with the radios. It is a fully integrated LCD touch screen running on Windows 2000 platform. The interface gives each operator control of individual radio frequency channels.

Deliverables

1. Efficient Training
2. Expanded Surveillance
3. Increase Flight Response Time
4. Local Remote-Control Interfaces
5. Operator Forms and Reports
6. Digital Maintenance Diagnostics
7. Digital Recording

Budget

NOMENCLATURE	Contact	Payment Types	Quantity	Cost
US Robotics Courier Modem	Metrocom		1	$257.00
YJ3-225H	Deseri Perez			
	281-495-6500			
Cyclades TS400	Metrocom		1	$155.25
4VM74	281-495-6500			
Asante FriendlyNet Switch	TMS Inc.		1	$269.00
	828-654-9735			
MPS800 Multiprotocol Server	TMS Inc.		1	$1,638.00
	828-654-9735			
Sun Enterprise 250 Server	Cisco Corp		2	$3,000.00
4500-M	800-553-6387			
Motorola Codex Modem	Motorola		1	$3,200.00
M3000	800-826-1913			
GPS Antenna	Zyfer Corp.		1	$300.00
WS-C3100B	714-917-1970			
Espirit Terminal	Cortelco INTL INC		1	$295.80
Fiber Optic Multiplexer	General Dynamics		2	$3,156.00
1450LS	703-876-3195			
RJ45 Patch Panel	PROVantage		1	$99.00
910C	800-851-7359			
APC Smart-UPS 2200VA	PC Mall		3	$2,598.00
39914	800-863-3282			
DB 9 Patch Panel	PROVantage		1	$69.39
AT-FH824U-SW	800-336-1166			
Channel Banks	Metrocom Comm.		2	$5,495.00
ST-8000A/DBIN	217-367-7373			
AccessNet Remote Control Unit	General Dynamics		1	$4,295.80
	703-876-3195			
Stancil Recorder	Stancil Corporation		1	$3,156.00
1450LS	714-546-2002			
UHF Radios	Harris Corporation		3	$11,499.00
910C	312-727-9100			
VHF Radios	Harris Corporation		1	$3,598.00
39914	312-727-9100			
				Total
				$43,081.24

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Proof of Design

This section will describe in detail the design of the mobile network. I will separate the proof of design context into two areas: user interface and hardware design.

User Interface

ASAC

The ASAC software was designed to allow work in a workgroup or a stand-alone configuration. The stand-alone configuration can be used to control aircraft but usually is used as a way to replay air picture simulations and recordings. The major data flows are accomplished using a pipeline configuration that decides the one-directional communication between subsystems.

The air traffic control operators did not have a large learning curve to learn the ASAC side of the network because of its similarities to the old module. The users are able to utilize a windows manager for controlling the different panels and screens that comprise the control setup. The administrator is responsible for setting up the accessing account before the user can start to work. Each position must be assigned a network username and password.

Once the administrator has setup the account the first step for the controller is to login in to the system. The second step for the operator is to start a recording session. Whether the session is group or standalone the startup is the same. Once the session group screen appears the controller must input which group join.

After joining the group the session manager automatically appears and the basic session manager panel opens. The session manager panel is where the menu bar, geographic position selects, message window, and time appear. Next the operator users the menu bar to select the different views needed for the mission.

AccessNet

The AccessNet system is the newer of the two sides of the network. The controllers were layman users in terms of learning the radio communications. However, the new system is simpler than the older communications module. Unlike the ASAC system the operator has limited control over the radio controls. The only task the operators are able to do is access the various telephone and radio lines needed to communicate with aircraft.

After logging onto the ASAC network the controller picks up a headset and either uses a foot control or hand control switch to key the microphone on the radios. The users then must contact the FAA to check the shout lines (direct emergency communication lines) and acknowledge control times to accept the mission. After the FAA has cleared the controller to take over the mission the controller then contacts the aircraft pilot to direct flight patterns.

Hardware Design

ASAC

The hardware design for the ASAC is premeditated to have the servers act as central control of all network peripherals. The following section will explicate the description of the network design of the ASAC.

Operating System

The operating system for the ASAC is the UNIX command set. All computers within the node use the Solaris operating system. The main reason for using this operating system is the military precedent that the primary language (Ada) for the ASAC used with Sun systems would be UNIX and that it would be more efficient in terms of maintenance since all technicians attend the UNIX course to learn the system. We use a time server utilizing NTP to establish synchronization for the network. For the users to understand and use the interface applicable to them an X windows graphical interface was designed.

Cabling and Topology

The backbone for the ASAC is an Ethernet network requiring cables to run in a star fashion from the network devices to all the nodes. We chose the TCP/IP protocol suite because of its low cost, interface options, scalability, and many protocol services it offers. We used NFS to share read-only files that only take up one machine. Clients' access files on the server by mounting the server's shared file system. The mount looks like a local mount and users' type commands as if the file system were local.

Addressing

The Class C internet addressing scheme is utilized but since this is an intra-organizational network we could have made a private subnet of any address and setup a router later to interface other networks. Each node on the network is assigned a sequential number, which is appended to the address base.

Network Flow

This section will serve to show the signal flow for the ASAC network and can be in conjunction with the network flowchart or diagram in the appendix to better understand the setup

As stated before the network control begins with the servers. The next equipment in line is the Mode 4 modem and the protocol server. The Mode 4 server allows the data sent to and from the aircrafts radio beacon to be read from the radar interface. The protocol server is used in conjunction with the Mode 4 server to interface the tactical equipment used to receive the radar picture and also to separate the tactical hardware form the commercial hardware. Next the signal from the time server is used to ride the data signal before the switch in order to provide network synchronization and to push out a steady and continuous air control picture to all nodes in the network. Finally the terminal positions accept the signal from the switch as part of the network to allow aircraft control.

AccessNet

Unlike the ASAC system the AccessNet is designed to have systems perform almost independently from each other. The system architecture is very flexible. There are no dependencies between the hardware and software. How the system is configured depends on the needs at the site for the mission. We purposely designed the system this way to allow future scalability.

Operating System

Many of the AccessNet functions and features are controlled through a variety of configuration and data files. The operating system used for the AccessNet network is Windows Server 2000. We chose this OS because it is the most widely supported system among military installations and it allows interoperability with various application nodes that could be used to interface the AccessNet system. To facilitate monitoring and management the software configuration is a formal configuration of management tools to maintain a streamline support at each site.

Cabling and Topology

The backbone for the AccessNet system is a star topology with Ethernet to fiber conversion. Again the TCP/IP protocol suite was used for this network because of its efficiency. The most common type of cabling used for this system is CAT5 with connection through patch panel conversion for other interface adapters. The network may also be connected as a node to an external WAN. This allows the other locations to scale the network to meet the needs of deployments ranging from a few subscribers to a full wing or command component.

Addressing

The operator console positions are setup in a Class C subnet. This classification was selected to allow me to have desktop administration to the recorder that monitors all call systems interacting with the AccessNet system.

Network Flow

This section will serve to show the signal flow for the AccessNet network and can be used in conjunction with the network flowchart or diagram in the appendix to better understand the setup.

In its current configuration the AccessNet system gets the communication signal for the recorder from an MCI managed T1. Normally this signal would originate from the AN/TSC-94 satellite van with a bandwidth of 600K. The signal is then connected to a demarcation panel used to distribute all communication lines via twisted pair. The T1 signal is connected with the channel bank on the local side of the equipment rack where it is broken out evenly over a 24 port channel bank. Next the 24 channels are connected to the recorder to produce a visual readout of each channels status. Below in figure 4.1 is a snapshot of what an operator or maintainer will see when viewing the status of a link.

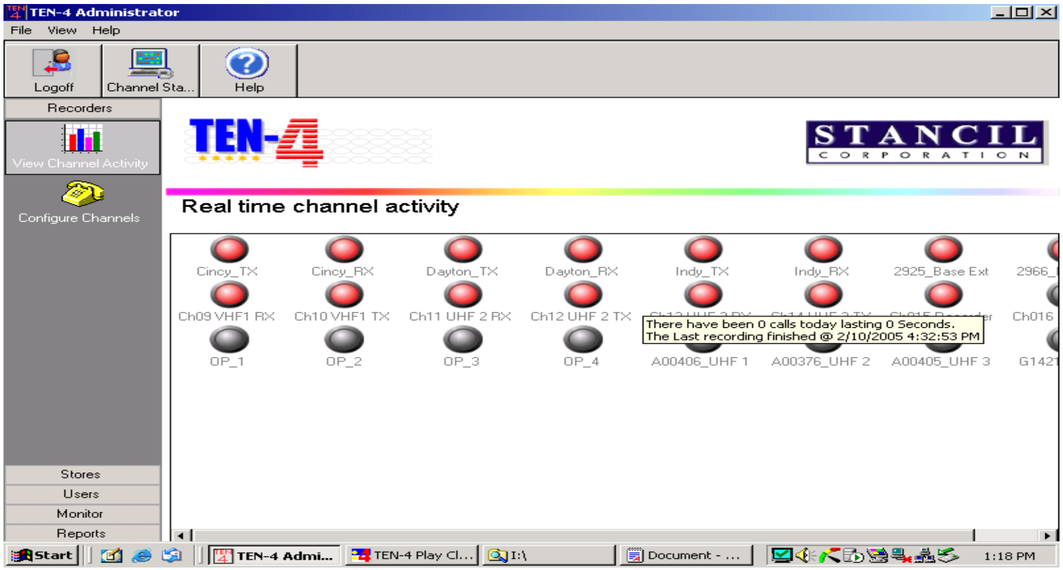

Figure 4.1 Operator Monitor Console

Next the voice and data switch interfaces with the recorder to begin the process of providing the remote location the interface option to the local AccessNet. The switch multiplexes the channels onto a single CAT5 line that is connected to the fiber multiplexer and sent to the remote location. The fiber multiplexer and channel bank demultiplex the signal and provide and interface to the RJ45 and DB9 patch panels that connect the tactical radios.

Conclusions and Recommendations

The focus is on making better use of the air traffic control information systems by creating a mobile local area network capable of facilitating more efficient communications. The networks were assessed on the following criteria:

- Technical considerations
- Cost
- Training and support.
- Time constraints
- Users and their needs
- Product Description
- Design Protocols
- Testing Plan
- Deliverables

Technically, the proposed network is a simple one. Because of this simplicity, and the competence of the unit technicians, the training provided will be minimal. However, unlike support, training was not included in the proposal's quoted price. As of right now I have received the only training for the hardware and the closest training for any software is still a few months away.

The initial development of the AccessNet portion was done without any prior knowledge of how the various pieces of equipment would work together and only an understanding of what we needed. The hardware packages that we requested were different than what we actually needed or ordered and thus facilitated our behind the schedule instances. Overall the systems in place are complete and satisfactory. Therefore I recommend that training be purchased with the equipment to allow a better understanding of its capabilities.

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