Emergency Medical Services: LifeLink Model Deployment Initiative System Design Document

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Acronym List

API	Application Programming Interface
ATMS	Advanced Traffic Management System
ATP	Acceptance Test Plan
BAMC	Brooks Army Medical Center
DTE	Data Terminal Equipment
FCC	Federal Communications Commission
ICM	Installable Compression Manager
ICS	Industrial Computer Source
ID	Identification
IP	Internet Protocol
LAN	Local Area Network
L1TC	Level 1 Trauma Center
LK	Link
MFC	Microsoft Foundation Classes
MMAC	MultiMedia Access Corporation
MSVC	Microsoft Visual C++ Version 5.0
OPI	Osprey Programming Interface
PC	Personal Computer
RTS	Request-to-Send
RX	Receive
SAFD	San Antonio Fire Department
SDI	Single Document Interface
SNMP	Simple Network Management Protocol
SwRI	Southwest Research Institute
TOC	TransGuide Operations Center
TX	Transmit
TxDOT	Texas Department of Transportation
VAC	Volts AC
VDC	Volts DC
VFW	Video for Windows
VT	Vital Transfer
WDM	Wave Division Multiplexer
WEB	Wireless Ethernet Bridge
WHMC	Wilford Hall Medical Center

1. Introduction

This document provides an organizational and functional description of the LifeLink System that has been developed by Southwest Research Institute (SwRI) for the Texas Department of Transportation (TxDOT). The basic purpose of the LifeLink System is to provide two-way video and audio conferencing and one-way vital statistic data telemetry capabilities between ambulances responding to major accidents and physicians in hospitals, specifically Level 1 Trauma Care (L1TC) facilities, such that early assessment and treatment may be initiated in the field.

Section 2.0 provides a high level description of the LifeLink System architecture and functional capabilities. Sections 3.0 through 6.0 provide more detailed descriptions of the four LifeLink System subsystems: Ambulance, Roadside Fiber Hub, TransGuide Operations Center (TOC), and Hospital. Figure 1 provides a block diagram showing the connectivity of the four subsystems that comprise the LifeLink System. Section 3.0 provides a description of the Ambulance Subsystem onboard equipment and how it operates. Section 4.0 provides a description of the Roadside Fiber Hub equipment that is used to provide a communication link between the Ambulance and TOC Subsystems. Section 5.0 provides a description of the TOC Subsystem equipment that is used to provide a communication link between the Roadside Fiber Hub and Hospital Subsystems. Section 6.0 provides a description of the Hospital Subsystem based equipment and the physician's video, audio, and vital statistic data interfaces with the ambulance. Section 7.0 provides a description of the LifeLink System software. Section 8.0 includes a traceability matrix for the LifeLink System that summarizes system requirements.

Note: Paragraphs that contain specific system requirements defined in the Section 8.0 Traceability Matrix are followed by bracketed text containing the requirement number. Example: [LL-GEN-04]

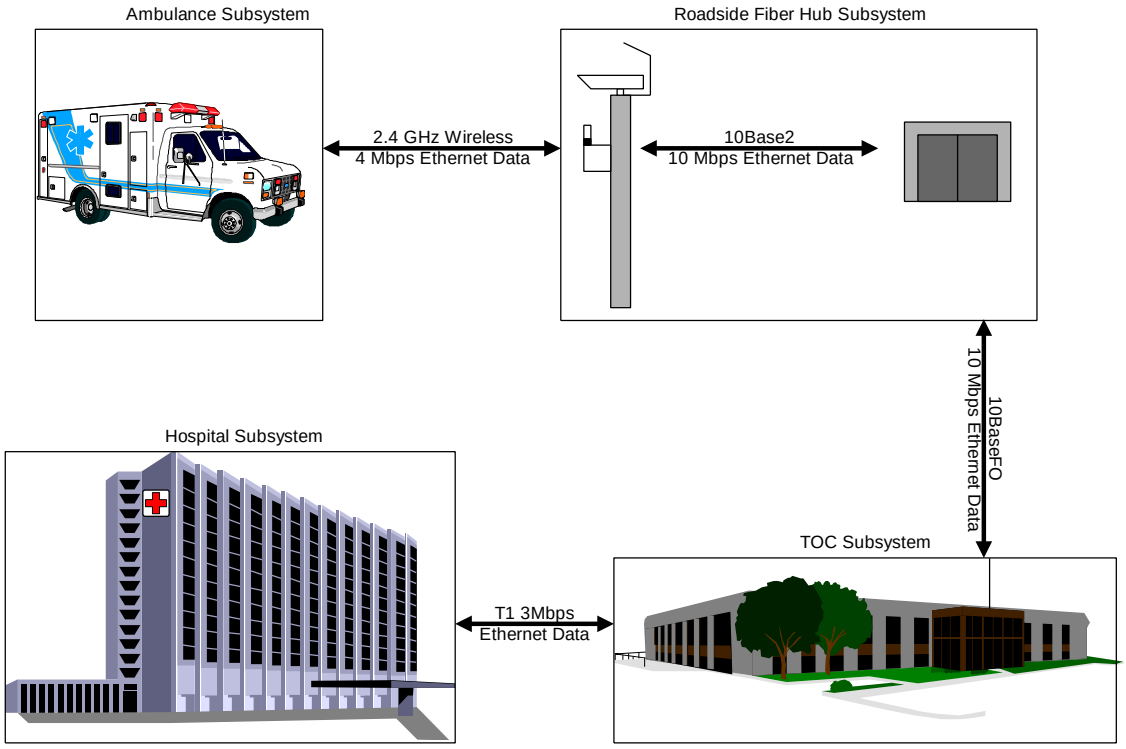


Figure 1. LifeLink Functional Overview

2. LifeLink System

The LifeLink System provides a distributed mobile Local Area Network (LAN) designed to link San Antonio Fire Department (SAFD) ambulances on or near San Antonio's freeway system with a hospital in the city. The link utilizes the facilities and roadside fiber-optic network of the TransGuide Advanced Traffic Management System (ATMS) to establish a communication link between a mobile ambulance and a hospital. The LifeLink System utilizes this mobile LAN communication network to conduct real-time videoconferencing between an ambulance and a physician at the hospital. Additionally, the ambulance crew can use portable medical data instruments to send vital statistic data to terminal equipment in the hospital over this same mobile LAN network. The LifeLink System utilizes a standard Ethernet LAN protocol that enables the use of Simple Network Management Protocol (SNMP) techniques for network management of configurable system devices such as the TOC Ethernet switching equipment and roadside Wireless Ethernet Bridge (WEB) radios. See section 5.0 for additional information on the LifeLink System SNMP computer. [LL-GEN-001, LL-SYS-007]

Each SAFD LifeLink-capable ambulance has been equipped with a computer configured with applicable videoconferencing hardware and software. The ambulance computer is connected to an onboard video camera and WEB radio. The onboard WEB radio enables communication with fixed LifeLink WEB radios that have been installed near the TransGuide ATMS roadside fiber hubs located along portions of the San Antonio freeway system. The WEB radios utilize a 2.4 GHz spread-spectrum communication link technology that does not require special FCC licensing. The ambulance-to-roadside radio communication link provides the ambulance computer with a bi-directional Ethernet link into the ground-based LifeLink Ethernet system which utilizes existing TransGuide fiber optic cable to link the roadside fiber hubs through an Ethernet switching hub at the TOC to a hospital. The hospital has been equipped with a computer configured with compatible videoconferencing hardware and software. The hospital computer connection into the LifeLink Ethernet system is via a temporary T1 telephone circuit until the fiber optic cable installation between the TOC and hospital can be made available for LifeLink use. [LL-GEN-004, LL-SYS-005]

The Ambulance and Hospital Subsystem computers have been configured to automatically load and start up the operating system and LifeLink software application upon power-up. The user interfaces have been designed to minimize user interactions required to initiate, participate, or terminate a videoconference session. The LifeLink System videoconferencing hardware and software application enables bi-directional transfer of video, audio, and data between a mobile ambulance and a hospital. The videoconference hardware and software application provides for CIF resolution (352 x 240), outputs an image scaleable to full screen, offers a local view output, and operates within the LifeLink System available radio bandwidth. [LL-SYS-003, LL-SYS-008]

During an active videoconference session, the LifeLink System provides the hospital node operator with a picture-in-picture screen view. The full screen image is that of the video being

sent by the ambulance and a small image in the upper left corner of the screen containing the local image being sent to the ambulance. The LifeLink System provides the ambulance node operator with a separate large screen view (10.4" display panel) of the hospital physician and small screen view (4" display panel) of the patient image being sent to the hospital node. The dual ambulance display concept was implemented to minimize the possibility of the patient seeing the transmitted image showing severity of injury. The smaller display is located in an area that cannot easily be viewed by the patient. A status bar located near the bottom edge of the large displays at each end of an active videoconference session includes the identity of the current remote terminal node. In the event of temporary loss in the ambulance to roadside fiber hub radio communication link due to line-of-site blockage which will occur when the ambulance travels under an overpass or other structure, the LifeLink System monitors will display a "frozen" image of the last good video image that was received. This "frozen" image will prevail until the transient blockage is removed. Breaks in the audio and vital statistic data channels may also occur during these transient blockages. This same phenomena may occur when the ambulance WEB radio switches ("hands off") between two fiber hub roadside WEB radios, but this process usually occurs quickly enough that it is not always detected. [LL-SYS-001, LL-SYS-002, LL-SYS-003, LL-SYS-004]

The videoconference link provides for bi-directional voice communication between the hospital and ambulance LifeLink System operators via a single headset provided at each end of the videoconference. A separate data channel has also been included for the transmission of optional vital statistic data from terminal equipment in the ambulance to a remote display terminal at the hospital. The vital statistic data channel is provided as an RS-232 link operating at 38.4 kbps. [LL-GEN-005, LL-SYS-006]

The LifeLink System ambulance and hospital user interfaces have been designed to only allow the Ambulance Subsystem to initiate a videoconference session. The hospital node contacted by the ambulance is called the control node. The control node is capable of both bi-directional audio and video communication with ambulance. The control node can also receive vital statistic data if the ambulance and hospital node are equipped with the appropriate equipment. An ambulance can only communicate with one hospital control node at a time. The operator at the hospital control node can transfer the control node function to another hospital node, but the original control node will at that time be disconnected from the videoconference session. The hospital control node operator can also connect other hospital nodes into the videoconference session as consultant nodes. The LifeLink System operator at the consultant node can listen to the ambulance operator audio and view the ambulance transmitted video, but can use a standard telephone link to communicate with the control note operator. [LL-GEN-002, LL-GEN-003, LL-GEN-006]

3. Ambulance Subsystem

SwRI has modified ambulances provided by the SAFD to include LifeLink equipment. The LifeLink Ambulance Subsystem equipment provides the ambulance with a mobile Ethernet LAN link to fixed Ethernet LAN radios located near portions of the San Antonio freeway system. This wireless Ethernet link enables LifeLink System operators in ambulances on or near portions of the San Antonio freeway system that have been equipped with LifeLink equipment to conduct a two-way videoconference with medical personnel at a hospital. The Ethernet LAN link is used to transfer video, audio, and vital statistic data to the hospital.

3.1 Major Components

The following subsections provide a description of the Ambulance Subsystem components that have been installed into each ambulance equipped for operation with the LifeLink System. Figure 2 provides a block diagram of the major Ambulance Subsystem components.

3.1.1 Computer

The LifeLink System ambulance computer utilizes an Industrial Computer Source 9301 Series computer chassis with 1 CPU, 3 ISA, and 4 PCI slots. The chassis also contains a 12 VDC input power supply, 3.5" 1.44MB floppy disk drive, and 1.6GB hard disk drive. The CPU slot contains a single board 200MHz Pentium MMX processor card with 48MB of onboard RAM. The computer operating system is Windows NT. [LL-AMB-002]

The computer, WEB radio, power system controller, and backup battery have been integrated into a custom LifeLink ambulance cabinet that has been rigidly mounted for safety and security. The cabinet includes a fan and temperature interlock to protect the LifeLink Ambulance Subsystem from extreme temperature conditions. Figure 3 provides a block diagram showing the major Ambulance Subsystem components that are in the PC/Radio/Power Supply enclosure.

3.1.1.1 Videoconference Card

A MultiMedia Access Corporation (MMAC) – Osprey 1000 videoconference card is installed in a PCI slot in the ambulance computer and serves as the host for the LifeLink videoconferencing application. The Osprey 1000 videoconferencing card and software application enables the LifeLink Ambulance Subsystem to conduct a two-way audio and videoconference with a hospital. [LL-AMB-003]

3.1.1.2 RS-232 Serial Ports

The ambulance computer CPU card provides support for 2 RS-232 serial ports. COM1 port is used to support the optional vital statistic data telemetry function at 38.4 kbps. See sections 3.1.5 and 3.3.3.3 for additional information on the vital statistic data telemetry function. COM2 port is connected to the patient camera RS-232 control port that may be used in the future to enable local and/or remote computer control of the camera. The camera control software required to provide this capability is not currently supported. [LL-AMB-005]

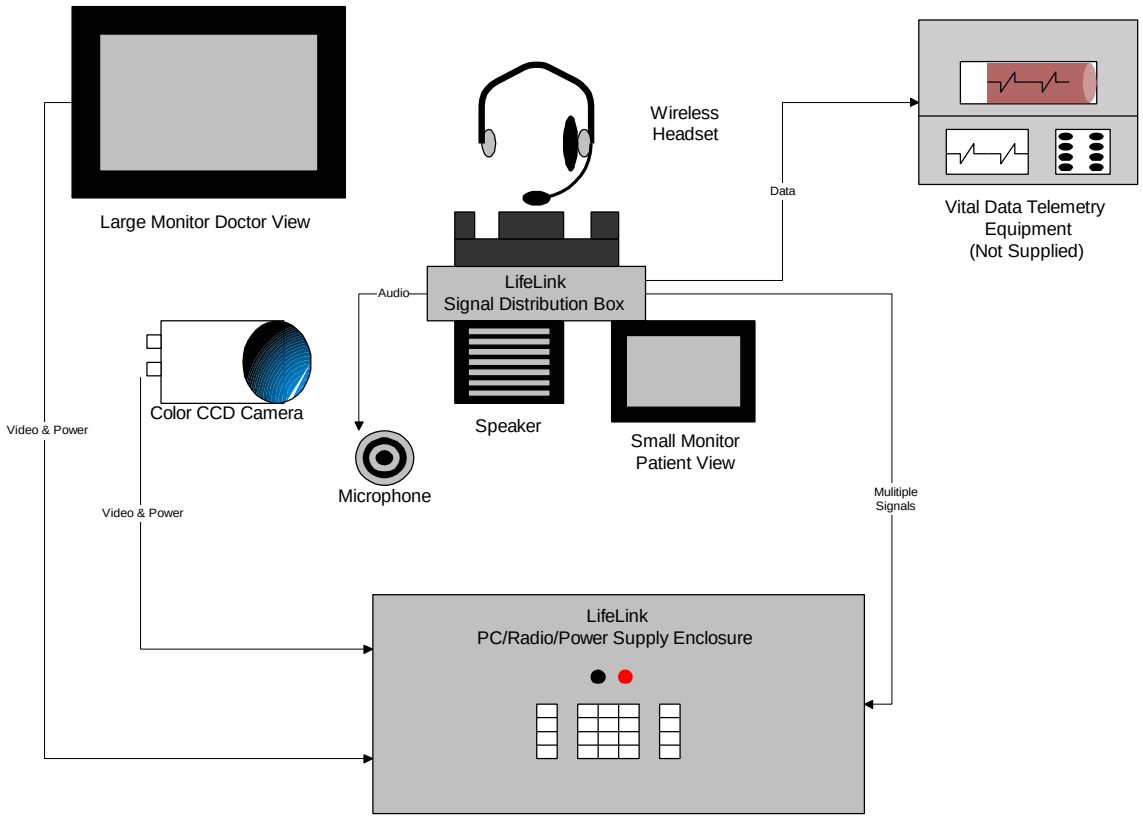


Figure 2. LifeLink Ambulance Subsystem

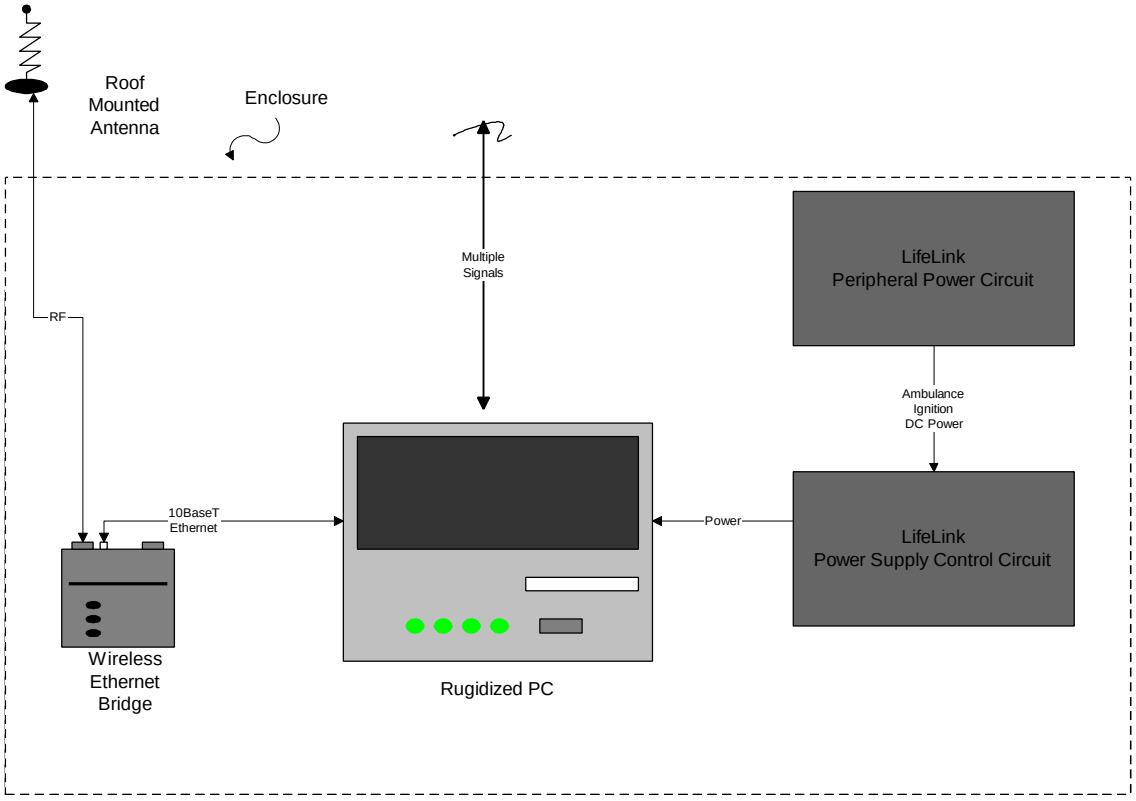


Figure 3. LifeLink PC/Radio/Power Supply Enclosure

3.1.1.3 Keypad Port

The ambulance computer includes a standard PC-AT keyboard connector port that interfaces to the LifeLink keypad (see Section 3.1.4) or to a full size standard PC-AT keyboard (not included) for improved maintenance capabilities.

3.1.1.4 Ethernet Port

The ambulance computer includes a 10BaseT Ethernet port for connection to the WEB radio. The computer includes a 3COM Model 3C905 PCI network interface card to provide this 10 Mbps Ethernet interface. [LL-AMB-004]

3.1.1.5 Display Port

The ambulance computer includes a VGA video port for connection to the primary cabin display unit. The computer includes a Number 9 Revolution 3D PCI video adapter with 4MB WRAM to provide this VGA interface.

3.1.1.6 Headphone/Microphone Ports

The ambulance computer MMAC videoconference card includes microphone input and headphone output ports for connection to a headset with microphone.

3.1.1.7 Power Monitor and Control Interface

The Ambulance Subsystem includes a custom power management system that has been designed to protect the LifeLink System from ambulance power system transients or inadvertent power-down sequences. The ambulance power management system contains its own backup battery to ensure that the LifeLink system can gracefully shutdown when an ambulance power failure occurs or if the ambulance power is inadvertently turned off. See Appendix A for more information on the ambulance power management system.

The ambulance computer can monitor the status of the ambulance power and shut down the LifeLink System when it detects a loss of ambulance power. The ambulance power management system uses an Industrial Computer Source ISA Model DIO8-P I/O card (general purpose I/O card with 8 isolated relay output channels and 8 optically isolated input channels) to monitor ambulance power status and to control LifeLink System power-down.

3.1.2 Video Camera

A Sony model EVI-G20 pan, tilt, zoom, auto focus, color video camera is located above the patient area. The EVI-G20 video camera has a scan resolution of 400 horizontal scan lines per frame. The camera has been placed such that at system power-up the camera defaults to a home position providing a full view of the patient head and body cavity with auto focus enabled. The EVI-G20 camera comes with an infrared remote control that can be used by ambulance personnel to manually position and control the camera. The EVI-G20 also has an RS-232 serial port connected to the ambulance computer COM2 port. This RS-232 serial port connection may be used in the future to enable local and/or remote computer control of the camera, but the software required to provide this capability is not currently supported. [LL-AMB-006, LL-AMB-007]

3.1.3 Displays

The Ambulance Subsystem contains two LifeLink display units in the patient cabin area. One display provides a local view of the transmitted image and the other display provides a view of the received remote image.

3.1.3.1 Local Patient Image Display

A 4” Sony model XVM-42 LCD Mobile Color Monitor is mounted in the ambulance cabin area. This display has been mounted in an area where it can easily be viewed by the ambulance LifeLink

System operator, but not by the patient lying on the gurney. This small display panel is connected directly to the output of the patient camera and provides the ambulance LifeLink System operator with a view of the image currently being transmitted to the hospital node. The small display panel view is active even without an active conference. A Signal Distribution Enclosure has been developed for the Ambulance Subsystem that serves as an I/O distribution point for the 4" monitor, external speaker, wireless headset, etc. Figure 4 provides a block diagram showing the major components of this enclosure.

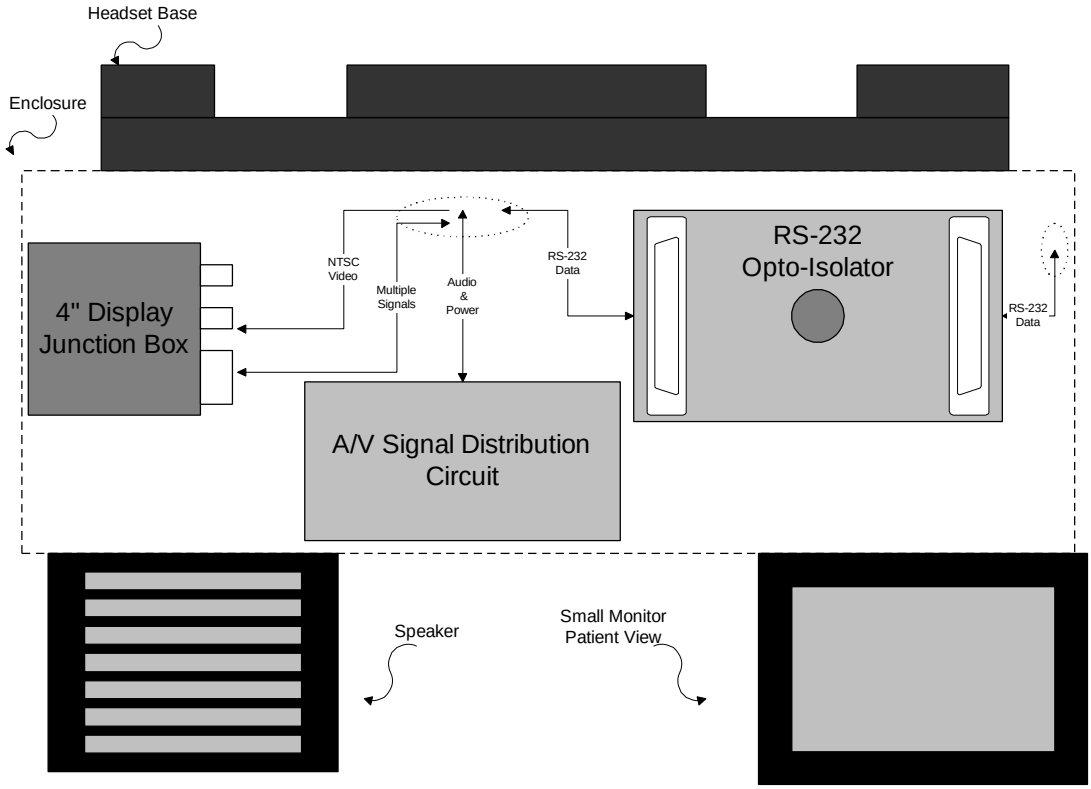


Figure 4. LifeLink Signal Distribution Enclosure

3.1.3.2 Received Remote Image Display

A 10.4" Dolch model PM-10T-VG-C VGA Flat Panel Display is also mounted in the ambulance cabin area. This display has been mounted in an area so that the ambulance LifeLink System operator, while either working on a patient on the gurney or sitting in the captain's chair, can view it. The patient can also view the display with the head of the gurney slightly raised.

3.1.4 Control Panel

The ambulance LifeLink control panel is located on the front door of the custom LifeLink ambulance cabinet. The control panel is comprised of three Storm Series 900 keypads that are connected to a Storm 700/900 Series Universal Encoder. The Storm 700/900 Series Universal Encoder is then connected to standard PC-AT keyboard connector on the rear of the ambulance computer. The LifeLink control panel keypad layout is shown in Figure 5.

Start/Stop Conference	**F1**	**7**	**8**	**9**	**-**
Reserved	**F2**	**4**	**5**	**6**	**®**
Reserved	**F3**	**1**	**2**	**3**	**¬**
Cancel	**F4**	**CE/C**	**0**	**ENT**	**–**

Figure 5. Control Panel Keypad

3.1.5 Vital Statistic Data Telemetry Option

Although vital statistic data monitoring equipment is not a required system component, the LifeLink System does provide optional support for transmitting vital statistic data from the ambulance to the hospital during a videoconference session when this equipment is available. The COM1 RS-232 serial port on the ambulance computer has been configured to transfer vital statistic data from the ambulance to the hospital when the appropriate equipment has been attached. The LifeLink System has been tested to provide support for Physio Control LifePak 11 and the Protocol Systems, Inc. ProPaq Encore vital statistic data monitor systems. Both units transmit data at 38.4 kbps. A special interface cable is required to interface these 2 devices to the ambulance computer serial port. Appendix B includes detailed information on the required interface cables and additional information on the LifePak 11 and ProPaq Encore systems.

WARNING – For patient safety, a Black Box Model SP340A RS-232 Opto-Isolator module has been placed in the link between the vital statistic data monitor and ambulance computer RS-232

ports. This module must remain in place in order prevent possible injury to a patient connected to the ambulance vital statistic data monitor.

3.1.6 Headset, Speakers, and Microphone

The ambulance subsystem provides the user with 2 options of voice communications during a videoconference. A Hello Direct 900MHz Cordless Headset (includes speakers and microphone) is provided to give the ambulance LifeLink System operator mobility around the patient. This approach can enable the ambulance LifeLink System operator to communicate with the hospital physician while the patient is being treated outside the ambulance cabin. As an alternative, a cabin microphone and speaker are provided to enable the ambulance LifeLink System operator and the patient to participate in the videoconference session. The ambulance LifeLink System operator has access to an audio select switch located in the patient cabin that controls the mode of operation. [LL-AMB-008]

3.1.7 Wireless Ethernet Bridge

Each ambulance is equipped with an Aironet BR2040EE spread-spectrum Wireless Ethernet Bridge (WEB) radio which enables the ambulance to transfer Ethernet packets containing video, audio, and vital statistic data to and from other WEB radios located near portions of the San Antonio freeway system. The WEB radio is mounted in the custom LifeLink ambulance cabinet. A RJ-45 terminated unshielded twisted pair category-5 cable is used to connect the WEB radio to the ambulance computer Ethernet port. [LL-AMB-001]

A whip style radio antenna is mounted to the top of the ambulance and connected to the WEB radio via a coaxial cable. The antenna is a Larsen FB-0005 2.4GHz ground plane antenna. The coaxial cable is a type RG-58 cable terminated with a straight type RTNC connector at the WEB radio end and a right angle type N connector at the antenna end.

3.2 Power Management System

The LifeLink Ambulance Subsystem operational power is derived from the ambulance 12 VDC ignition power bus. The ambulance power system also contains its own backup battery to provide momentary LifeLink System power when ignition power is lost (ignition turned off or power failure). The ambulance power system utilizes the 115 VAC shoreline power to charge the backup battery when the ambulance is parked and ambulance 12 VDC ignition power to charge the battery when the ambulance ignition is "ON". [LL-AMB-010, LL-AMB-011]

The power management system includes a master power toggle switch and fuse in the main power connection to the ambulance ignition power bus. The switch and fuse are located on the custom LifeLink ambulance cabinet. The switch can be used to completely disable operation of the Ambulance LifeLink Subsystem. Two momentary pushbutton switches on the front face of the

custom LifeLink ambulance cabinet control powering "ON" and "OFF" of the ambulance subsystem. The "ON" switch is used to power-up the LifeLink ambulance subsystem and the "OFF" switch is used to initiate a graceful power-down sequence. The "ON" momentary pushbutton switch can be used to activate power to the LifeLink Ambulance Subsystem only when ignition power is "ON". Once activated the power system provides the following power levels to the following LifeLink ambulance components. [LL-AMB-012]

1. Computer +12 VDC
2. WEB radio +15 VDC
3. Patient camera +9 VDC
4. 10.4" cabin display +12 VDC
5. 4" cabin display +12 VDC
6. Wireless headset +12 VDC

The power management system provides the LifeLink ambulance computer access to an ignition status signal. When the Ambulance Subsystem detects that the ignition power has been turned "OFF" or if the ignition power system fails to provide adequate power, it will begin an automatic system shutdown approximately 10 seconds after detection of ignition power loss. The Ambulance Subsystem shutdown process requires approximately 2 minutes to gracefully shut down the Windows NT operating system and to turn off LifeLink operational power. The user can also force a LifeLink Ambulance Subsystem shutdown by pressing the pushbutton "OFF" switch. The system will display a shutdown message and begin the LifeLink shutdown process in approximately 10 seconds unless the user presses the "Cancel" button on the keypad. [LL-AMB-013]

The power management system includes circuits that automatically force a LifeLink power shutdown sequence in the event that the ambulance computer does not respond to either the ignition "OFF" or activation of the "OFF" switch for more than approximately 3 minutes.

[NOTE: The backup battery is only intended to provide several minutes of LifeLink system operating power after the ambulance ignition switch has been turned off or after an ambulance power system failure. The LifeLink System is only intended to be operated when ambulance ignition is "ON" and the ambulance engine is "RUNNING".] [LL-AMB-010]

3.3 Operational Description

The following subsections provide an operational description of the LifeLink System as seen from the ambulance operator perspective. The description covers normal system operation from power-up to power-down and also addresses special cases like loss of LifeLink radio coverage or inadvertent loss of primary power. See section 7.0 for a more detailed description of the LifeLink System software application.

3.3.1 System Startup

Before the LifeLink Ambulance Subsystem can be started, the primary LifeLink MASTER switch must be placed in the "ON" position. The MASTER switch provides an emergency means of completely shutting down power to the entire LifeLink ambulance subsystem. The normal operating position for this switch is the "ON" position. The MASTER switch is located on the custom LifeLink ambulance cabinet.

With the MASTER switch "ON", the user must next press the momentary "ON" pushbutton switch to activate Ambulance Subsystem power. At this point, the front panel keypads will illuminate to indicate that the system boot process has begun. The ambulance computer has been configured such that the LifeLink software application will be installed and configured automatically when the computer is turned "ON". Device drivers are automatically installed for the videoconference hardware, the Ethernet adapter, and the RS-232 port. System software that enables TCP/IP networking are also installed and configured. The boot process, which takes approximately 90 seconds, is completed when the System Ready screen shown in Figure 6 is displayed on the main cabin 10.4" display and the local camera view is displayed on the cabin 4" display. [Note: The operator must also turn "ON" the 4" display panel because it does not have a constant "ON" switch.] As part of the LifeLink System startup process, a backup battery test is performed. If the backup battery test fails, a message will be displayed alerting the user that the battery may not be capable of protecting the system during momentary ignition power transients or premature ignition off-situations. The user can clear the message by pressing "F4" cancel key or "ENT" enter key on the keypad. The user can proceed with operation of the system, but system problems will be experienced if the ambulance power system does not provide good constant ignition power to the LifeLink Ambulance Subsystem. [NOTE: If this error occurs, the Ambulance Subsystem backup battery and charging system should be serviced soon.] [LL-SYS-003]

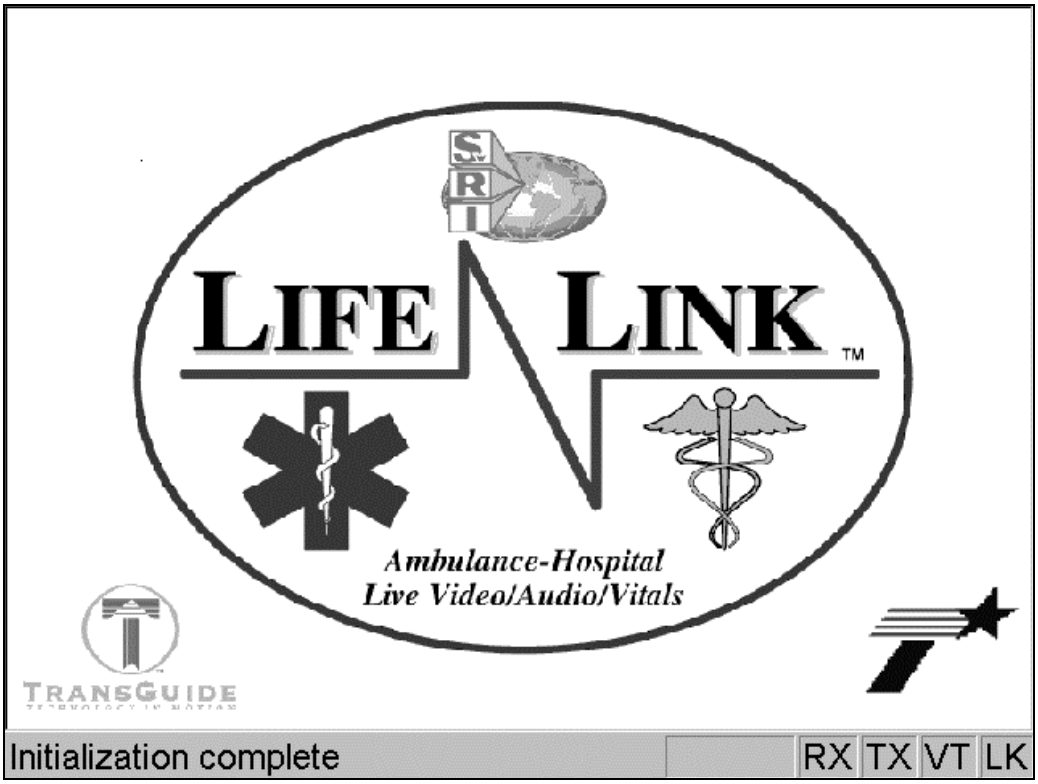


Figure 6. Ambulance System Ready Screen

3.3.2 Wireless Ethernet Link Available

Whenever the LifeLink Ambulance Subsystem is running in either the System Ready screen or any other LifeLink operational screen, the user is provided with the current status of LifeLink radio coverage availability. Radio coverage availability is indicated by the color of the "LK" block on the lower right corner of the main cabin display. A green block indicates that the ambulance is within the LifeLink System coverage area and a videoconference can be conducted. A red block indicates that the ambulance is currently outside the LifeLink System coverage area and a videoconference cannot be conducted. This status indicator is updated approximately every second. The ambulance LifeLink System operator can use this indication to determine if a videoconference should be initiated. The ambulance LifeLink System operator can initiate a videoconference while outside the LifeLink System coverage area, and the Ambulance Subsystem will automatically continue trying to initiate the videoconference session as the ambulance moves toward the hospital.

3.3.3 Ambulance-to-Hospital Videoconference

The following subsections describe the ambulance crew interaction with the LifeLink Ambulance Subsystem after the system has reached the System Ready screen state. The user interface has

been designed to minimize ambulance crew interaction and to enable the ambulance crew to easily initiate, conduct, and terminate a videoconference session. The Ambulance Subsystem is intended to only initiate videoconference sessions.

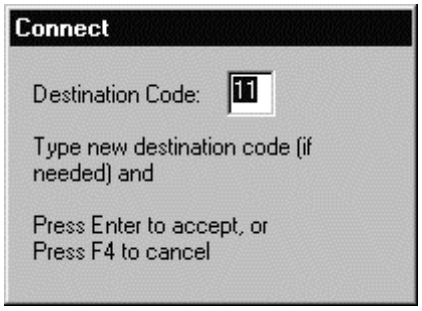


Figure 7. Ambulance Conference Initialization Screen

3.3.3.1 Initiate Videoconference

With the Ambulance Subsystem System Ready screen state, the ambulance crew can begin the videoconference initialization process by pressing the "F1" key on the keypad mounted on the face of the custom LifeLink ambulance cabinet. At this point, the user will be prompted on the 10.4" display as shown in Figure 7. The user at this point can accept the default hospital destination or use the numeric keypad to enter a new 2-digit destination code. Table 1 provides a listing of currently supported destination codes. Pressing the "F4" cancels the videoconference initialization process and returns the Ambulance Subsystem back to the System Ready screen. [LL-AMB-009]

Table 1 LifeLink Destination Codes and Names

DESTINATION CODE	DESTINATION NAME AND NODE
00	Local Loop Back Mode – Test Only
01	BAMC Node – Future
02-05	Reserved
06	University Hospital Node
07-18	Reserved
19	WHMC Node – Future
20-31	Reserved
32-39	University Hospital Node #2-9 – Future
40-41	Reserved
42-49	BAMC Node #2-9 - Future
50-51	Reserved
52-59	WHMC Node #2-9 – Future
60-61	Reserved
62-69	Hospital 4 Node #2-9 – Future
70-98	Reserved
99	TOC SNMP Node – For Testing Only

Upon accepting or entering a new destination code and pressing the "ENT" key on the numeric keypad, the Ambulance Subsystem will attempt to link up with the target destination. A message identifying the destination facility name will be displayed during the link process along with a message stating that the user can press either "F1" or "F4" to terminate the link process. If the ambulance is outside the LifeLink System coverage area as indicated by a red "LK" in the lower right hand portion of the 10.4" display, then the Ambulance Subsystem will attempt to complete the link-up once the ambulance enters the LifeLink radio coverage area. If the ambulance is inside the LifeLink System coverage area as indicated by a green "LK" in the lower right hand portion of the 10.4" display, then the Ambulance Subsystem will complete the videoconference connection if the target destination node is not already in a videoconference session and the destination node is in a ready state. [LL-SYS-009]

Once the videoconference communication link has been established, bi-directional video and audio and uni-directional vital statistic data transfer processes will be available to the ambulance crew.

The ambulance LifeLink System operator can use the headset to conduct audio communications with the hospital personnel. The Ambulance Subsystem user will be presented with a remote image view (from the destination node video camera) on the 10.4" display as shown in Figure 8. The default outgoing video image to the hospital will be the image from the cabin video camera current set position (camera default home position after system power-up). The vital statistic data transfer channel is also available to the ambulance crew if needed. During a normal videoconference session the "RX" and "TX" blocks in the lower right corner of the display should remain green. If the Ambulance Subsystem does not receive data or is unable to transmit data via the radio link for ½ second, these indicators will turn yellow. If the delay interval exceeds 1 second, then these indicators will turn red. These indicators are provided to alert the user of breaks in the radio coverage which will impact the videoconference quality. In the latter state, breaks in audio and momentary freeze frames will occur. If the ambulance moves outside the coverage area for less than approximately 5 minutes during an active conference session, then the conference will resume without ambulance or hospital system operator intervention. If the outside coverage area exceeds 5 minutes, then the system will automatically terminate the conference session. In this case, the ambulance operator will have to reinitiate the conference session. [LL-SYS-010, LL-SYS-011]

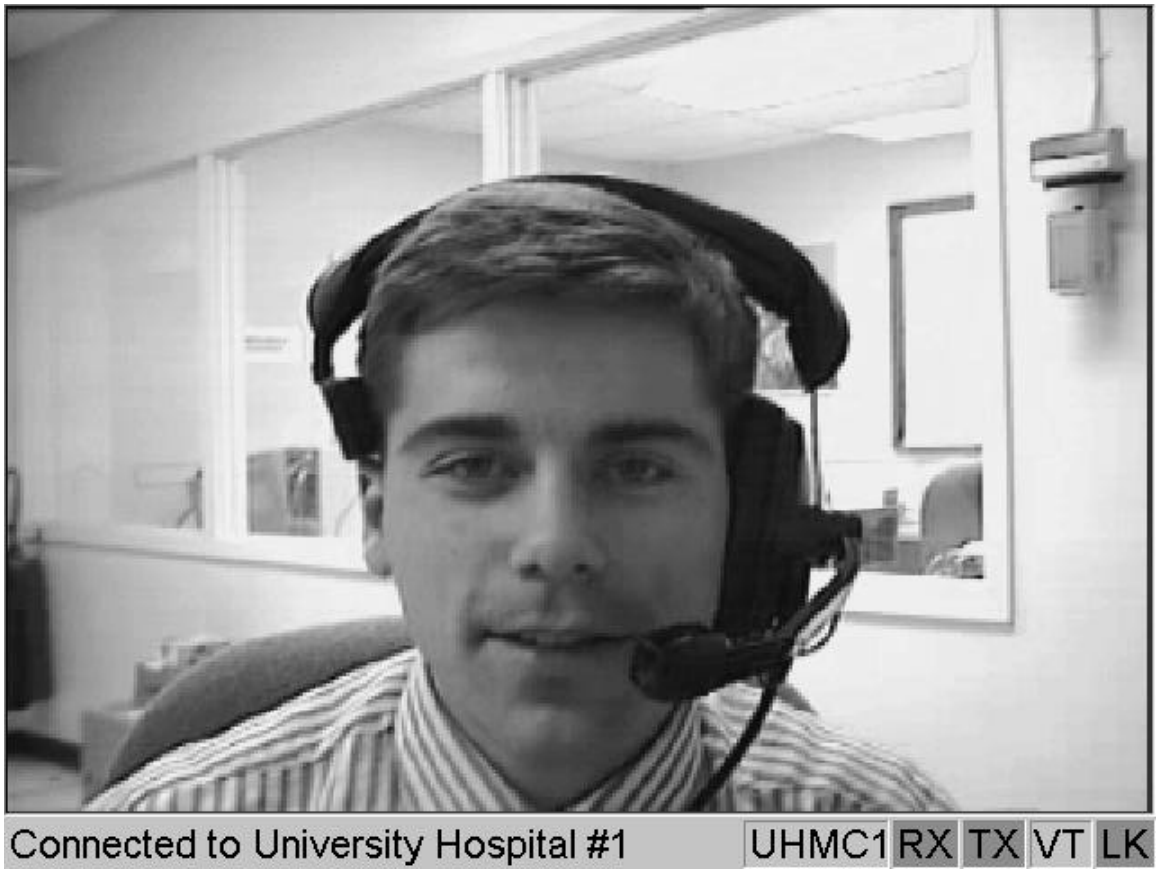


Figure 8. Ambulance Active Videoconference Screen

3.3.3.2 Local Patient Camera Control

The video image that is being sent to the hospital node during a videoconference session is provided by a Sony EVI-G20 video camera mounted inside the cabin above the patient area. This video camera includes pan, tilt, zoom, and focus control features. The ambulance crew can use the EVI-G20 infrared remote control to manually adjust the camera settings while watching the local 4" display panel that shows the current video camera output image which is being transmitted to the hospital. The infrared remote is attached to the cabin front wall near the ambulance captain's chair via a strip of Velcro. Upon system power-up, the camera defaults to a fixed-home position which is auto-focus-enabled showing a view of the ambulance gurney area where the patient body cavity (just above the head down to below the hips) would be located.

3.3.3.3 Vital Statistic Data Transfer

The LifeLink communication system can be used to transfer vital statistic data from portable monitoring equipment on the ambulance to a remote display terminal at the hospital. The Ambulance Subsystem provides support for transmitting either LifePak 11 or ProPaq Encore data to applicable hospital node equipment. Both the Ambulance and Hospital Subsystems include RS-232 ports for connection of the vital statistic monitoring and display equipment. Both the Ambulance and Hospital Subsystems participating in the videoconference session must be configured for operation with the same vital statistic data equipment, either the LifePak 11 or ProPaq Encore, in order for the transparent LifeLink vital statistic data channel to operate. With equipment connected and powered up at both ends, the vital statistic data transfer process will begin automatically when the ambulance-to-hospital videoconference is started. See Appendix B for additional information on the connection and operation of the vital statistic data monitoring equipment via the optional LifeLink System communication channel. The "VT" block in the lower right corner of the display will remain gray until the LifeLink software application detects the start of vital statistic data transmissions. Once transmissions begin, the "VT" status indicator will turn green and remain green while continuous vital statistic data transmissions are ongoing. If the Ambulance Subsystem does not receive data or is unable to transit vital statistic data via the radio link for ½ second, this indicator will turn yellow. If the delay interval exceeds 1 second, then this indicator will turn red. The yellow and green indicator states are provided to alert the user of breaks in the radio coverage which may impact the vital statistic data transfer process. In the latter state, transmissions delays or breaks in ProPaq Encore realtime data may occur.

If LifeLink software application determines that transmissions have stopped for more that 20 seconds and other videoconference data transmissions are still ongoing, the indicator will again turn gray to indicate that transmissions have completed or have been terminated by the user.

3.3.4 Termination of Videoconference Session

The following sections provide a description of possible ways to terminate a videoconference session.

3.3.4.1 User Requested Termination

The ambulance crew can terminate a videoconference session at any time. In order to terminate a videoconference session, the ambulance crew must depress the "F1" key on the keypad mounted on the face of the custom LifeLink ambulance cabinet. This will result in immediate termination of the videoconference session and the Ambulance Subsystem will return to the System Ready screen.

3.3.4.2 Remote Terminal Requested Termination

The hospital control node can terminate a videoconference session at any time (refer to Section 6.2.4). When this occurs, the Ambulance Subsystem will return to the System Ready screen.

3.3.4.3 Loss of Primary Power

If ignition power to the LifeLink Ambulance Subsystem is disrupted (ignition switch turned off or an ignition power fault has occurred) for more than 10 seconds, the Ambulance Subsystem will provide the user with the message that primary power has been lost. Once this has occurred, the Ambulance Subsystem will automatically terminate the videoconference session and go through an orderly power-down process to protect system integrity.

3.3.5 Ambulance LifeLink System Power-Down

The ambulance crew can initiate an Ambulance Subsystem power-down sequence at any time by pressing the momentary "OFF" switch on the front of the custom LifeLink ambulance cabinet. The system will display a message stating that a system power-down has been requested and the user will be given 10 seconds to cancel the power-down process by pressing the "F4" cancel key. If the user does not cancel the power-down request, the system will automatically terminate an ongoing videoconference session and begin the power-down sequence. The power-down sequence will complete within 2 minutes.

4. Roadside Fiber Hub Subsystem

The Roadside Fiber Hub Subsystem represents the LifeLink System communications interface between the Ambulance and TOC Subsystems. LifeLink equipment has been added to existing TransGuide roadside fiber hub and video camera locations that provide for a communications link capable of supporting data transmission between an ambulance radio and the fiber hub WEB radio to the TOC. LifeLink WEB radios with a 10Base2 Ethernet port, antenna, lighting arrester, and enclosure have been mounted on existing TransGuide camera poles. Other equipment has been installed inside the roadside fiber hub to convert the 10Base2 Ethernet signal into a 10BaseFO Ethernet signal and then multiplex it (using WDMs) onto the TransGuide fiber optic network. The equipment that has been installed in the roadside fiber hub includes the Ethernet transceiver, half-to-full duplex converter, fiber optic transceiver, and WDMs. As an ambulance moves along the freeway system, the onboard WEB radio can transfer data via the wireless link to a roadside fiber hub WEB radio. **Error! Reference source not found.** shows a block diagram of the major roadside fiber hub components. The following subsections describe the fiber hub equipment starting from the TransGuide fiber optic network interface to the WEB radio which is located next to the TransGuide pole-mounted video camera. [LL-FBH-003, LL-FBH-004]

4.1 Wave Division Multiplexers

A pair of Wave Division Multiplexers (WDMs) has been installed at each fiber hub equipped with LifeLink equipment. The WDMs are located on the LifeLink retractable shelf. U.S. Fiber Optics Corporation part number WDM-B4-35-1A-1TU WDMs have been used. One WDM is used to multiplex the TOC bound 1310nm TransGuide data and 1550nm LifeLink optical data. The second WDM is used to de-multiplex the Fiber Hub bound 1310nm TransGuide data and 1550nm LifeLink data. The original TransGuide protect fiber optic cable pair (TX and RX fibers) between the fiber hub LGX panel and DDM-2000 OC-3 MUX has been rerouted between the WDMs and the DDM-2000 OC-3 MUX. A new fiber optic cable pair has been installed between the LGX panel and WDMs to complete the original connection path. Another new fiber optic cable pair is used to connect the WDM 1550nm ports to the LifeLink fiber optic transceiver. [LL-FBH-002]

4.2 Fiber Hub Ethernet Transceivers

A fiber optic Ethernet transceiver has been installed in each roadside fiber hub equipped with LifeLink equipment. The fiber optic transceivers are connected via an AUI port to a half-to-full duplex converter which also provides transceiver power. The fiber optic transceiver that is connected to the half-to-full duplex converter is located on the same retractable shelf as the WDMs. The fiber hub transceiver is an NBase Communications type NX300FP/1550 which operates at 1550nm. Each NX300FP/1550 transceiver includes an ST terminated TX and RX fiber optic connector which is connected to the fiber optic cable pair coming from the WDMs 1550nm ports. These transceivers convert the full duplex copper wire Ethernet bus (AUI port)

into a full duplex fiber optic TX and RX signal pair capable of providing the long distance range required to link the remote fiber hubs to the TOC.

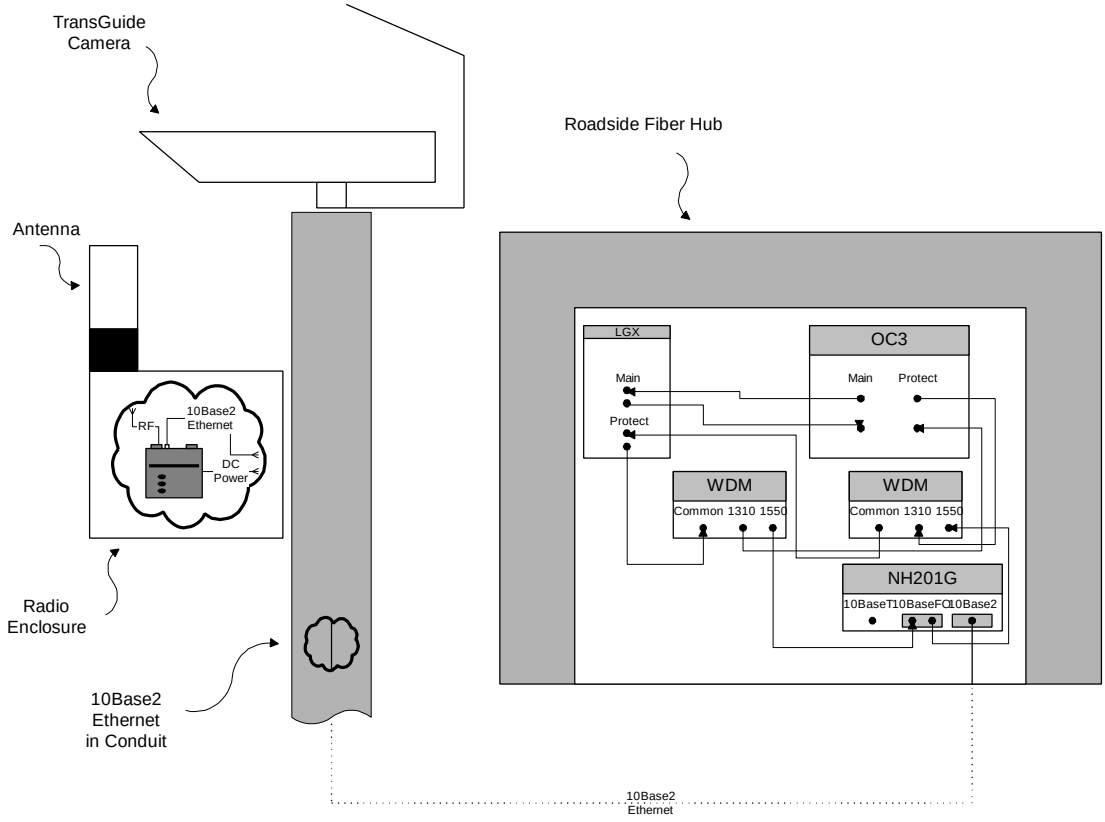


Figure 9. LifeLink Roadside Fiber Hub Subsystem

4.3 Half-to-Full Duplex Ethernet Converters

A half-to-full duplex converter has been installed at the roadside fiber hub on the same retractable shelf as the WDMs and fiber optic transceiver. The half-to-full duplex converter converts the full duplex Ethernet port of the fiber optic transceiver to a half-duplex Ethernet port for connection to the AUI to coax adapter. The half-to-full duplex converter is an NBase Communications model NH201G device. The NH201G 60Hz, 115 VAC power cord is connected to an existing UPS power outlet in the fiber hub. The two NH201G AUI ports provide operating power for the attached fiber optic transceiver and AUI-to-coax adapter modules. The third RJ45 port is not used for the LifeLink System application. Ports 1 and 3 of the NH201G duplex dipswitch are set to half-duplex and port 2 is configured for full duplex. The NX300FP/1550 fiber optic transceiver is connected to port 2 and the AUI-to-coax transceiver is connected to port 1.

4.4 AUI-To-Coax Adapter

An AUI-to-coax adapter has been installed at the roadside fiber hub on the same retractable shelf as the WDMs and half-to-full duplex converter. The AUI-to-coax adapter is used to convert the NH201G half-duplex AUI port to a coax type port for connection to the WEB radio. The AUI-to-coax adapters are either a Lantronix model LTX-2 or an Addtron model ET-10C1B device. The AUI-to-coax transceiver device derives its power from the NH201G AUI port. A coax cable (less than 200 meters in length) has been used to connect the roadside WEB radio mounted on the TransGuide camera pole to the 10Base2 port on the transceiver.

4.5 Wireless Ethernet Bridge Radio

Each roadside fiber hub has been equipped with one or two (one site requires an upper and lower deck WEB radio) Aironet BR2040EE spread spectrum Wireless Ethernet Bridge (WEB) radios. These radios serve as one end of a wireless bi-directional bridge between the ambulance and LifeLink Ethernet communication system for transferring Ethernet packets containing the video, audio, and vital statistic data. The WEB radio is an Aironet part number BR2040EE 2.4GHz, 4.0Mbps device. The WEB radio has been installed into a double-walled box (outer box serves as a sun shield) with mounting bracket that enables it to be attached to the existing TransGuide camera pole just below the camera. An Aironet 420-003354 lightening arrestor and Aironet part number 430-002506 3dB Omni-directional antenna is also attached to each radio box. A coaxial cable (less than 200 meter in length) has been used to connect the WEB radio to the AUI to 10Base2 transceiver located in the roadside fiber hub cabinet. [LL-FBH-001]

An Acopian AC-to-DC power converter module (part number 18WB165) has been installed in the J-box located at the base of each Overhead Sign Bridge tower. The AC-to-DC power converter is connected to the TransGuide camera AC power source at this point. The power converter +18 VDC output is used to power the WEB radio.

4.6 Fiber Hub Operation

The fiber hub equipment and communication link into the TransGuide communication network is a key element to the LifeLink System, but for the most part is transparent to system operation. Once the system has been configured, no user intervention is required during normal system operation. The fiber hub equipment and TransGuide fiber optic cable network serve as a communication carrier for the ambulance-to-hospital Ethernet videoconference link.

5. TOC Subsystem

The TOC Subsystem is the central part of the LifeLink System communication infrastructure. The TOC LifeLink equipment primarily serves as an Ethernet switch that connects and maintains a communication link between a hospital and an ambulance moving through a series of roadside fiber hub WEB radios distributed throughout the TransGuide infrastructure. The LifeLink equipment at the TOC has been installed in the main computer room in three 24" wide cabinets provided by TxDOT. One cabinet is used to mount the Wave Division Multiplexers (WDMs) which are to be used to separate/combine the TransGuide SONET (1310nm) and LifeLink Ethernet (1550nm) data that is being multiplexed on the TransGuide protect fiber optic cable pair. The second cabinet includes the LifeLink fiber optic transceivers and Ethernet switching equipment. The LifeLink SNMP computer resides in the third cabinet. Figure 10 is a block diagram showing the major TOC Subsystem components.

5.1 Wave Division Multiplexers

A pair of Wave Division Multiplexers (WDMs) has been installed in the WDM cabinet for each fiber hub that has been equipped with LifeLink equipment. The WDM part number is WDM-B4-35-1A-1TU and is manufactured by U.S. Fiber Optics Corporation. One WDM is used to multiplex the TransGuide OC-3 1310nm transmit data and LifeLink 1550nm transmit data onto one fiber running to the fiber hub. The other WDM is used to de-multiplex the composite 1310nm and 1550nm data from the fiber hub back into separate 1310nm data for the TransGuide OC-3 receiver input and 1550nm data for the LifeLink receiver input. In order to accomplish this, the protect fiber optic cable pair that used to run between the LGX and the DDM-2000 OC-3 MUX cabinets has been rerouted between the WDM and DDM-2000 OC-3 cabinets, and a new fiber optic cable pair has been installed between the LGX and WDM cabinets to re-establish the original communication link through the WDM 1310nm ports. Another new fiber optic cable pair has been installed to extend the LifeLink 1550nm data between the WDM cabinet and the LifeLink Ethernet switching equipment cabinet.

5.2 TOC Fiber Optic Ethernet Transceivers

The TOC 1550nm fiber optic transceivers are installed in the LifeLink Ethernet switching equipment cabinet. The fiber optic transceivers are rack mount style NBase Communications NX301CFP/1550 devices. These transceivers convert the full duplex copper wire Ethernet bus into a full duplex fiber optic TX and RX signal pair capable of providing the long distance range required to link the remote fiber hubs to the TOC. These transceivers are installed into NBase Communications NH3216 fiber optic transceiver racks that provide power for up to 16 fiber optic transceivers. The fiber optic transceiver TX port is connected to a multiplexing WDM and the RX port is connected to a de-multiplexing WDM in the LifeLink WDM cabinet via a fiber optic cable. The NX301CFP/1550 also includes a full duplex 10BaseT port that is connected to a full duplex 10BaseT port on a switched Ethernet hub.

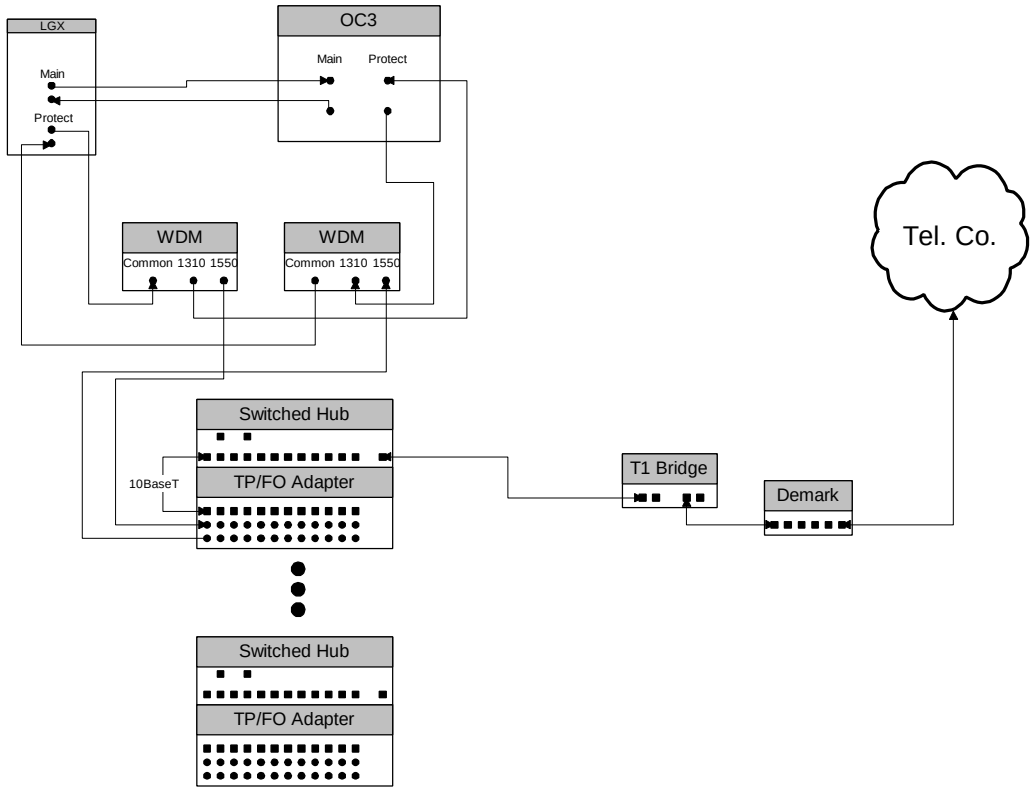


Figure 10. LifeLink TOC Subsystem

5.3 Switched Ethernet Hub

The major function of the LifeLink Switched Ethernet hub is to provide for automatic routing of Ethernet communications between a mobile ambulance and a selected hospital. The system design can provide simultaneous support for multiple ambulances, and in the future, multiple hospitals. The LifeLink System Switched Ethernet hub consists of the following Cabletron Systems components.

1. One (1) SmartSwitch 6000 Chassis (part number 6C105) which provides slots for up to five (5) expansion modules.

2. Two (2) 510 Watt AC power supplies (part number 6C205-3) which provide redundant power for the SmartSwitch 6000 Chassis.

3. Three (3) SmartSwitch Modules (part number 6E122-26), each providing support for twenty-four 10BaseT connections. Each SmartSwitch Module is equipped with 2 Fast Ethernet Port Interface Modules (part number FE-100TX) that can operate as either 100BaseTX or 10BaseT ports.

These Switched Ethernet hub components are installed in the same cabinet as the fiber optic transceivers. The twenty-four 10BaseT ports (ports 1 through 24) on each of the three 6E122-26 SmartSwtich modules are used to interface with the fiber optic transceivers that extend the Ethernet links to the TransGuide roadside fiber hubs. The remaining two 100BaseTX/10BaseT ports (ports 25 and 26 of each SmartSwitch Module) are used to interface to the hospital and SNMP computer.

5.4 University Hospital Interface

University Hospital is targeted to be the first hospital to be connected into the LifeLink Switched Ethernet network. The long-term plan is to connect University Hospital to the TOC via a dedicated fiber optic link, but at the time that the LifeLink System is to go on line, this link will not be available. As an interim solution, TxDOT has implemented a dedicated T1 link between the two facilities. At the TOC end, port 26 on one of the SmartSwitch Modules is connected to the T1 communication link equipment. Port 26 will be configured for half-duplex 10MB operation when connected to the T1 communication link. Under this configuration, University Hospital will be limited to conducting no more than two simultaneous videoconference sessions. [LL-TOC-003]

When the fiber optic cable run between the TOC and University Hospital is completed, a fiber optic communication link will be established. The fiber optic link will be implemented using a pair of NBase Communications NH2001-FO/S1 MegaSwitch EZ units (one each at the TOC and University Hospital). Port 26 of the SmartSwitch Module will have to be reconfigured for half-duplex 100MB operation. Once configured as a 100BaseTX Ethernet link, University Hospital will be able to support several simultaneous videoconference sessions if and when multiple LifeLink terminal nodes are implemented. The NH2001 has a RJ-45 port connector that must be configured for 100MB half-duplex operation. This port will be connected to the reconfigured SmartSwitch Module port 26. The NH2001 fiber optic port will be connected to the dedicated fiber optic cable pair to University Hospital. The NH2001 fiber optic transceiver (1310nm) port operates at 100MB full duplex.

5.5 SNMP Function Equipment

A Simple Network Management Protocol (SNMP) network management computer has been installed at the TOC to be used for LifeLink configuration control and maintenance support. Cabletron SPECTRUM Element Manager software application has been installed on the SNMP computer. The SNMP computer has been installed into the third LifeLink System cabinet at the TOC. The SNMP computer is connected to port 25 of one of the SmartSwitch Modules in the LifeLink Ethernet switching equipment cabinet. Port 25 has been configured as a half-duplex 100Base-TX port. The SNMP computer can be used to access status and control registers of the Ethernet switching equipment and fiber hub WEB radios. The SNMP computer can also be used

by maintenance personnel to monitor network performance and traffic, aid in network problem determination, and provide network access security. [LL-TOC-001]

5.5.1 Computer

A Hewlett Packard model VL5/200 Series 5DT (part number D4596A #ABA) computer has been installed at the TOC to serve as the SNMP computer. This is a desktop 200MHz Pentium computer with 48 MB of RAM. The VL5 package includes 3.5" floppy drive, hard disk drive, CD ROM drive, video adapter, and sound card. The computer includes expansion ISA and PCI slots. The SNMP computer has been installed in the third LifeLink cabinet at the TOC. The computer operating system is Windows NT.

5.5.1.1 Ethernet Port

The SNMP computer includes a 100BaseTX Ethernet port for connection to port 25 of one of the SmartSwitch Modules in the LifeLink Ethernet switching equipment cabinet at the TOC. The computer includes a 3COM Model 3C905 PCI network interface card to provide this Ethernet interface.

5.5.1.2 Display Port

The SNMP computer includes a VGA video port for connection to a monitor. The standard Hewlett Packard VL5 computer on-motherboard video adapter provides this VGA interface.

5.5.1.3 Keyboard Port

The SNMP computer includes a port for connection of a PS/2 style 101-key keyboard.

5.5.1.4 Mouse Port

The SNMP computer includes a port for connection of a PS/2 style mouse.

5.5.2 Display

The SNMP computer system includes an NEC model XV17+ SVGA monitor that serves as the LifeLink SNMP computer user display interface.

5.5.3 Keyboard

The SNMP computer system includes a full size PS/2 style keyboard user interface.

5.5.4 Mouse

The SNMP computer system includes a PS/2 style mouse user interface.

5.6 TOC Videoconference Test Equipment

Additional hardware and software components have been added to the SNMP computer that enables it to conduct test LifeLink videoconference sessions. This capability has been provided for test purposes only. The SNMP computer can be used to initiate a videoconference session with a hospital node to check the TOC-to-hospital communication link, or an ambulance within the LifeLink System radio coverage area can also initiate a videoconference session to the SNMP computer to check the ambulance-to-TOC communication link. This videoconference test capability is not the primary SNMP computer function and requires that an operator at the TOC reconfigure the computer before a videoconference link can be established. Coordination between the TOC operator and hospital or ambulance terminal operator will be required to perform these LifeLink System communication link tests. [LL-TOC-002]

5.6.1 Videoconferencing Card

A MultiMedia Access Corporation (MMAC) – Osprey 1000 videoconference card is installed in a PCI slot in the SNMP computer and serves as the host for the LifeLink videoconferencing application. The Osprey 1000 videoconferencing card and software application provide the LifeLink SNMP computer with the capability to conduct two-way audio and video test conferences with either a LifeLink hospital or ambulance.

5.6.2 Headset/Microphone

The SNMP computer MMAC videoconference card includes microphone input and headphone output ports for connection to a headset with microphone. The SNMP computer terminal includes a headset with microphone that can be used during videoconference link testing.

5.6.3 Video Camera

A Sony model EVI-G20 pan, tilt, zoom, auto focus color video camera is located in the SNMP computer cabinet at the TOC. The EVI-G20 camera comes with an infrared remote control that can be used by TOC personnel to manually position and control the camera.

5.7 TOC Computer Operation

The LifeLink TOC equipment is intended to operate transparently without user intervention during normal system operation. User intervention with the TOC equipment is only intended to occur during system setup or when system maintenance is required. The TOC operator can use

the SNMP computer to perform LifeLink System setup and maintenance operations. The SNMP computer can be initialized to operate in three different operational modes. Section 5.7.1 describes how the SNMP computer can be initialized to configure and maintain the LifeLink System communication infrastructure. Section 5.7.2 describes how the SNMP computer can be initialized as an ambulance node, therefore enabling the TOC operator to verify the hospital videoconferencing capability. Section 5.7.3 describes how the SNMP computer can be initialized as a hospital node, therefore enabling the TOC operator to verify an ambulance videoconferencing capability.

5.7.1 SNMP Monitor/Control

In order to use the SNMP computer to modify or perform maintenance operations on the LifeLink System communication infrastructure, the TOC operator must initiate the SNMP management program by double-clicking the SNMP icon on the computer's desktop.

With the SNMP computer operating in the SNMP Monitor and Control mode, the TOC operator can perform the following types of operations.

Check and/or change system configuration of the LifeLink System Ethernet devices such as the switching Ethernet equipment (SmartSwitch Modules) and roadside WEB radios. The SNMP network management software can be used to access control and status registers of system Ethernet devices in order to change configurations or to verify that these devices are operating properly. This can be done during either routine maintenance checks or in resolving actual system failures.

The SNMP computer can be used to set or change the roadside and ambulance WEB radio common 6-digit hexadecimal security code that prevents non-LifeLink radios from being able to link into the LifeLink communication network.

Once the SNMP computer has been initialized for SNMP monitor and control, it will automatically and periodically check the status registers of the LifeLink system Ethernet devices and provide indication if any problems are detected.

The SNMP computer can be used to perform individual and manual checks of the operational status of each fiber hub WEB radio. Since this check assumes functional connectivity to the WEB, this check indirectly verifies the entire LifeLink communication link between the SNMP computer and the queried WEB.

The SNMP computer can be used to access status registers within each of the SmartSwitch Modules to determine the amount of data that has been received or sent to each of the individual fiber hub WEB radios. These registers can be reset periodically to help identify WEB radios that may not be operating properly.

5.7.2 Test Ambulance Node

The SNMP computer can be initialized as an ambulance node, therefore enabling the TOC operator to verify a hospital videoconferencing capability. In order to operate the SNMP computer as a test ambulance node, the operator must initiate the LifeLink application by double-clicking the Ambulance icon on the desktop.

This mode of operation is intended to enable the TOC LifeLink System operator to verify the videoconference capabilities of a hospital node. The TOC LifeLink System can make arrangements with hospital personnel to run a test videoconference session as part of routine maintenance or when a potential problem has been identified. With the SNMP computer operating in this mode, the TOC operator will be provided with capabilities similar to those defined in section 3.3.3 for an ambulance node excluding the vital statistic data transfer capability which requires special equipment.

5.7.3 Test Hospital Node

The SNMP computer can be initialized as a hospital node, therefore enabling the TOC operator to verify an ambulance videoconferencing capability. In order to operate the SNMP computer as a test ambulance node, the operator must initiate the LifeLink application by double-clicking the Hospital icon on the desktop.

This mode of operation is intended to enable the TOC LifeLink System operator to verify the videoconference capabilities of an ambulance node which is within the LifeLink radio coverage area. The TOC LifeLink System can make arrangements with SAFD personnel to run a test videoconference session as part of routine maintenance or when a potential problem has been identified. With the SNMP computer operating in this mode, the TOC operator will be provided with capabilities similar to those defined in Section 6.2 for a hospital node excluding the vital statistic data receiving capability which requires special equipment.

6. Hospital Subsystem

The Hospital Subsystem consists of the hospital components that are required to interface to the LifeLink Ethernet switch at the TOC and the terminal equipment required to conduct a videoconference with a LifeLink System-equipped mobile SAFD ambulance. The installation of the LifeLink Hospital Subsystem components shall provide unobstructed access to other hospital equipment or walkways. The following sections describe the equipment and functionality of a LifeLink Hospital Subsystem single videoconferencing node at a hospital. Figure 11 shows a block diagram of the Hospital Subsystem components. [LL-HOS-004]

The LifeLink Ethernet switching equipment at the TOC routes data destined for a hospital via either a dedicated fiber optic cable or T1 communication link between the hospital and the TOC. A hospital LifeLink videoconference node can operate in one of two modes. When operating as a control node, the hospital node has full videoconferencing capabilities including bi-directional audio and video and the capability to receive vital statistic data. Operation of the vital statistic data channel requires that the hospital node and ambulance be equipped with compatible vital statistic data monitoring equipment. The hospital node can also operate as a consultant node. When operating as a consultant node, the hospital node operator will be able to see the ambulance video and listen to the ambulance LifeLink System operator audio. The consultant node operator will be unable to hear the control node operator audio or receive vital statistic data.

6.1 Major Components

The primary components of the LifeLink Hospital Subsystem include a personal computer, applicable videoconferencing hardware and software, an optional vital statistic data display computer, and the communications equipment required to couple to the LifeLink communications network. Although a hospital consultant node does not require a video camera or vital statistic monitoring equipment, this document assumes that all hospital nodes are configured the same and can operate as either a control or consultant node terminal. The following subsections provide a description of the Hospital Subsystem components that have been installed at University Hospital, the first LifeLink hospital node. [LL-HOS-001]

6.1.1 Videoconference Computer

A Hewlett Packard model VL5/200 Series 5MT (part number D5220A #ABA) computer has been installed at University Hospital to serve as the hospital computer. This is a mini-tower 166MHz Pentium computer with 48 MB of RAM. The VL5 package includes 3.5” floppy drive, hard disk drive, CD ROM drive, video card, and sound card. The computer includes expansion ISA and PCI slots. The computer has been installed in the University Hospital Emergency Room area. The computer operating system is Windows NT. The computer requires 60Hz, 115 VAC power input. An Un-interruptible Power Source (UPS) has been installed to protect the hospital computer and peripheral equipment.

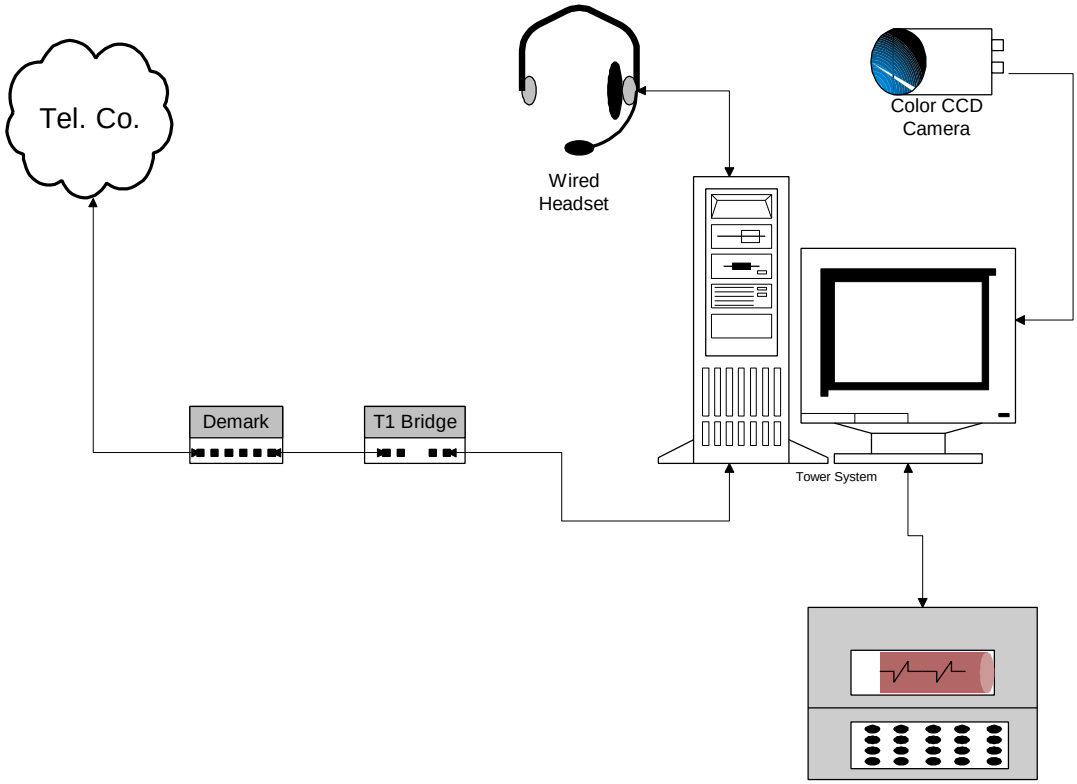


Figure 11. LifeLink Hospital Subsystem

6.1.1.1 Videoconference Card

A MultiMedia Access Corporation (MMAC) – Osprey 1000 videoconference card is installed in a PCI slot in the hospital computer and serves as the host for the LifeLink videoconferencing application. The Osprey 1000 videoconferencing card and software application enables the LifeLink Hospital Subsystem the capability to conduct a two-way audio and videoconference with a hospital.

6.1.1.2 RS-232 Serial Port

The hospital computer provides support for 2 RS-232 serial ports. COM1 port is used to support the optional vital statistic data telemetry function at 38.4 kbps. See Sections 6.1.6 and 6.2.3.4 for additional information on the vital statistic data telemetry function. COM2 port is connected to the hospital video camera RS-232 control port that may be used in the future to enable local computer control of the camera. The camera control software required to provide this capability is not currently supported. [LL-HOS-002]

6.1.1.3 Ethernet Port

The hospital computer includes a 10BaseT Ethernet port for connection to the interim T1 communication circuit bridge or in the future to the NBase Communications NH2001-FO/S1 MegaSwitch EZ unit when the TOC to University Hospital fiber optic cable deployment has been completed. The computer includes a 3COM Model 3C905 PCI network interface card to provide this Ethernet interface. [LL-HOS-003]

6.1.1.4 Display Port

The hospital computer includes a VGA video port for connection to a monitor. The standard Hewlett Packard VL5 computer on-motherboard video adapter provides this VGA interface.

6.1.1.5 Headset/Microphone Port

The hospital computer MMAC videoconference card includes microphone input and headphone output ports for connection to a headset with microphone.

6.1.2 Video Camera

A Sony model EVI-G20 pan, tilt, zoom, auto focus color video camera is located near the hospital computer node to provide the video image that will be transmitted to the ambulance during a videoconference session. The camera has been positioned such that at system power-up the camera defaults to a home position providing an upper body view of the LifeLink System hospital operator seated in the chair in front of the computer terminal. The camera power-up state is auto focus enabled. The EVI-G20 camera is equipped with an infrared remote control that can be used by hospital personnel to manually position and control the camera. The EVI-G20 also has an RS-232 serial port connected to the hospital computer COM2 port. This RS-232 serial port connection may be used in the future to enable local computer control of the camera, but the software required to provide this capability is not currently supported.

6.1.3 Display

The hospital computer system includes an NEC model XV17+ SVGA monitor that serves as the LifeLink hospital computer user display interface for viewing the ambulance transmitted video.

6.1.4 Keyboard

The hospital computer system includes a full size PS/2 style keyboard user interface.

6.1.5 Mouse

The hospital computer system includes a PS/2 style mouse user interface. The mouse is a standard computer item but is not necessary for operation of the LifeLink Hospital Subsystem.

6.1.6 Vital Statistic Data Display Equipment

Although vital statistic data monitoring equipment is not a required system component, the LifeLink System does provide optional support for transmitting vital statistic data from the ambulance to the hospital during a videoconference session when this equipment is available. The COM1 RS-232 serial port on the hospital computer has been configured to transfer vital statistic data from the ambulance to the hospital when the appropriate equipment has been attached. The LifeLink System has been tested to provide support for Physio Control LifePak 11 and the Protocol Systems, Inc. ProPaq Encore vital statistic data monitor systems. Both units transmit data at 38.4 kbps. A special interface cable is required to interface these 2 devices to the hospital computer serial port. Appendix B includes detailed information on the required interface cables and additional information on the LifePak 11 and ProPaq Encore systems.

6.1.6.1 LIFEPAK 11 - RS 100 Receiving Station

If an ambulance is equipped with a portable Physio-Control LifePak 11 vital statistic data monitor unit, then the hospital must be equipped with a Physio-Control RS 100 Receiving Station. The RS 100 Receiving Station does not display the vital statistic data, but instead provides a hard copy printout of the vital statistic data which has been received from the ambulance LifePak 11 unit. The RS-100 Receiving Station utilizes an RS-232 interface port for communications and the Mortara, or in some cases the Extended Mortara, proprietary communications protocol. The interface cable between the hospital videoconferencing computer and the RS-100 Receiving Station is an RS-232 cable. The LifePak 11 to RS-100 communication is in block format, which means that the ambulance LifeLink System operator must first set up a patient record followed by pressing the “Transmit” button on the LifePak 11. When the “Transmit” button is pressed, the data is transmitted to the RS-100 unit where a hard copy is generated. The patient record data is transmitted as a continuous block.

6.1.6.2 Propaq Encore - Acuity Display Station

If an ambulance is equipped with a portable Protocol Systems, Inc. ProPaq Encore vital statistic data monitor unit, then the hospital must be equipped with a Protocol Systems, Inc. Acuity Monitoring Station. The Acuity Monitoring Station can operate as a continuous remote real time display for the ambulance ProPaq Encore unit. The Acuity system interface port is RS-423, but has been adapted via a special interface cable that enables the Acuity system and the hospital videoconferencing computer to communicate via the RS-232 port available on the hospital computer. The interface cable between the hospital videoconferencing computer and the Acuity

system is a hybrid cable required to adapt the RS-232 signals generated by the hospital computer to the RS-423 format signals required to drive the Annex Terminal Ethernet hub. Once established, communications between the ProPaq Encore and Acuity Monitoring System utilizes a continuous serial data stream. When the LifeLink Hospital Subsystem operator activates the ProPaq Encore unit in the ambulance, real time data will be continuously available to the hospital physician on the Acuity system display.

6.1.7 TOC Communication Interface

University Hospital is targeted to be the first hospital to be connected into the LifeLink Switched Ethernet hub. The long-term plan is to connect University Hospital to TOC via a dedicated fiber optic link, but at the time that the LifeLink System is to go on line, this link will not be available. As an interim solution, TxDOT has implemented a dedicated T1 link between the two facilities. At the hospital end, the computer Ethernet port has been connected to the T1 communication link equipment. This port has been configured for half-duplex 10MB operation when connected to the T1 communication link. Under this configuration, University Hospital will be limited to conducting two simultaneous videoconference sessions, if and when multiple nodes have been implemented.

When the fiber optic cable run between the TOC and University Hospital is completed, a fiber optic communication link will be established. The fiber optic link will be achieved using a pair of NBase Communications NH2001-FO/S1 MegaSwitch EZ units (one each at the TOC and University Hospital). The hospital computer will be reconnected to the NH2001-FO/S1 RJ-45 port that must be configured for half-duplex 100MB operation. Once configured as a 100BaseTX Ethernet link, University Hospital will be able to support several simultaneous videoconference sessions, if and when multiple nodes have been implemented. The NH2001 fiber optic port will be connected to the dedicated fiber optic cable pair to the TOC. The NH2001 fiber optic transceiver (1310nm) port operates at 100Mbps full duplex.

6.2 Hospital Videoconference Node Operation

The following subsections provide an operational description of the LifeLink System as seen from the hospital node operator perspective. The description covers normal system operation from power-up to power-down and also addresses special cases like loss of LifeLink radio coverage. The operational descriptions apply to a LifeLink System hospital node operating as either a control or consultant node unless otherwise noted. See Section 7.0 for a more detailed description of the LifeLink System software application.

6.2.1 System Startup

The LifeLink System Hospital Subsystem terminal node has been configured to start the boot process automatically on power-up. The hospital computer has been configured such that the

LifeLink software application will be installed and configured automatically when the computer is turned "ON". The 17" monitor and video camera power switches must also be placed in the "ON" position. Device drivers are automatically installed for the videoconference hardware, the Ethernet adapter, and the RS-232 port. System software that enables TCP/IP networking are also installed and configured. The boot process, which takes approximately 90 seconds, has completed when the System Ready screen shown in Figure 12 is displayed on the 17" monitor. The upper left-hand corner of the 17" monitor will be showing the local camera view image. The hospital node is now ready to receive a request to enter into a videoconference session with an ambulance as a control node or to receive a request to enter into a videoconference session with an ambulance as a consultant node if the current control node initiates the consultation session. [LL-SYS-003]

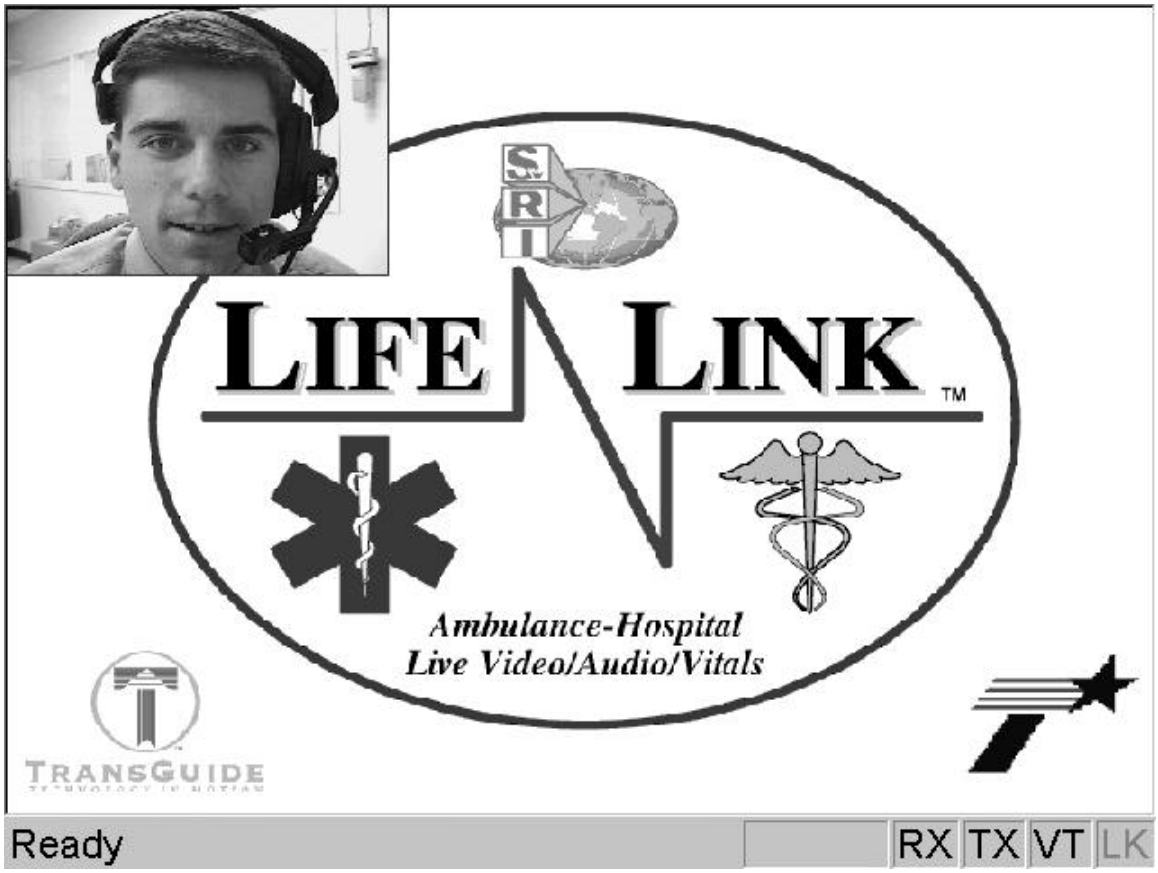


Figure 12: Hospital Terminal System Ready Screen

6.2.2 Answering An Incoming Videoconference

With the hospital node in the LifeLink System Ready state, the node is now ready to receive requests from an ambulance or an active LifeLink control node to enter into a videoconference session. When a hospital node receives a request to enter into a videoconference session, the 17"

monitor will appear as in Figure 13 and the computer will output a continuous chime which alerts hospital personnel of the incoming videoconference session. The chime terminates when the hospital node operator acknowledges the incoming videoconference session by pressing the "Enter" key on the keyboard. [LL-HOS-005]

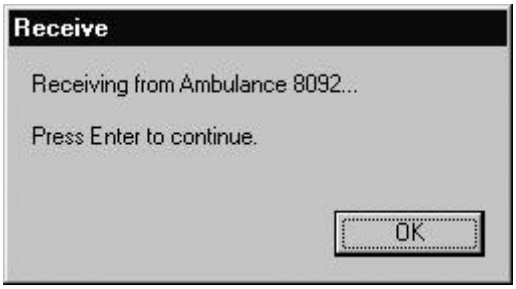


Figure 13. Hospital Terminal Incoming Videoconference Request Screen

6.2.3 Active Videoconference Session

When the hospital node operator acknowledges an incoming videoconference session, the 17" monitor appears as shown in Figure 14. Once the videoconference communication link has been established, bi-directional video and audio and uni-directional vital statistic data transfer processes will be available to the hospital node operator. The hospital node operator can use the headset to conduct audio communications with ambulance personnel. The hospital node user will be presented with a remote image view (from the ambulance video camera) on the 17" monitor. The default outgoing video image (shown upper left-hand corner of 17" monitor) to the ambulance will be the image from the local hospital node camera (camera default home position after system power-up). The vital statistic data transfer channel is also available to the hospital node operator if needed. During a normal videoconference session the "RX" and "TX" blocks in the lower right corner of the 17" monitor should remain green. If the Hospital Subsystem does not receive data or is unable to transit data via the Ethernet link to the TOC for ½ second, these indicators will turn yellow. If the delay interval exceeds 1 second, then these indicators will turn red. These indicators are provided to alert the user of breaks in the radio coverage between the ambulance and roadside radios which will impact the videoconference quality. In the latter state, breaks in audio and momentary freeze frames will occur.

If the hospital node is operating as a control node, then the user will be able to send and receive audio from the ambulance and also receive vital statistic data if the ambulance is transmitting vital statistic data. If the hospital node is operating as a consultant node, the terminal operator will only be capable of viewing the ambulance video and listening to the ambulance transmitted audio. The consultant node terminal operator cannot receive vital statistic data or transmit audio to the ambulance and control node operators.

A hospital node operator will be provided with a text message on the status bar and control node operator audio if another ambulance attempts to enter into a conference session with that same

node. When an ambulance operator attempts to initiate a conference session with a hospital node that is already in a conference session with another ambulance, then the ambulance operator will be provided with a busy indication. When this occurs, the ambulance computer will continue to establish the link. If the hospital node operator desires to conference with the second ambulance, then the ongoing conference session must first be terminated. [LL-SYS-012]

Figure 14. Hospital Terminal Videoconference Operational Screen

6.2.3.1 Local Hospital Camera Control

The video image that is being sent to the ambulance terminal during a videoconference session is provided by a Sony EVI-G20 video camera mounted near the hospital control node terminal. This video camera includes pan, tilt, zoom, and focus control features. The hospital node operator can use the EVI-G20 infrared remote control to manually adjust the camera settings while watching the upper left-hand corner of the 17" monitor to view the current video image which is being transmitted to the ambulance. The infrared remote is attached to the top of the 17" monitor via a strip of Velcro. Upon system power-up the camera defaults to a fixed home position which is auto focus enabled showing a view of the hospital node operator sitting in a chair positioned in front of the 17" monitor.

6.2.3.2 Call Transfer To Another Hospital Terminal

After an ambulance has entered into a videoconference session with a hospital node, the hospital node operator can initiate a videoconference transfer to another hospital node at its facility or at another hospital. This operation would normally be performed when a decision is made to hand off control of the incoming patient to another facility expert or if a decision is made to transport the patient to another facility. In order to initiate the videoconference session transfer process, the hospital node operator must press "F5" which brings up the screen shown in Figure 15. The hospital must then enter the appropriate LifeLink terminal destination code as shown in Table 1. After entering the destination code and pressing "Enter" the videoconference session and control node capabilities are transferred to the new hospital node, and the hospital node which initiated the transfer returns to the system ready screen as shown in Figure 14.

The videoconference transfer capability is not available on a hospital node that is operating as a consultant node. If there were any consultant hospital nodes prior to the transfer of a videoconference session they will remain in the videoconference session as consultant nodes. [LL-HOS-005]

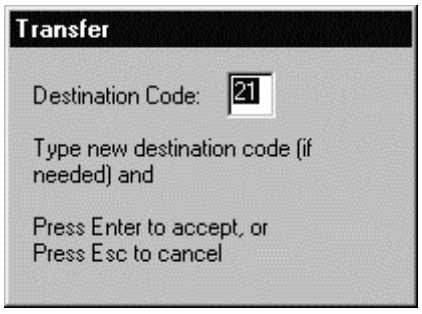


Figure 15. Hospital Terminal Call Transfer Screen

6.2.3.3 Adding Consultant Hospital Terminal To Videoconference

After an ambulance has entered into a videoconference session with a hospital node, the hospital node operator can enable another hospital node capability to enter into an active videoconference session as a consultant node. As a consultant node, the new hospital node operator will receive the ambulance video and audio transmissions, but cannot receive vital statistic data or transmit video or audio to the ambulance. This operation would normally be performed when the control node operator desires assistance in reviewing the incoming patient condition. In order to enable another hospital node to enter a videoconference session as a consultant node, the hospital control node operator must press the "F6" function key that brings up the screen shown in Figure 16. The hospital must then enter the appropriate LifeLink node destination code as shown in Table 1. After entering the destination code and pressing "Enter", the control node will return to the normal videoconference operational screen shown in Figure 14, and the new consultant node

terminal will begin to receive the current videoconference session video and audio transmissions from the ambulance. [LL-HOS-005]

The consultant node will continue to receive ambulance video and audio data until the ambulance terminates the videoconference session. The consultant node can also exit the videoconference session at any time by pressing the "F1" function key. The add consultant node capability is not available on a hospital node that is operating as a consultant node.

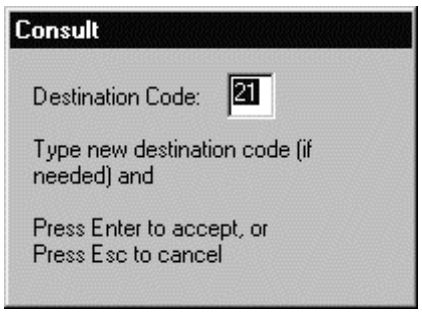


Figure 16. Hospital Node Call Consult Screen

6.2.3.4 Vital Statistic Data Monitoring

The LifeLink communication system can be used to transfer vital statistic data from portable monitoring equipment on the ambulance to a remote display node at the hospital control node. A hospital node operating as a consultant node cannot receive vital statistic data from an ambulance. The Hospital Subsystem provides support for receiving either LifePak 11 or ProPaq Encore data from applicable ambulance vital statistic data monitoring equipment. Both the Ambulance and Hospital Subsystems include RS-232 ports for connection of the vital statistic monitoring and display equipment. Both the Ambulance and Hospital Subsystems participating in the videoconference session must be configured for operation with the same vital statistic data equipment, either the LifePak 11 or ProPaq Encore, in order for the transparent LifeLink vital statistic data channel to operate. With equipment connected and powered up at both ends, the vital statistic data transfer process will begin automatically when the ambulance-to-hospital videoconference is started. See Appendix B for additional information on the connection and operation vital statistic data monitoring equipment via the optional LifeLink System communication channel. The "VT" block in the lower right corner of the display will remain gray until the LifeLink software application detects the start of incoming vital statistic data transmissions. Once transmissions begin, the "VT" status indicator will turn green and remain green while continuous vital statistic data transmissions are ongoing. If the Hospital Subsystem does not receive data or is unable to transit vital statistic data via the radio link for ½ second this indicator will turn yellow. If the delay interval exceeds 1 second, then this indicator will turn red. The yellow and green indicator states are provided to alert the user of breaks in the radio coverage which may impact the vital statistic data transfer process. In the latter state, transmission delays or breaks in ProPaq Encore realtime data may occur.

If LifeLink software application determines that transmissions have stopped for more that 20 seconds and other videoconference data transmissions are still ongoing, the indicator will again turn gray to indicate that transmissions have completed or been terminated by the user.

6.2.4 Termination Of Videoconference Session

The following sections provide a description of possible ways to terminate a videoconference session.

6.2.4.1 User Requested Termination

The hospital node operator can terminate a control or consultant node videoconference session at any time. In order to terminate a videoconference session, the node operator must press the "F1" key on the keyboard. This will result in immediate termination of the videoconference session, and the Hospital Subsystem will return to the System Ready screen.

6.2.4.2 Remote Node Requested Termination

The ambulance crew can terminate a videoconference session at any time (refer to Section 3.3.4). When this occurs, the Hospital Subsystem control and consultant nodes will automatically return to the System Ready screen.

7. LifeLink Software Subsystem Design

The LifeLink application was designed to support bi-directional audio/video conferencing between an ambulance and a hospital across an Ethernet link. The application also supports the bi-directional transfer of medical vital statistic data originating from RS232 serial ports between instruments in the ambulance and the hospital across the same Ethernet link. The application includes support for the Internet Protocol (IP) multicasting of audio and video data from the ambulance, allowing multiple hospitals to receive the audio and video from the ambulance. The user interface was designed to provide a full screen view of the remote video and a status bar for displaying conferencing status and transient messages. The application does not require the use of a mouse or a standard keyboard: only a few function keys, a numeric keypad, and an Enter key are needed.

7.1 Design Summary

The LifeLink application is a C++ program developed using the Microsoft Foundation Classes (MFC) for Microsoft Visual C++ Version 5.0 (MSVC) with the Microsoft Developer Studio. It was initially built using the MFC AppWizard as a Single Document Interface (SDI) application. The initial SDI application project consisted of an application primary thread class (CLifeLinkApp), a class for document management (CLifeLinkDoc), a class for document viewing (CLifeLinkView), and a class for the main frame window (CMainFrame). The project was extended to include audio/video data management classes, user interface dialog classes, medical vital statistic data transfer classes, and a number of support classes. A summary of the LifeLink application classes is shown in Table 2.

Table 2 LifeLink Class Summary

Class Instance	Base Class	Instance Owner
CLifeLinkApp	CWinApp	(Global)
CMainFrame	CFrameWnd	CLifeLinkApp
CLifeLinkView	CView	CLifeLinkApp
CLifeLinkDoc	CDocument	CLifeLinkApp
CAboutDlg	CDialog	CLifeLinkApp
CEnterDlg	CDialog	CMainFrame
CWaitDlg	CDialog	CMainFrame
CBackupBat	CDialog	CMainFrame
CGenProp	CPropertyPage	CMainFrame
CNetProp	CPropertyPage	CMainFrame
CVitalProp	CPropertyPage	CMainFrame
CVidProcThrd	CWinThread	CMainFrame
CAudioThrd	CWinThread	CMainFrame
CAudioSock	CAsyncSocket	CAudioThrd
CVidSndThrd	CWinThread	CMainFrame
CVidSndSock	CAsyncSocket	CVidSndThrd
CVidRcvThrd	CWinThread	CMainFrame
CVidRcvSock	CAsyncSocket	CVidRcvThrd
CVitalData	(None)	(Global)
CSerialPort	(None)	CVitalData
CCmdSocket	CAsyncSocket	(Global)
CDestDoc	(None)	CMainFrame
CResourceLock	(None)	CLifeLinkView
CPowerStatus	(None)	(Global)
CRadioStatus	(None)	(Global)

The LifeLink application was designed as a multi-threaded application, because most of the processes involved in video conferencing are asynchronous in nature. This means that each thread in the application is usually blocked, waiting for input from some source. In addition to the primary thread class created by the AppWizard, several secondary thread classes were created. These include thread classes for managing the display of received video, managing audio data, managing network transmission of video data, managing network reception of video data, and managing medical vital statistic data. The secondary threads, with the exception of the vital statistic data management threads, are started within the constructor of the main frame window class instance. The vital statistic data management threads are started when a conference is initiated.

7.1.1 Main Thread

The LifeLink main, or primary, thread is defined by the AppWizard generated CLifeLinkApp class. Only one instance of this class is created. The primary thread creates instances of the application main window frame (CMainFrame), the application document (CLifeLinkDoc), and the application view (CLifeLinkView). The document class is not used but is needed as a placeholder for other operations.

The main window frame defines the frame window that is displayed on the computer monitor. It encompasses the title bar, menu bar, view window, and status bar. The CMainFrame class that defines the main frame also defines all the operations and support functions performed in response to user input (via the keyboard).

The CMainFrame class is supported by several user interface dialog classes. The CEnterDlg class is used to get conferencing destination selections from the user. The CWaitDlg class is used to inform the user with conferencing startup status information. The CBackupBat class is used to inform the user with a system shutdown countdown while the ambulance computer is operating on its backup battery. The application property page dialog classes, CGenProp, CNetProp, and CVitalProp, are used to display and change the application configuration settings.

The view window is defined by the CLifeLinkView class, and it is used as the interface to display the video received from the remote conferencing node. This class was extended to include operations and attributes supporting the capture of video and audio data to be sent to the remote conferencing node. Video and audio data capture configuration is performed using the Microsoft Video For Windows (VFW) Application Programming Interface (API). An important part of this configuration is the registration of capture callback functions, one for video data and one for audio data. As video and audio is captured from the Osprey 1000 codec card, these callback functions are called by VFW, and the callback functions can then process the data and inform the secondary threads of available data. This class also encapsulates video configuration operations using the Osprey raw driver interface and the Osprey Programming Interface (OPI) API.

A specialized network socket, defined by the CCmdSocket class, is used to send messages to and receive messages from other computers on the network running the LifeLink application. This socket is defined in global memory and accessed primarily by operations of the CMainFrame class. The messaging on this socket controls the synchronization between computers on the network when a conference is to be started, stopped, transferred, or shared.

Two additional classes, which are only used by the ambulance computer, manage the ambulance power system and Ethernet radio status display. The power system management class, CPowerStatus, hides the access of a digital I/O card connected to the ambulance power system. The Ethernet radio status display class, CRadioStatus, hides the implementation of a Simple Network Management Protocol (SNMP) session that is used to access the status of the Ethernet radio.

7.1.2 Video Data Display Management Thread

The display of received video data is placed in a separate thread in order to lower the priority of this task below the other tasks. The display of received video data is a fast operation relative to transmitting and receiving video data on the network.

The CVidProcThrd Windows thread class encapsulates the video data display functionality using its own message queue and message loop. When a frame of video data is received from the network, a message is posted to this thread's message queue. When tasking priority allows it, the message is processed by the thread and the video is written to the view window.

7.1.3 Audio Data Management Thread

The handling of audio data is placed in a separate thread in order to raise the priority of this task above all other tasks. It is important to optimize the flow of audio data because disruptions of the audio stream are much more noticeable than video disruptions.

The CAudioThrd Windows thread class encapsulates the audio handling functionality using its own message queue, a message loop, and an instance of the CAudioSock network socket class. As audio data is captured, messages are posted to this thread's message queue. When a message is received, the audio data socket is used to send the audio data to the remote conference node. When audio data is received by the audio socket from the remote conference node, it is queued for playback.

7.1.4 Video Data Network Management Threads

The handling of video data is placed in separate threads, one for transmitting network data and one for receiving network data, in order to use separate network sockets for transmitting and receiving. This is important because of the high data rate needed for sending and receiving video

data to and from the remote conference node. These threads have equal priority that is higher than the primary thread but lower than the audio data management thread.

The CVidSndThrd Windows thread class encapsulates the video data transmission functionality using its own message queue, a message loop, and an instance of the CVidSndSock network socket class. As video data is captured, messages are posted to this thread's message queue. When a message is received, the video data transmission socket is used to send the video data to the remote conference node.

The CVidRcvThrd Windows thread class encapsulates the video data reception functionality using its own message queue, a message loop, and an instance of the CVidRcvSock network socket class. When video data is received by the video reception socket from the remote conference node, it is processed and a message is posted to the video data display management thread (CVidProcThrd).

7.1.5 Medical Vital Statistic Data Management Threads

The handling of medical vital statistic data is placed in two separate threads. One thread waits on data received from the RS232 serial port, and one thread waits on data received from the remote conference node using a network socket. This is done because each of these operations is asynchronous and will usually be blocked. These threads have equal priority that can be adjusted via an application property. Note that this thread pair is present at each end of the conference since the vital statistic data transfer is actually bi-directional because of handshaking.

The CVitalData class encapsulates the attributes and operations needed to manage the flow of the medical vital statistic data. An instance of the CSerialPort class, which encapsulates much of the RS232 port access, is owned by this class. An instance of the standard CSocket class, which handles the network data flow, is also owned by this class.

7.2 Interfaces

The LifeLink application depends on several hardware and file interfaces for its operation. The hardware interfaces include an Osprey 1000 video/audio codec card, a 3Com 3C905 Ethernet card, a NumberNine Revolution 3D graphics card (ambulance only), an RS232 serial port, an Industrial Computer Source (ICS) DIO8 digital I/O card (ambulance only), and a keyboard input device. The file interfaces include an application properties file and a destination list file. These interfaces are explained in detail in the following paragraphs.

7.2.1 Osprey 1000

The Osprey 1000 codec card provides encoding and decoding of the audio and video used for LifeLink conferencing. The following list details the functionality of the card subsystems.

Video Encoder	Provides compressed video frames to the application via a callback function using the VFW API. The compression (and decompression) format is determined by application properties.
Video Decoder	Performs decompression of a video frame using Microsoft Installable Compression Manager (ICM) and VFW APIs.
Audio Encoder	Provides compressed audio frames to the application via a callback function. The compression (and decompression) format is determined by application properties.
Audio Decoder	Performs decompression and playback of an audio frame.

7.2.2 3COM 3C905

The 3Com 3C905 Ethernet card provides the network connectivity used to transfer video data, audio data, vital statistic data, and command information between local and remote LifeLink computers. This card supports both 10 Mbps and 100 Mbps operation, and it supports IP multicasting.

7.2.3 NumberNine Revolution 3D

The NumberNine Revolution 3D graphics card provides a full screen hardware video draw capability needed in the ambulance computer. (The hospital computer does not need an added graphics card, since the built-in graphics adapter will perform a full screen software draw without excessive burden on the CPU.)

7.2.4 RS232 Serial Port

The RS232 serial port is used to support the transfer of medical vital statistic data from the ambulance to the hospital. A vital statistic data monitor instrument will be connected to the RS232 serial port in the LifeLink ambulance computer, and a vital statistic data display instrument will be connected to the RS232 serial port in the LifeLink hospital computer. The vital statistic data will be transferred between the computers via the Ethernet network.

7.2.5 ICS DIO8 Digital I/O

The ICS DIO8 digital I/O card, installed only in the ambulance LifeLink computer, is used to interface with the ambulance computer power system. The inputs include a user power-down request signal, a backup battery test status signal, and a backup battery operational signal. The outputs include a backup battery test initiation signal and a power system shutdown signal.

7.2.6 Keyboard

The keyboard is the only input device needed by the user for operating the LifeLink computer and application. A standard keyboard will be used in the hospital, and a special keypad will be used in the ambulance. This keypad will consist of function keys F1 through F4, a numerical keypad, and four directional arrow keys.

7.2.7 Application Properties

The application properties input file (LifeLink.ini) resides in the Windows system directory. The contents of the file are managed by an application properties sheet dialog from within the LifeLink application using standard MFC objects. The application properties defined for LifeLink are listed in Table 3.

Table 3 Application Properties

Property	Default Value	Description
GeneralSection		
Hospital	0	Flag value that is 0 for hospital and non-zero for ambulance.
FullScreen	1	Flag value that is 0 for windowed video display and non-zero for full screen.
AutoInit	1	Flag value that is 0 for manual initialization and non-zero for automatic initialization.
DIO8BaseAddr	768	I/O space base address (in decimal notation) of the DIO8 I/O card used in the ambulance. Note that the actual value is input as hexadecimal in the application properties sheet.
ShutdownOnError	1	Flag value that is 0 for no automatic shutdown on error and non-zero for automatic shutdown on error.

Property	Default Value	Description
AudioSection		
AudioFormat	65533	Audio compression format identifier. The default indicates G.722 format.
AudioChannels	1	Number of audio channels: monaural.
AudioSamplesPerSec	8000	Number of audio samples per second.
AudioBytesPerSec	8000	Number of bytes of audio data collected per second.
AudioBlockAlign	1	Minimum sample size that can be accessed.
AudioBitsPerSample	8	Size of audio sample in bits.
AudioCbSize	0	Size in bytes of extra format information.
AudioEnable	1	Flag value that is 0 for disabled audio and non-zero for enabled audio.

Property	Default Value	Description
VideoSection		
LocalView	0	Flag value that is 0 for disabled local video view and non-zero for enabled local video view.
Overlay	0	Flag value that is 0 for disabled PIP local video and non-zero for enabled PIP.
LocalPosition	0	Position of local view on received video window. 0, 1, 2, or 3: Top left, Lower left, Top right, or Lower right.
Diagonal	30	Percentage of screen to be used by Overlay local view.
SvideoIn	0	Flag value that is 0 for composite video input and non-zero for S-video video input.
HardwareDraw	1	Flag value that is 0 for disabled hardware video drawing and non-zero for enabled hardware video drawing.
FrameRate	15	Approximate video capture frame rate in frames per second.
KbitRate	512	Nominal video data rate in Kilobits per second.
Quantization	10	Video quantization factor: a lower number will sacrifice frame rate in favor of higher quality.
VideoDisplay	1	Flag value that is 0 for video to video out port and non-zero for video to computer screen.

Property	Default Value	Description
NetworkSection		
DefaultConnectID	11	Default destination ID for establishing a conference (between ambulance and hospital).
DefaultTransferID	21	Default destination ID for transferring a conference (from one hospital to another).
DefaultConsultID	21	Default destination ID for inviting another hospital to receive the conference.
MulticastEnable	0	Flag value that is 0 for disabled IP multicasting and non-zero for enabled IP multicasting.
MulticastAddr	225.1.1.1	Default IP multicast IP for an ambulance: must be changed for each ambulance.
Timeout	5	Timeout value in minutes: if no video received before the timeout expires, the conference will end automatically.
AgentAddr	172.16.4.1	Default IP address of the ambulance Ethernet radio: must be changed for each ambulance.
DestFile	DestList.txt	Default destination list file name. Contains the destination list database.
LogParentNode	0	Flag value that is 0 for disabled ambulance radio parent ID logging and non-zero for enabled logging.
DisplayParentNode	0	Flag value that is 0 for disabled ambulance radio parent ID display and non-zero for enabled display.
VitalDataSection		
Datagram	0	Flag value that is 0 for vital data stream sockets and non-zero for vital data datagram sockets.
VitalsPriority	1	Vital data thread priority: 0 = Above normal; 1 = Highest; 2 = Time critical.
CommPort	COM1	Name of the RS232 port to use for medical vital statistic data transfers.
BitRate	38400	Data rate of the RS232 port in Kbits per second.

7.2.8 Destination List

The destination list input file (DestList.txt) resides in the application directory with the application executable file. It contains a comma-delimited list of conferencing destinations used by the ambulance user and the hospital user. Each entry (line) in the file consists of four comma-delimited fields that describe a destination: ID (entered by the user), IP address, short description, and long description. The following lines show a sample of the file contents:

```
11,172.16.5.100,UHMC,University Hospital #1,
21,172.16.6.100,BAMC,Brook Army MC #1,
```

7.3 Global Data

Some of the class instances, including the application instance itself, are defined in global memory. Table 4 lists the class names and instance names used by LifeLink.

Table 4 Global Data

Class Name	Instance Name	Description
CLifeLinkApp	theApp	This is the AppWizard generated instance of the LifeLink application.
CCmdSocket	CommandSock	This is the instance of the specialized socket interface used to communicate between LifeLink applications across the network.
CVitalData	VitalData	This is the instance of the medical vital statistic data management class. It encapsulates the RS232 serial port and network socket used to transfer vital statistic data.
CRadioStatus	RadioStat	This is the instance of the radio status class used to monitor the Ethernet radio in the ambulance.
CPowerStatus	PowerStat	This is the instance of the power system status class used to monitor the computer power system in the ambulance.

7.4 LifeLink Classes Design Details

This section describes the classes used by the LifeLink application. It is organized by thread definition classes, followed by thread support classes. The last few classes described are support classes. Figure 17 illustrates the relationships between all of the LifeLink classes.

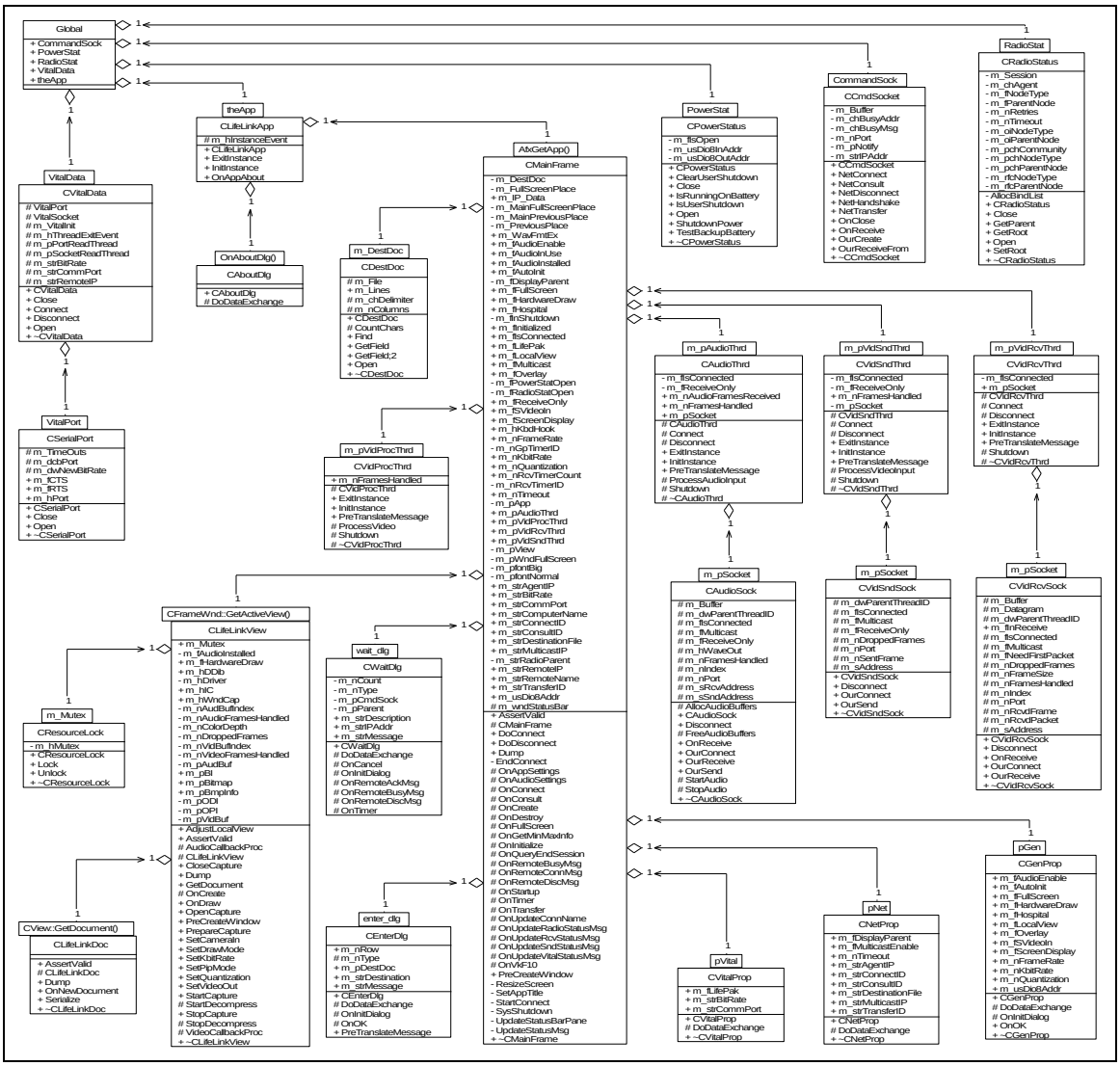


Figure 17. LifeLink Classes

7.4.1 Application Primary Thread Class

Class Name: **CLifeLinkApp**
Base Class: **CWinApp**
Instance Owner: **(Global)**

This class encapsulates the primary thread and message pump for the LifeLink application. It also creates the instances of the main user interface class (CMainFrame) and the document (CLifeLinkDoc) and view (CLifeLinkView) classes for the application. This is one of the classes originally created by the AppWizard for the LifeLink application.

The LifeLinkApp class contains the following attributes:

Private:

m_hInstanceEvent	Instance handle for application.

The LifeLinkApp class contains the following operations:

Public:

CLifeLinkApp	Class constructor; generated by MSVC++ App Wizard.

Private:

ExitInstance	Override of default function used to delete any resources allocated by the thread instance.
InitInstance	Required override of default function used to initialize the main thread instance.
OnAppAbout	Handler for application information request event.

7.4.2 Main Frame Window Class

Class Name: CMainFrame
Base Class: CFrameWnd
Instance Owner: CLifeLinkApp

This class encapsulates the frame window of the application. It is responsible for managing user input for menu items and accelerator keys. The frame window provides a container for the application menu bar (not used by LifeLink), the view window, and the status bar. It also contains many operations that directly result from user actions and instances of many of the other support classes. This is one of the classes originally created by the AppWizard for the LifeLink application.

The CMainFrame class contains the following attributes:

Public:

m_fAudioEnable	Indicates use of audio in conference.
m_fAudioInstalled	Indicates availability of audio subsystem.
m_fAudioInUse	Indicates use of audio during conference.
m_fAutoInit	Indicates initialization at app startup.
m_fDatagram	Indicates the type of vital data socket to use.
m_fFullScreen	Indicates the initial video window size.
m_fHardwareDraw	Indicates the type of video draw.
m_fHospital	Indicates app usage.
m_fInitialized	Indicates initialization state.
m_fIsConnected	Indicates conference connection status.
m_fLocalView	Indicates if local view is to be used.
m_fMulticast	Indicates use of IP multicast.
m_fOverlay	Indicates type of local view.
m_fReceiveOnly	Indicates control/consult status of a conference.
m_fScreenDisplay	Indicates the video output to use.
m_fSVideoIn	Indicates the video input to use.
m_hKbdHook	Handle of installed keyboard hook routine.
m_IP_Data	Holds IP and socket identity of current conference.
m_nDiagonal	Holds the screen diagonal percentage used for overlay local view.
m_nFrameRate	Holds the video frame rate in use.
m_nKbitRate	Holds the video kbps rate in use.
m_nLocalPosition	Holds the screen position of local view: 0..3 (UL, LL, UR, LR).
m_nQuantization	Holds the video quantization in use.
m_nRcvTimerCount	Tracks elapsed time since last video data was received.

m_nTimeout	Holds the period (in seconds) of no video received before conference is terminated.
m_nVitalsPriority	Holds the vital data thread priority: (0..2) (Above Normal, Highest, Time Critical).
m_pAudioThrd	Pointer to audio network xmit/recv thread.
m_pVidProcThrd	Pointer to received video decode & display thread.
m_pVidRcvThrd	Pointer to video network receive thread.
m_pVidSndThrd	Pointer to video network transmit thread.
m_strAgentIP	Holds the IP address of the radio in this ambulance.
m_strBitRate	Holds the kbps rate used for vital statistic data passthru.
m_strCommPort	Holds the comm port used for vital statistic data passthru.
m_strComputerName	Holds computer name of this computer.
m_strConnectID	Holds the default control node destination ID.
m_strConsultID	Holds the default consult node destination ID.
m_strDestinationFile	Holds the name of the destination list file.
m_strMulticastIP	Holds the IP multicast address for this ambulance.
m_strRemoteIP	Holds IP address of current conference partner.
m_strRemoteName	Holds short name of current conference partner.
m_strTransferID	Holds the default transfer node destination ID.
m_usDio8Addr	Holds the base address of the I/O card.
m_WavFmtEx	Audio format and control members.

Private:

m_DestDoc	Instance of destination list document class.
m_fDisplayParent	Indicates if radio parent name should be displayed.
m_fInShutdown	Indicates a system shutdown in progress.
m_fLogParent	Indicates if radio parent name should be logged.
m_fPowerStatOpen	Indicates status of power status functions.
m_fRadioStatOpen	Indicates status of radio status functions.
m_FullScreenPlace	Holds dimensions of previous screen state.
m_MainFullScreenPlace	Holds dimensions of previous main window.
m_MainPreviousPlace	Holds position of previous main window.
m_nGpTimerID	ID of multi-use timer.
m_nRcvTimerID	ID of timer for tracking video reception loss.
m_pApp	Pointer to application class instance.
m_pfontBig	Points to font used for full screen video.
m_pfontNormal	Points to font used for windowed video.
m_PreviousPlace	Holds position of previous screen position.
m_pView	Pointer to view class instance.
m_pWndFullScreen	Pointer to full screen window.
m_strRadioParent	Holds radio parent name.
m_wndStatusBar	Instance of Stingray status bar class.

The CMainFrame class contains the following operations:

Public:

~CMainFrame	Class destructor override. Destroys the one and only app frame window class instance.
DoConnect	Displays a dialog that will continue sending connection requests to the remote node until acknowledged by the remote node or cancelled by the local user.
DoDisconnect	Ends the active conference and sends notification to the remote node.
PreCreateWindow	Window pre-creation message override. Sets the size of the frame window.

Private:

CMainFrame	Class constructor override. Creates the one and only app frame window class instance.
EndConnect	Perform actions to end a conference.
OnAppSettings	Manage the viewing and/or changing of the app property sheet; called as a result of the accelerator key sequence Ctrl-Alt-Shift-S.
OnAudioSettings	Manage the viewing and/or changing of the audio settings for the app. Note that the actual dialog is displayed by the system function; called as a result of the accelerator key sequence Ctrl-Alt-Shift-A.
OnConnect	Perform actions to initiate or end a conference with a remote node; called as a result of the accelerator key sequence F1.
OnConsult	Perform actions to invite a hospital node to join a conference in view-only mode; called as a result of the accelerator key sequence F6.
OnCreate	Window creation message override. Creates status bar and command socket.
OnDestroy	Message handler override for the WM_DESTROY system message; called by system when window is to be destroyed.
OnFullScreen	Toggle the app view from window to full screen; called as a result of the accelerator key sequence Ctrl-Alt-Shift-F12.
OnGetMinMaxInfo	Message handler override for the WM_GETMINMAXINFO system message; called by system when window size is about to change.
OnInitialize	Perform initial Osprey codec setup operations; called as a result of the accelerator key sequence Ctrl-Alt-Shift-I.
OnQueryEndSession	Message handler override for WM_QUERYENDSESSION system message; called by system when a Windows

	session is to be ended.
OnRemoteBusyMsg	Message handler for WM_REMOTEBUSY application message; sent when the Wait dialog receives a busy notification message from this node's command socket in response to remote node busy notification.
OnRemoteConnMsg	Message handler for WM_REMOTECONNECT application message; sent by this node's command socket in response to remote node when its operator initiates a conference.
OnRemoteDiscMsg	Message handler for WM_REMOTEDISCONNECT application message; sent by this node's command socket in response to remote node when its operator ends a conference.
OnStartup	Message handler for UM_INITIALIZE application message; this message is posted by the View window at the end of its creation.
OnTimer	Message handler override for WM_TIMER system message; called by system when a timer event owned by this window occurs.
OnTransfer	Perform actions to transfer a conference from one hospital node to another; called as a result of the accelerator key sequence F5.
OnUpdateConnName	Status bar connection name field update handler. Called by system when attached string is changed.
OnUpdateRadioStatusMsg	Message handler for status bar Ethernet radio registration field update message (UM_RADIO_STATUS).
OnUpdateRcvStatusMsg	Message handler for status bar video receive field update message (UM_RCV_STATUS).
OnUpdateSndStatusMsg	Message handler for status bar video send field update message (UM_SND_STATUS).
OnUpdateVitalStatusMsg	Message handler for status bar vital statistic data reception field update message

	(UM_VITAL_STATUS).
OnVitalExitMsg	Message handler for vital data thread exit notification message (UM_VITAL_EXIT).
OnVkF10	Debug function used to cause the ambulance Ethernet radio to unregister from its parent and reregister with a (possibly) new parent.
ResizeScreen	Toggle the frame and client windows between window (normal) sizing and full screen sizing.
SetAppTitle	Set the text of the frame (app title bar) to indicate Hospital or Ambulance app type.
StartConnect	Perform actions to start a conference.
SysShutdown	Schedule an orderly Windows shutdown in preparation for power loss.
UpdateStatusBarPane	Status bar indicator update handler common to video send and receive, vital statistic data, and radio registration indicators.
UpdateStatusMsg	Message handler for updating status bar message area.

7.4.3 Main Document Class

Class Name: **CLifeLinkDoc**
Base Class: **CDocument**
Instance Owner: **CLifeLinkApp**

This class encapsulates the document interface of the SDI application. While not used by LifeLink, this class and its functions are required for the proper functionality of the application. This is one of the classes originally created by the AppWizard for the LifeLink application.

The LifeLinkDoc class contains the following operations:

Public:

~CLifeLinkDoc	Class destructor.
OnNewDocument	Handler for new document creation.
Serialize	Input/output serialization handler.

Private:

CLifeLinkDoc	Class constructor.

7.4.4 Main View Class

Class Name: CLifeLinkView
Base Class: CView
Instance Owner: CLifeLinkApp

This class encapsulates control of the view of documents: in the case of LifeLink, the displayed video received from the remote conferencing node. This class has been extended to include all of the video and audio capture operations for the Osprey 1000 video and audio codec. This is one of the classes originally created by the AppWizard for the LifeLink application.

The LifeLinkView class contains the following attributes:

Public:

m_fHardwareDraw	Indicates if hardware draw is possible
m_hDDib	Handle of draw DIB interface
m_Hic	Handle of installable compression manager
m_hWndCap	Handle of capture window
m_Mutex	Holds instance of mutex semaphore
m_pBI	Pointer to bitmap info header
m_pBitmap	Pointer to bitmap buffer
m_pBmpInfo	Pointer to bitmap info buffer

Private:

m_fAudioInstalled	Indicates if audio system available
m_hDriver	Holds handle of capture driver
m_nAudBufIndex	Current audio buffer in use
m_nAudioFramesHandled	Holds a count of audio packets captured
m_nColorDepth	Holds color depth being used
m_nDroppedFrames	Holds the current count of captured and dropped video frames
m_nVidBufIndex	Current video buffer in use
m_nVideoFramesHandled	Holds a count of video frames captured
m_pAudBuf	Array of pointers to audio buffers
m_pLogoBmp	Pointer to LifeLink logo bitmap data
m_pODI	Pointer to Osprey device instance
m_pOPI	Pointer to Osprey system instance
m_pVidBuf	Array of pointers to video buffers

The LifeLinkView class contains the following operations:

Public:

~CLifeLinkView	Class destructor override. Destroys the one and only app view window class instance.
AdjustLocalView	Set the overlay local view size and visibility.
CloseCapture	Disconnect from capture driver and destroy capture window.
OnDraw	Message handler override for WM_DRAW system message. Used to draw LifeLink logo to view window when no conference video is being displayed.
OpenCapture	Create audio/video capture window and connect to capture driver.
PreCreateWindow	Window pre-creation message override. Set the size of the view window to CIF resolution.
PrepareCapture	Set video and audio capture parameters, and set video decompression parameters.
SetCameraIn	Select camera input: NTSC or S-Video using the OPI interface.
SetDrawMode	Select video draw mode: hardware or software using the OPI interface.
SetKbitRate	Set the compressed video output data rate in Kbits per second using the raw codec driver interface.
SetPipMode	Set the picture-in-picture (PIP) mode of the codec using the raw codec driver interface.
SetQuantization	Set the quantization factor for video capture using the raw codec driver interface. The lower the value, the greater the quality of captured video, at the expense of frames generated per unit of time.
SetVideoOut	Select video out mode: to screen or directly to video out using the OPI interface.
StartCapture	Start non-file audio/video capture. Implemented as a separate function from PrepareCapture to allow for correct sequencing of operations during conference startup.
StopCapture	Stop audio/video capture and video decompression.

Private:

AudioCallbackProc	Callback function registered with the capture driver. Called when a captured audio buffer is ready for app processing.
CLifeLinkView	Class constructor override. Initializes the one and only app view window class instance.
OnCreate	Window creation message override.
StartDecompress	Locate and open the decompression manager.
StopDecompress	Stop the decompression process.
VideoCallbackProc	Callback function registered with the capture driver. Called when a captured video frame is ready for app processing.

7.4.5 Application About Dialog Class

Class Name: CAboutDlg
Base Class: CDialog
Instance Owner: CLifeLinkApp

This is the standard dialog class used to show version information about the application. This is one of the classes originally created by the AppWizard for the LifeLink application.

The CAboutDlg class contains the following operations:

Public:

CAboutDlg	Class constructor.

Private:

DoDataExchange	Data exchange function override. This function manages the transfer of data to and from the class object variables and the screen.

7.4.6 Destination Entry Dialog Class

Class Name: **CEnterDlg**
Base Class: **CDialog**
Instance Owner: **CMainFrame**

This class presents a dialog to the user that manages the destination code entry by the user. The dialog's appearance is tailored for one of three operations: (1) starting a conference with a remote node, (2) transferring an active conference to another remote node, and (3) inviting a remote node to start a conference in consulting mode (receive only).

The CEnterDlg class contains the following attributes:

Public:

m_nRow	Holds selected row after operation.
m_pDestDoc	Pointer to destination list document instance.
m_strDestination	Holds destination string written by caller.
m_strMessage	Holds message string written by caller.

Private:

m_nType	Hold dialog type

The CEnterDlg class contains the following operations:

Public:

CEnterDlg	Class constructor.
PreTranslateMessage	Override function that sees all messages sent to dialog before they are dispatched. This is a convenient place to capture keystrokes and act on them in a non-standard way.

Private:

DoDataExchange	Data exchange function override. This function manages the transfer of data to and from the class object variables and the screen.
OnInitDialog	Message handler override for WM_INITDIALOG system message. Needed to initialize the display strings based on dialog type and force focus to a particular field after default initialization.
OnOK	Override of default OnOK member function. Needed to process the destination selection correctly.

7.4.7 Progress Notification Dialog Class

Class Name: **CWaitDlg**
Base Class: **CDialog**
Instance Owner: **CMainFrame**

This class presents a dialog to the user that manages the display of operation status for a user action. The dialog's appearance is tailored to the status being displayed: (1) conference initiation request status, (2) conference transfer request status, (3) consulting mode invitation status, and (4) acknowledgement of an accepted conference request.

The CWaitDlg class contains the following attributes:

Public:

m_strDescription	Description to display: set by parent.
m_strIPAddr	IP/ID address to display: set by parent.
m_strMessage	Message to display; set by parent.

Private:

m_nCount	Busy notification counter.
m_nType	Hold dialog type.
m_pCmdSock	Pointer to network command socket from construction.
m_pParent	Pointer to parent window.

The CWaitDlg class contains the following operations:

Public:

CWaitDlg	Class constructor.

Private:

DoDataExchange	Data exchange function override. This function manages the transfer of data to and from the class object variables and the screen.
OnCancel	OnCancel base class member override. Needed to perform some extra steps before calling base class member.
OnInitDialog	Message handler override for WM_INITDIALOG system message. Needed to initialize the display strings based on dialog type and start a timer.
OnRemoteAckMsg	Message handler for WM_REMOTEACKNOWLEDGE application message. It is sent by this node's command socket in response to it receiving the message from the remote node when its command socket receives a Connect message from this node.
OnRemoteBusyMsg	Message handler for application WM_REMOTEBUSY message. It is sent by this node's command socket in response to it receiving the message from the remote node when its command socket receives a Connect message from this node and it is already engaged in a conference.
OnRemoteDiscMsg	Message handler for WM_REMOTEDISCONNECT application message. It is sent by this node's command socket in response to it receiving the message from the remote node when its operator ends a conference. Received by this dialog while displaying the "Receiving from" message or the "Transferring to" message.
OnTimer	Timer event function override. Used to resend command socket messages to the remote every 2 seconds.

7.4.8 Battery Operation Countdown Dialog Class

Class Name: **CBackupBat**
Base Class: **CDialog**
Instance Owner: **CMainFrame**

This class manages the display of the backup battery operation countdown message dialog. Implemented as a modeless dialog, this dialog is displayed without input focus in the upper right corner of the screen. The time in seconds that the ambulance computer will continue to operate is updated and displayed every second.

The CBackupBat class contains the following attributes:

Private:

m_nCountdown	Initial countdown value to be displayed.
m_pParent	Pointer to parent window.

The CBackupBat class contains the following operations:

Public:

CBackupBat	Class constructor.

Private:

DoDataExchange	Required data exchange function override that calls the base class member function.
OnCountdownMsg	Message handler for the UM_COUNTDOWN application message. It is sent by the parent window to perform an update of the displayed countdown value.
OnInitDialog	Message handler override for the WM_INITDIALOG system message. Used to initialize the displayed countdown initial value, set the initial position, and display the dialog.

7.4.9 Application General Properties Dialog Class

Class Name: **CGenProp**
Base Class: **CPropertyPage**
Instance Owner: **CMainFrame**

This class manages the data entry and validation of general properties, video properties, and miscellaneous properties for the application. This property page, along with the other property pages, is controlled by a runtime instance of a CPropertySheet class object that presents the complete properties dialog to the user.

The CGenProp class contains the following attributes:

Public:

m_fAudioEnable	Holds the audio enable setting; set and retrieved by the parent.
m_fAutoInit	Holds the automatic codec initialization setting; set and retrieved by the parent.
m_fFullScreen	Holds the default video window size setting; set and retrieved by the parent.
m_fHardwareDraw	Holds the video drawing method setting; set and retrieved by the parent.
m_fHospital	Holds the application type setting; set and retrieved by the parent.
m_fLocalView	Holds the local view enable setting; set and retrieved by the parent.
m_fOverlay	Holds the local view method setting; set and retrieved by the parent.
m_fScreenDisplay	Holds the video output setting; set and retrieved by the parent.
m_fSVideoIn	Holds the camera input selection setting; set and retrieved by the parent.
m_nDiagonal	Holds the screen diagonal percentage used for overlay local view.
m_nFrameRate	Holds the video frame rate (frames per second) setting; set and retrieved by the parent.
m_nKbitRate	Holds the video data rate (Kbits per second) setting; set and retrieved by the parent.
m_nLocalPosition	Holds the screen position of local view: 0..3 (UL, LL, UR, LR).
m_nQuantization	Holds the video quality setting; set and retrieved by the parent.
m_usDio8Addr	Holds the digital I/O card base address setting; set and retrieved by the parent.

The CGenProp class contains the following operations:

Public:

~CGenProp	Class destructor.
CGenProp	Class constructor.
OnOK	Override of default OnOK member function. Needed to process the radio button groups correctly.

Private:

DoDataExchange	Data exchange function override. This function manages the transfer of data to and from the class object variables and the screen.
OnInitDialog	Message handler override for WM_INITDIALOG system message. Needed to initialize the radio button groups correctly.

7.4.10 Application Network Properties Dialog Class

Class Name: **CNetProp**
Base Class: **CPropertyPage**
Instance Owner: **CMainFrame**

This class manages the data entry and validation of network related application properties. This property page, along with the other property pages, is controlled by a runtime instance of a CPropertySheet class object that presents the complete properties dialog to the user.

The CNetProp class contains the following attributes:

Public:

m_fDisplayParent	Holds the ambulance Ethernet radio parent display enable setting; set and retrieved by the parent.
m_fMulticastEnable	Holds the ambulance IP multicast enable setting; set and retrieved by the parent.
m_nTimeout	Holds the conference timeout on no video received setting; set and retrieved by the parent.
m_strAgentIP	Holds the ambulance Ethernet radio IP address setting; set and retrieved by the parent.
m_strConnectID	Holds the default conference destination ID setting; set and retrieved by the parent.
m_strConsultID	Holds the default consulting node destination ID setting; set and retrieved by the parent.
m_strDestinationFile	Holds the name and location of the file containing the conference destination ID list; set and retrieved by the parent.
m_strMulticastIP	Holds the ambulance multicast IP address setting; set and retrieved by the parent.
m_strTransferID	Holds the default conference transfer node destination ID setting; set and retrieved by the parent.

The CNetProp class contains the following operations:

Public:

~CNetProp	Class destructor.
CNetProp	Class constructor.

Private:

DoDataExchange	Data exchange function override. This function manages the transfer of data to and from the class object variables and the screen.

7.4.11 Application Vital Statistic Data Properties Dialog Class

Class Name: **CVitalProp**
Base Class: **CPropertyPage**
Instance Owner: **CMainFrame**

This class manages the data entry and validation of medical vital statistic data transfer related application properties. This property page, along with the other property pages, is controlled by a runtime instance of a CPropertySheet class object that presents the complete properties dialog to the user.

The CVitalProp class contains the following attributes:

Public:

m_fDatagram	Indicates the type of vital data socket to use.
m_nVitalsPriority	Holds the vital data thread priority: (0..2) (Above Normal, Highest, Time Critical).
m_strBitRate	Holds the ambulance multicast IP address setting; set and retrieved by the parent.
m_strCommPort	Holds the ambulance multicast IP address setting; set and retrieved by the parent.

The CVitalProp class contains the following operations:

Public:

~CVitalProp	Class destructor.
CVitalProp	Class constructor.

Private:

DoDataExchange	Data exchange function override. This function manages the transfer of data to and from the class object variables and the screen.

7.4.12 Video Playback Processing Thread Class

Class Name: **CVidProcThrd**
Base Class: **CWinThread**
Instance Owner: **CMainFrame**

This class provides a separate thread of execution for the decoding and display of video data received from the network. It also provides a message pump for the thread allowing it to receive messages from the other threads.

The CVidProcThrd class contains the following attributes:

Public:

m_nFramesHandled	Holds count of video frames displayed

The CVidProcThrd class contains the following operations:

Public:

ExitInstance	Override of default function used to delete any resources allocated by the thread instance.
InitInstance	Required override of default function used to initialize the thread instance.
PreTranslateMessage	Override function that sees all messages sent to the thread before they are dispatched. This is a convenient place to interpret and act on received messages.

Private:

~CVidProcThrd	Class destructor.
CVidProcThrd	Protected class constructor used by dynamic creation.
ProcessVideo	Decompress and (optionally) display a video frame.
Shutdown	Initiate thread termination.

7.4.13 Audio Processing Thread Class

Class Name: **CAudioThrd**
Base Class: **CWinThread**
Instance Owner: **CMainFrame**

This class provides a separate thread of execution for the processing of audio data. An instance of the CAudioSock class manages the transfer of audio data on the Ethernet. It provides a message pump for messages to the CAudioSock class from the main thread, from the audio capture callback function, and from the audio output device.

The CAudioThrd class contains the following attributes:

Public:

m_nAudioFramesReceived	Holds count of audio packets received.
m_nFramesHandled	Holds count of audio packets played.
m_pSocket	Pointer to audio socket class instance.

Private:

m_fIsConnected	Indicates current conference connection status.
m_fReceiveOnly	Indicates consulting mode.

The CAudioThrd class contains the following operations:

Public:

ExitInstance	Override of default function used to delete any resources allocated by the thread instance.
InitInstance	Required override of default function used to initialize the thread instance.
PreTranslateMessage	Override function that sees all messages sent to the thread before they are dispatched. This is a convenient place to interpret and act on received messages.

Private:

~CAudioThrd	Class destructor.
CAudioThrd	Protected class constructor used by dynamic creation.
Connect	Handler for connection message that will call socket function to create and connect the socket.
Disconnect	Handler for disconnection message that will call socket functions to disconnect and close the socket.
ProcessAudioInput	Handler for audio data ready message that will call socket function to send audio data on network to remote host.
Shutdown	Handler for app shutdown message that will initiate thread termination.

7.4.14 Audio Network Socket Class

Class Name: **CAudioSock**
Base Class: **CAsyncSocket**
Instance Owner: **CAudioThrd**

This class handles the operations of sending and receiving audio data on the network. This class also participates in the management of the audio playback device and the playback of received audio data.

The CAudioSock class contains the following attributes:

Private:

ip_mreq m_Mreq	Buffer used for multicast join requests.
m_Buffer	Array of audio playback buffer pointers.
m_dwParentThreadID	Holds ID of parent thread.
m_fIsConnected	Connection to remote machine established?
m_fMulticast	Using multicast send?
m_fReceiveOnly	Indicates consulting mode.
m_hWaveOut	Handle of WAVE audio output device.
m_nFramesHandled	Count of audio frame received from network.
m_nIndex	Audio playback buffer index.
m_nPort	Socket port for network audio stream.
m_sRcvAddress	IP address for sending audio to conference partner.
m_sSndAddress	IP address for receiving audio from conference partner.

The CAudioSock class contains the following operations:

Public:

~CAudioSock	Class destructor; releases audio buffers.
CAudioSock	Class constructor; allocates audio buffers.
Disconnect	Close connection to remote socket.
OnReceive	Override of default handler called by system when data is ready on the socket. Needed to call our socket read member function.
OurConnect	Create the audio socket and connect to the remote host.
OurReceive	Handler for audio data received via the network from the remote node.
OurSend	Send captured audio data to the remote node using this socket object.

Private:

AllocAudioBuffers	Allocate audio buffers.
FreeAudioBuffers	Release all audio buffers.
StartAudio	Open the WAVE audio output device.
StopAudio	Reset and close the WAVE audio output device.

7.4.15 Video Transmit Processing Thread Class

Class Name: **CVidSndThrd**
Base Class: **CWinThread**
Instance Owner: **CMainFrame**

This class provides a separate thread of execution for the processing of captured video data. An instance of the CVidSndSock class manages the transfer of captured video data to a remote conferencing node via the Ethernet. It provides a message pump for messages to the CVidSndSock class from the main thread and from the video capture callback function.

The CVidSndThrd class contains the following attributes:

Public:

m_nFramesHandled	Count of video frames sent on network.

Private:

m_fIsConnected	Indicates current state of conference connection.
m_fReceiveOnly	Indicates consulting mode (receive only).
m_pSocket	Pointer to video send socket instance.

The CVidSndThrd class contains the following operations:

Public:

ExitInstance	Override of default function used to delete any resources allocated by the thread instance.
InitInstance	Required override of default function used to initialize the thread instance.
PreTranslateMessage	Override function that sees all messages sent to the thread before they are dispatched. This is a convenient place to interpret and act on received messages.

Private:

~CVidSndThrd	Class destructor.
Connect	Handler for connection message that will call socket function to create and connect the socket.
CVidSndThrd	Protected class constructor used by dynamic creation.
Disconnect	Handler for disconnection message that will call socket functions to disconnect and close the socket.
ProcessVideoInput	Handler for video data ready message that will call socket function to send video data on network to remote host.
Shutdown	Handler for app termination message that will initiate thread termination.

7.4.16 Video Transmit Network Socket Class

Class Name: **CVidSndSock**
Base Class: **CAsyncSocket**
Instance Owner: **CVidSndThrd**

This class handles the operations of receiving video frames from the video capture callback function, disassembling the frames into packets, and sending the packets over the network to the conference partner.

The CVidSndSock class contains the following attributes:

Private:

m_dwParentThreadID	ID of parent thread.
m_fIsConnected	Connection to remote machine established?
m_fMulticast	Using multicast send?
m_fReceiveOnly	Indicates consulting mode (not sending).
m_nDroppedFrames	Current count of frames not sent.
m_nPort	Socket port used for sending video data.
m_nSentFrame	Sequence nbr of last video frames sent on network.
m_sAddress	IP address used for sending video data.

The CVidSndSock class contains the following operations:

Public:

~CVidSndSock	Class destructor.
CVidSndSock	Class constructor.
Disconnect	Close connection to remote host.
OurConnect	Create the video send socket and connect to the remote host.
OurSend	Send captured video data to the remote node using this socket object.

7.4.17 Video Receive Processing Thread Class

Class Name: **CVidRcvThrd**
Base Class: **CWinThread**
Instance Owner: **CMainFrame**

This class provides a separate thread of execution for the processing of video received from the remote conferencing node via the Ethernet. An instance of the CVidRcvSock class manages the

reception of video data. It provides a message pump for messages to the CVidRcvSock class from the main thread and from the asynchronous socket message manager.

The CVidRcvThrd class contains the following attributes:

Public:

m_pSocket	Pointer to receive video socket instance.

Private:

m_fIsConnected	Indicated current conference connection status.

The CVidRcvThrd class contains the following operations:

Public:

ExitInstance	Override of default function used to delete any resources allocated by the thread instance.
InitInstance	Required override of default function used to initialize the thread instance.
PreTranslateMessage	Override function that sees all messages sent to the thread before they are dispatched. This is a convenient place to interpret and act on received messages.

Private:

~CVidRcvThrd	Class destructor.
Connect	Handler for connection message that will call socket function to create and connect the socket.
CVidRcvThrd	Protected class constructor used by dynamic creation.
Disconnect	Handler for disconnection message that will call socket functions to disconnect and close the socket.
Shutdown	Handler for app termination message that will initiate thread termination.

7.4.18 Video Receive Network Socket Class

Class Name: **CVidRcvSock**
Base Class: **CAsyncSocket**
Instance Owner: **CVidRcvThrd**

This class handles the operations of receiving packetized video data from the network, assembling the packets into complete video frames, and passing the frames to the CVidProcThrd class for additional processing and display.

The CVidRcvSock class contains the following attributes:

Public:

m_fInReceive	Indicates if socket is currently reading data.

Private:

m_Buffer	Array of pointers to input buffers.
m_Datagram	Buffer for single video packet.
m_dwParentThreadID	ID of parent thread.
m_fIsConnected	Connection to remote machine established?
m_fMulticast	Using multicast receive?
m_fNeedFirstPacket	Wait for beginning of frame?
m_Mreq	Structure used in multicast join requests.
m_nDroppedFrames	Count of current dropped frames.
m_nFramesHandled	Count of video frames received.
m_nFrameSize	Size of current frame.
m_nIndex	Index into pointer array.
m_nPort	Socket port used for receiving video.
m_nRcvdFrame	Current frame being received.
m_nRcvdPacket	Current packet of current frame.
m_sAddress	IP address for receiving video.

The CVidRcvSock class contains the following operations:

Public:

~CVidRcvSock	Class destructor; used to release video buffers.
CVidRcvSock	Class constructor; used to allocate video buffers.
Disconnect	Close connection to remote host.
OnReceive	Override of default handler called by system when data is ready on the socket. Needed to signal parent thread of data being ready.
OurConnect	Create the video receive socket and connect to the remote host.
OurReceive	Handler for video data received via the network from the remote node.

7.4.19 Vital Statistic Data Management Class

Class Name: **CVitalData**
Base Class: **(None)**
Instance Owner: **(Global)**

This class owns and manages the serial port class, Ethernet socket class, and execution threads used to perform the transfer of medical vital statistic data from monitoring equipment (in an ambulance) across the network to display equipment (in a hospital).

The CVitalData class contains the following attributes:

Private:

m_fDatagram	Flag to indicate use of datagram socket or stream socket.
m_fHospital	Flag to indicate hospital or ambulance mode.
m_hThreadExitEvent	Handle of event semaphore used to exit threads.
m_pPortReadThread	Pointer to thread that reads vital statistic data from comm port.
m_pSocketReadThread	Pointer to thread that reads vital statistic data from socket.
m_strBitRate	BitRate (kbps) to used by comm port.
m_strCommPort	Comm port to be used.
m_strRemoteIP	IP address of conference partner.
m_VitalInit	Buffer for thread initialization data.
VitalPort	Instance of serial port class for vital statistic data transfers.
VitalSocket	Instance of socket class for vital statistic data transfers.

The CVitalData class contains the following operations:

Public:

~CVitalData	Class destructor.
Close	Close the vital statistic data serial port.
Connect	Connect to the remote host's vital statistic data socket and start the vital statistic data processing threads.
CVitalData	Class constructor.
Disconnect	End the vital statistic data processing session.
Open	Opens the serial port and Ethernet socket resources needed by the vital statistic data task.

7.4.20 Serial Port Class

Class Name: **CSerialPort**
Base Class: **(None)**
Instance Owner: **CVitalData**

This class encapsulates the access of a system RS232 serial port used to connect vital statistic data monitoring equipment to the LifeLink computer, allowing transparent connectivity of the devices across the network.

The CSerialPort class contains the following attributes:

Public:

m_fCTS	Indicates current state of port CTS line.
m_fRTS	Indicates current state of port RTS line.
m_hPort	Handle of serial port.

Private:

m_dcbPort	Serial port data control block.
m_dwNewBitRate	Data rate (kbps) used by serial port.
m_TimeOuts	Timeout values used by serial port.

The CSerialPort class contains the following operations:

Public:

~CSerialPort	Class destructor.
Close	Close the serial port.
CSerialPort	Class constructor.
Open	Opens the serial port and sets the port operating parameters.

7.4.21 Command and Control Network Socket Class

Class Name: **CCmdSocket**
Base Class: **CAsyncSocket**
Instance Owner: **(Global)**

This class provides a separate network socket used for command and acknowledgment messaging between the LifeLink ambulance and hospital conference nodes.

The CCmdSocket class contains the following attributes:

Private:

m_Buffer	Buffer for incoming socket messages.
m_chBusyAddr	Buffer to hold IP/ID on busy return.
m_chBusyMsg	Buffer to hold name on busy conference node.
m_nPort	Socket port for command channel.
m_pNotify	Pointer to window that will receive message reception notification.
m_strIPAddr	Buffer for IP address of message sender.

The CCmdSocket class contains the following operations:

Public:

~CCmdSocket	Class destructor.
CCmdSocket	Class constructor.
NetConnect	Send a connect invitation message to the passed control host IP.
NetConsult	Send a consult invitation message to the passed consulting host IP.
NetDisconnect	Sends a disconnect message to the current remote host.
NetHandshake	Send a handshake message to the current remote host. This will allow hosts with different timeouts or hosts that missed a disconnect message to end a broken conference.
NetTransfer	Send a transfer command message to the current remote host. The message includes the passed IP of the new host.
OnClose	Override of default handler called by system when socket is closed.
OnReceive	Override of default handler called by system when data is ready on the socket. Needed to process received messages.
OurCreate	Member function that will create the command socket.
OurReceiveFrom	Handler for command messages received via the network from some remote node.

7.4.22 Power System Management Class

Class Name: **CPowerStatus**
Base Class: **(None)**
Instance Owner: **(Global)**

This class encapsulates the access of the Industrial Computer Source (ICS) DIO8 digital I/O card via the ICS PeekPoke device driver. It includes functions for testing the backup battery connected to the ambulance computer, checking for backup battery operation, and beginning a system power-down sequence.

The CPowerStatus class contains the following attributes:

Private:

m_fIsOpen	Indicates if digital I/O card interface driver is open.
m_usDio8InAddr	I/O space address for reading from card.
m_usDio8OutAddr	I/O space address for writing to card.

The CPowerStatus class contains the following operations:

Public:

~CPowerStatus	Class destructor.
ClearUserShutdown	Toggles an output to reset the user shutdown request.
Close	Closes the I/O card interface device driver.
CPowerStatus	Class constructor.
IsRunningOnBattery	Samples the DIO8 input connected to the Running-On-Battery detection circuit and returns the result.
IsUserShutdown	Samples the DIO8 input connected to the User Shutdown switch and returns the result.
Open	Opens the PeekPoke device driver that will interface with the Industrial Computer Source DIO8 I/O card.
ShutdownPower	Sets the system power-down output bit. This may be as a result of a user shutdown request or a loss of primary power (running on backup battery).
TestBackupBattery	Toggles an output to start a test of ambulance LifeLink computer system backup battery.

7.4.23 Ethernet Radio Status Class

Class Name: **CRadioStatus**
Base Class: **(None)**
Instance Owner: **(Global)**

This class encapsulates the access of the Simple Network Management Protocol (SNMP) management API used to interrogate the ambulance Ethernet radio about its registration (with a root radio) status.

The CRadioStatus class contains the following attributes:

Private:

m_chAgent	Buffer for SNMP agent IP address.
m_fNodeType	Indicates if node type object ID is valid.
m_fParentNode	Indicates if parent node name object ID is valid.
m_nRetries	SNMP request retry count.
m_nTimeout	SNMP request timeout (milliseconds).
m_oiNodeType	Object identifier for node type.
m_oiParentNode	Object identifier for parent node name.
m_pchCommunity	Pointer to SNMP community name string being used.
m_pchNodeType	Pointer to node type string.
m_pchParentNode	Pointer to parent node name string.
m_rfcNodeType	Bind list for retrieving node type.
m_rfcParentNode	Bind list for retrieving parent node name.
m_Session	SNMP session handle.

The CRadioStatus class contains the following operations:

Public:

~CRadioStatus	Class destructor.
Close	Close the SNMP manager session.
CRadioStatus	Class constructor.
GetParent	Retrieve the parent name of the radio this Ethernet radio is registered to. The name will be an empty string if this radio is not registered.
GetRoot	Retrieve the root/non-root status of the Ethernet radio. This function is only used as a test aid to toggle the Ethernet radio between root and non-root operation.
Open	Open a SNMP manager session in preparation for monitoring the ambulance Ethernet radio for registration status.
SetRoot	Set the root/non-root status of the Ethernet radio. This function is only used as a test aid to toggle the Ethernet radio between root and non-root operation.

Private:

AllocBindList	Member function that allocates memory for variable binding list and copies passed object ID to it.

7.4.24 Resource Lock Management Class

Class Name: **CResourceLock**
Base Class: **(None)**
Instance Owner: **CLifeLinkView**

This class encapsulates the functionality of a mutual exclusion (mutex) semaphore used to ensure single access to shared resources.

The CResourceLock class contains the following attributes:

Private:

m_hMutex	Handle of mutual exclusion (mutex) semaphore.

The CResourceLock class contains the following operations:

Public:

~CResourceLock	Class destructor; closes the mutex semaphore.
CResourceLock	Class constructor; creates the mutex semaphore.
Lock	Attempt to gain ownership of the mutex semaphore.
Unlock	Release ownership of the mutex semaphore.

7.4.25 Destination List Document Access Class

Class Name: **CDestDoc**
Base Class: **(None)**
Instance Owner: **CMainFrame**

This class encapsulates the access of a destination list file that is used to map destination codes (entered by the user) to IP addresses and node descriptions.

The CDestDoc class contains the following attributes:

Public:

m_Lines	Array of string used to hold lines from the destination list file.

Private:

m_chDelimiter	Character to be used as column delimiter.
m_File	Destination list file object.
m_nColumns	Count of columns in file.

The CDestDoc class contains the following operations:

Public:

~CDestDoc	Class destructor.
CDestDoc	Class constructor.
Find	Find the row with the passed reference string in the passed column.
GetField	Scan passed string using passed delimiter character to retrieve a particular column from the string.
GetField	Overload of previous GetField that takes a row number that is then used to retrieve a string from the string array and call GetField with it.
Open	Open the conference destination list file and load the entries into a string array.

Private:

CountChars	Obtain a count of the delimiter character in the passed string.

7.5 Operational Sequence Diagrams

This section contains a number of sequence diagrams intended to illustrate the interaction between classes during several important operations. The diagrams show both process sequencing and data flow paths.

7.5.1 Codec Initialization

Initialization of the Osprey video and audio codec normally occurs automatically during program startup. For testing purposes, the codec may need to be un-initialized and re-initialized. A chorded key sequence (Ctrl+Alt+Shift I) will toggle the program between these two states. Figure 18 illustrates the sequence of the CMainFrame::OnInitialize operation.

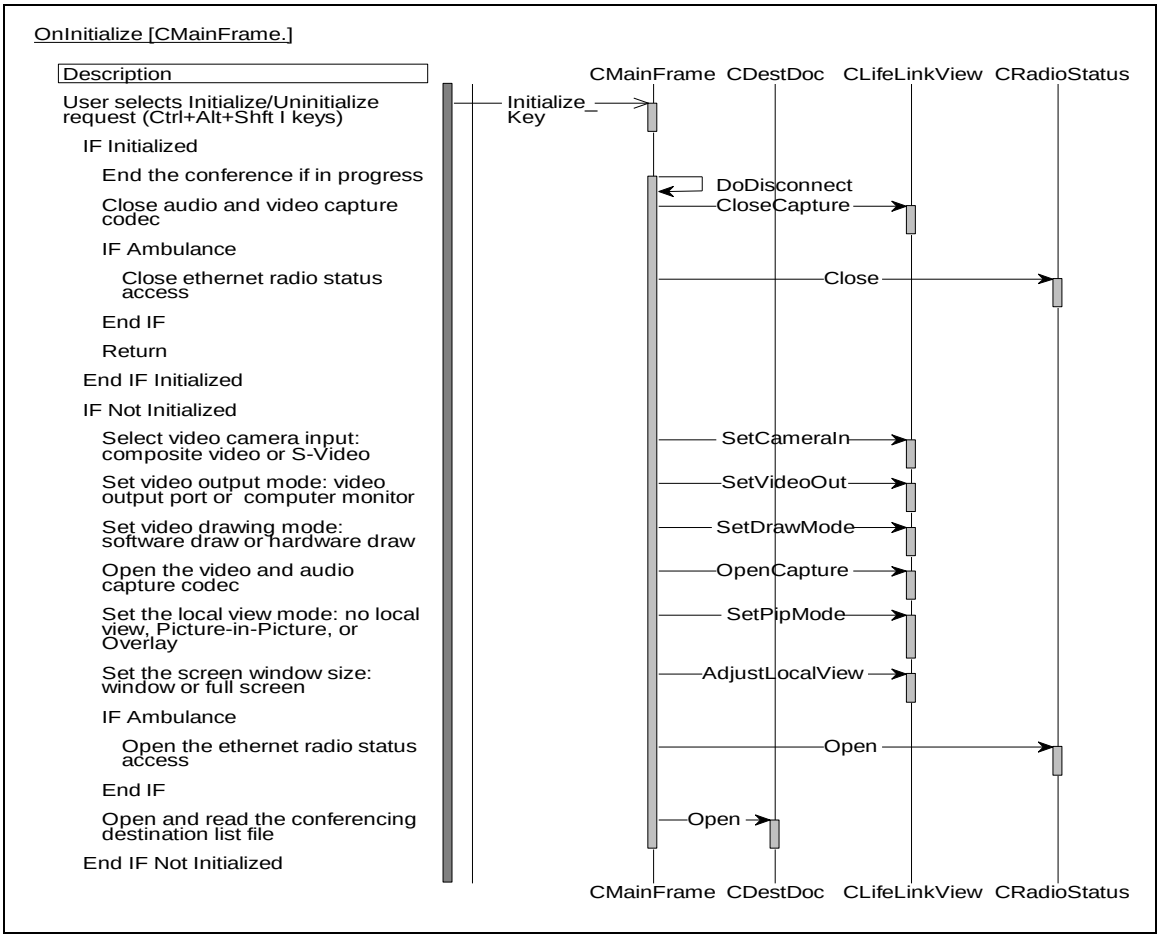


Figure 18. Codec Initialization

7.5.2 Conference Connection

Initiation of a conference begins at the ambulance computer when the user presses the F1 key. This key will toggle the program between initiating a conference and ending an existing conference. Figure 19 illustrates the sequence of the CMainFrame::OnConnect operation.

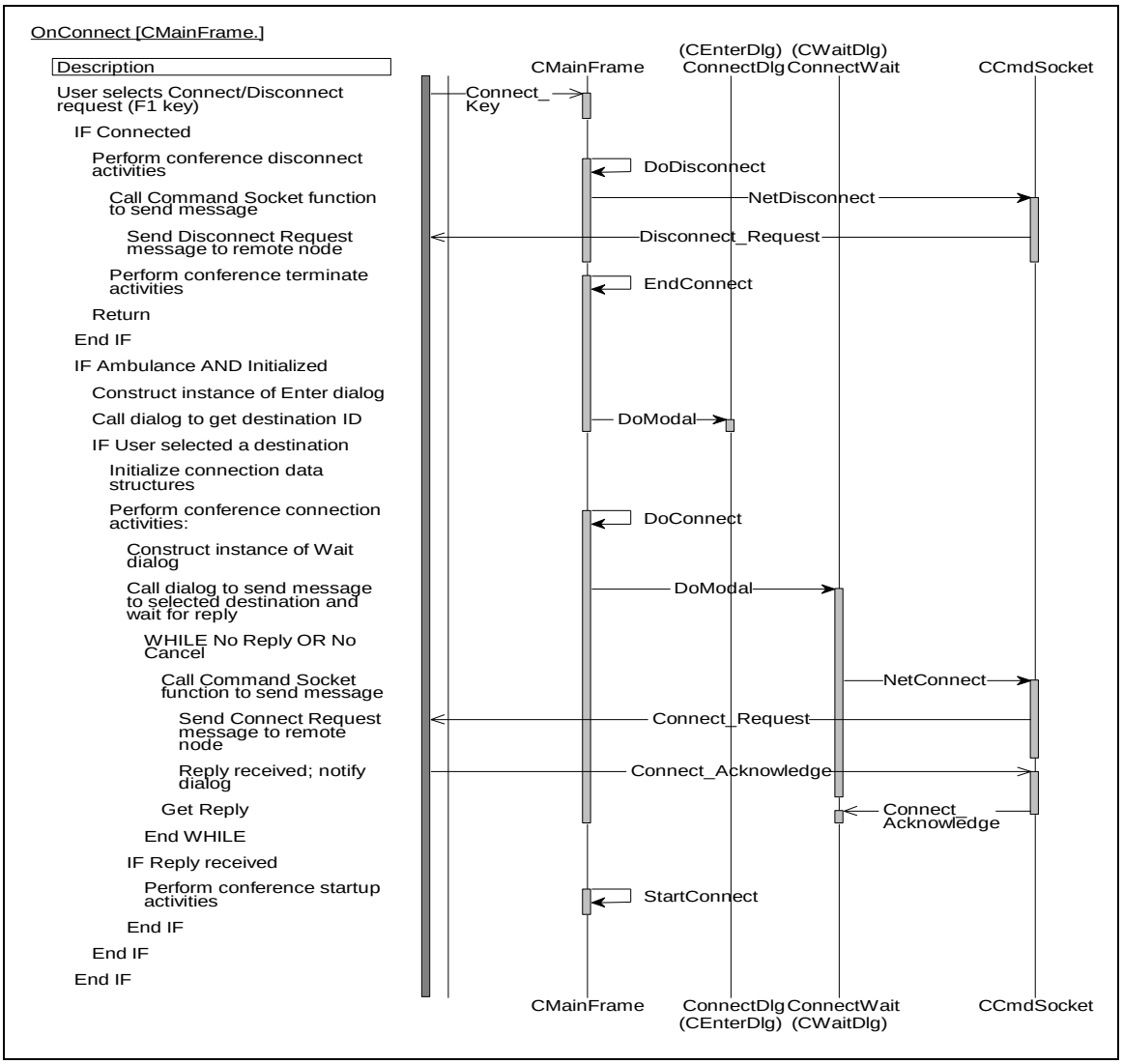


Figure 19. Conference Connection

7.5.3 Conference Transfer

Transfer of a conference begins at the hospital computer when the user presses the F5 key. This key is only valid for the hospital computer when a conference is in progress. Figure 20 illustrates the sequence of the CMainFrame::OnTransfer operation.

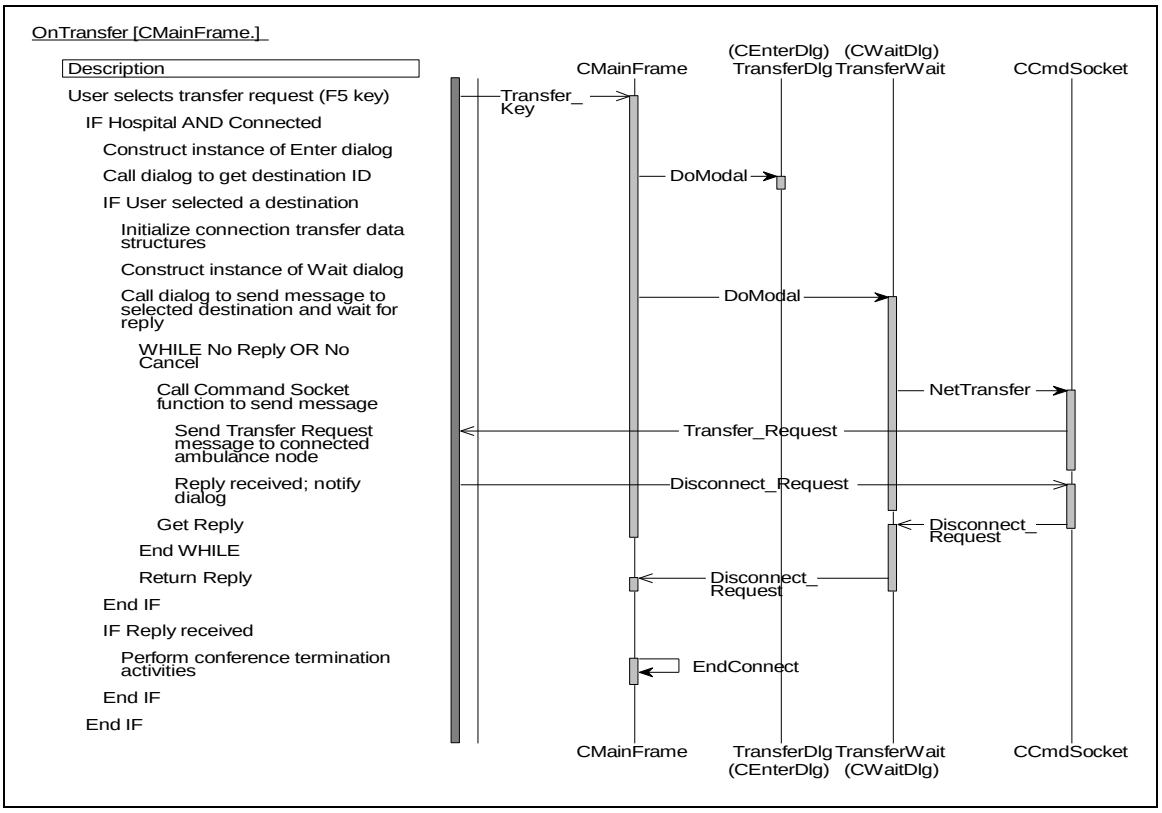


Figure 20. Conference Transfer

7.5.4 Conference Consult

Consult invitation into an existing conference begins at the hospital computer when the user presses the F6 key. This key is only valid for the hospital computer when a conference is in progress. Figure 21 illustrates the sequence of the CMainFrame::OnConsult operation.

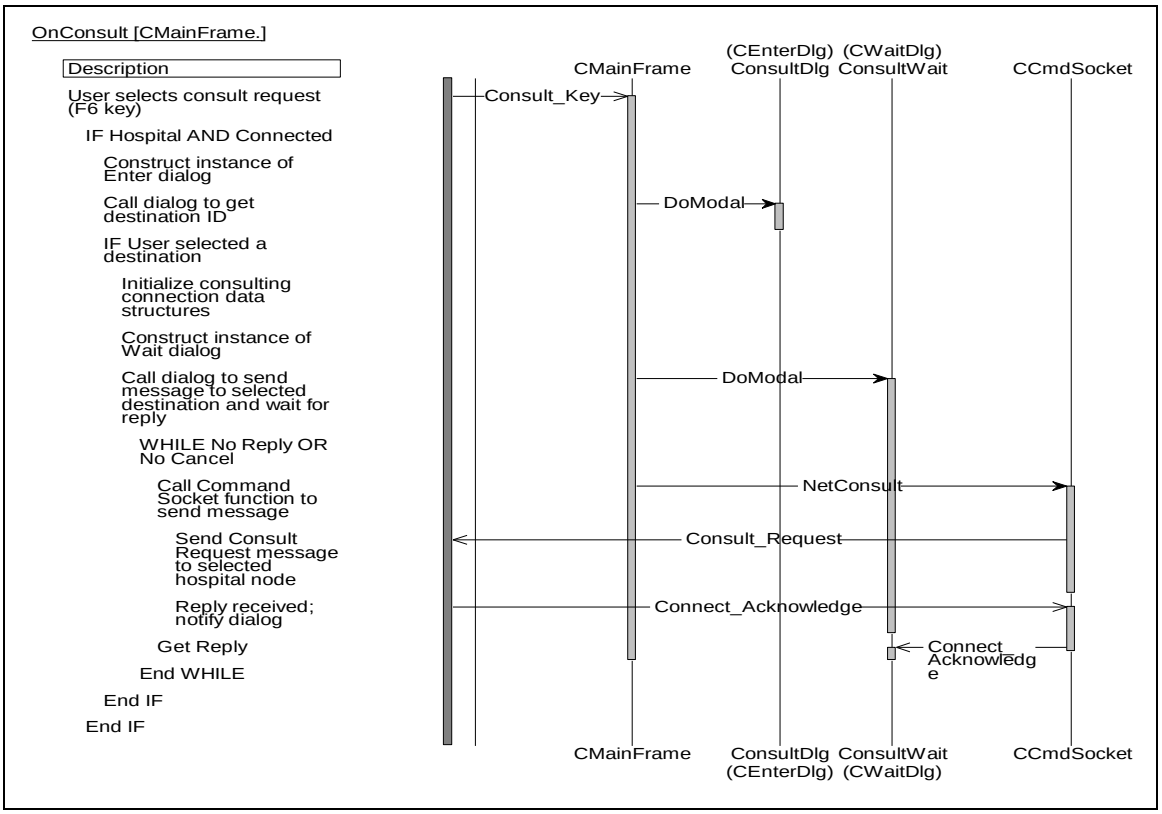


Figure 21. Conference ConsultConference Startup

7.5.5 Conference Startup

Conference startup requires interaction between several classes. Several operations are performed to complete initialization of the video/audio codec, and conference startup messages are sent to the secondary support threads. Figure 22 illustrates the sequence of the CMainFrame::StartConnect operation.

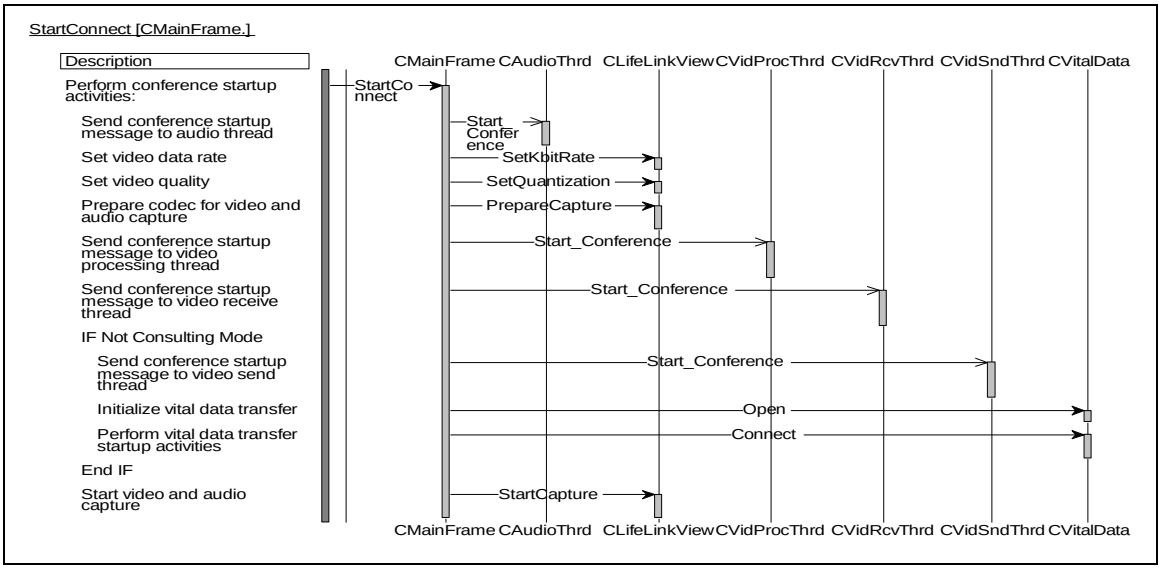


Figure 22. Conference Startup

7.5.6 Conference Termination

Conference termination requires interaction between several classes. The video and audio capture is stopped, and conference termination messages are sent to the secondary support threads. Figure 23 illustrates the sequence of the CMainFrame::EndConnect operation.

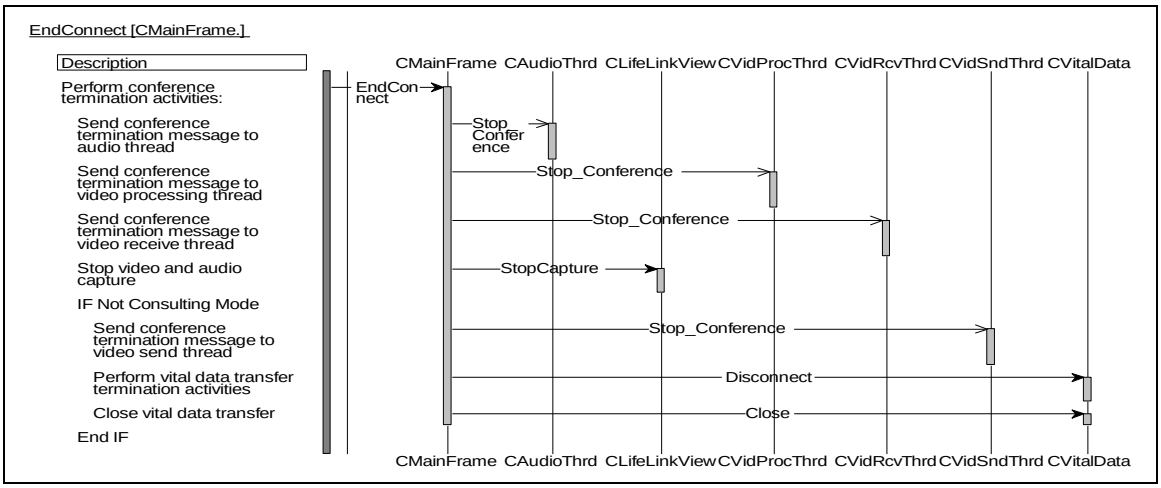


Figure 23. Conference Termination

7.5.7 Video Thread Message Processing

The Video Processing thread, responsible for displaying video received from the remote conferencing node, operates asynchronously. It communicates with the other LifeLink threads using messages. Figure 24 illustrates the message processing sequences of the CVidProcThrd::PreTranslateMessage operation, which is a part of the thread's message processing loop.

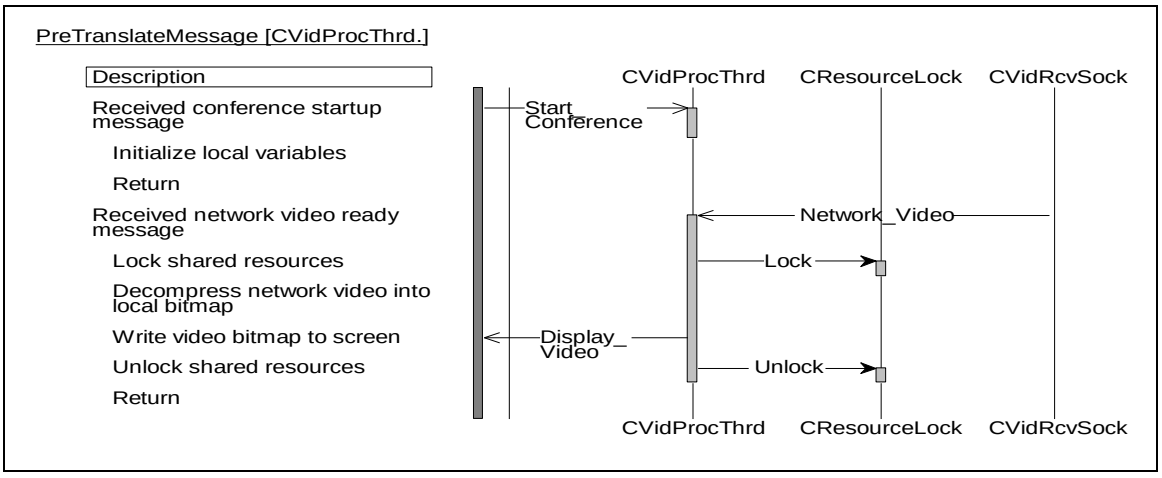


Figure 24. Video Thread Message Processing

7.5.8 Audio Thread Message Processing

The Audio Processing thread, responsible for sending audio to and receiving audio from the remote conferencing node, operates asynchronously. It communicates with the other LifeLink threads using messages. Figure 25 illustrates the message processing sequences of the CAudioThrd::PreTranslateMessage operation, which is a part of the thread's message processing loop.

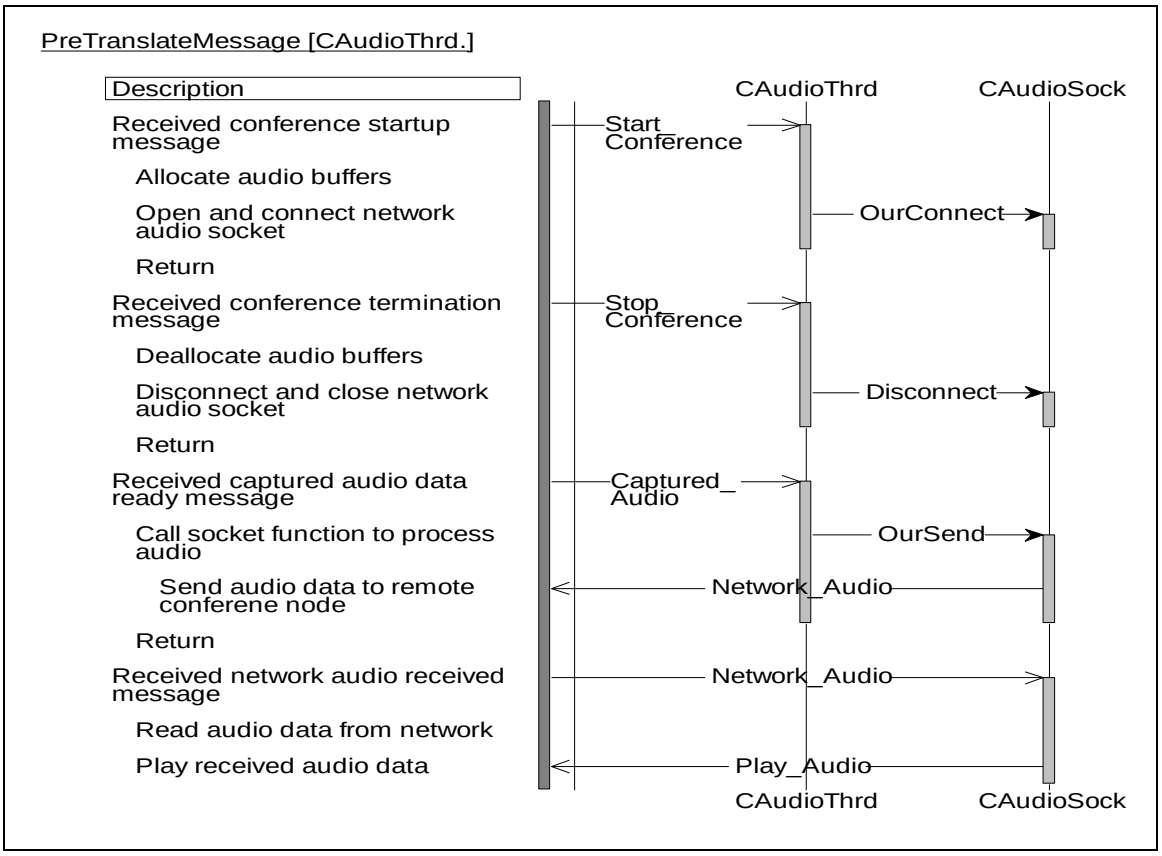


Figure 25. Audio Thread Message Processing

7.5.9 Video Send Thread Message Processing

The Video Transmit Processing thread, responsible for sending video to the remote conferencing node, operates asynchronously. It communicates with the other LifeLink threads using messages. Figure 26 illustrates the message processing sequences of the CVidSndThrd::PreTranslateMessage operation, which is a part of the thread's message processing loop.

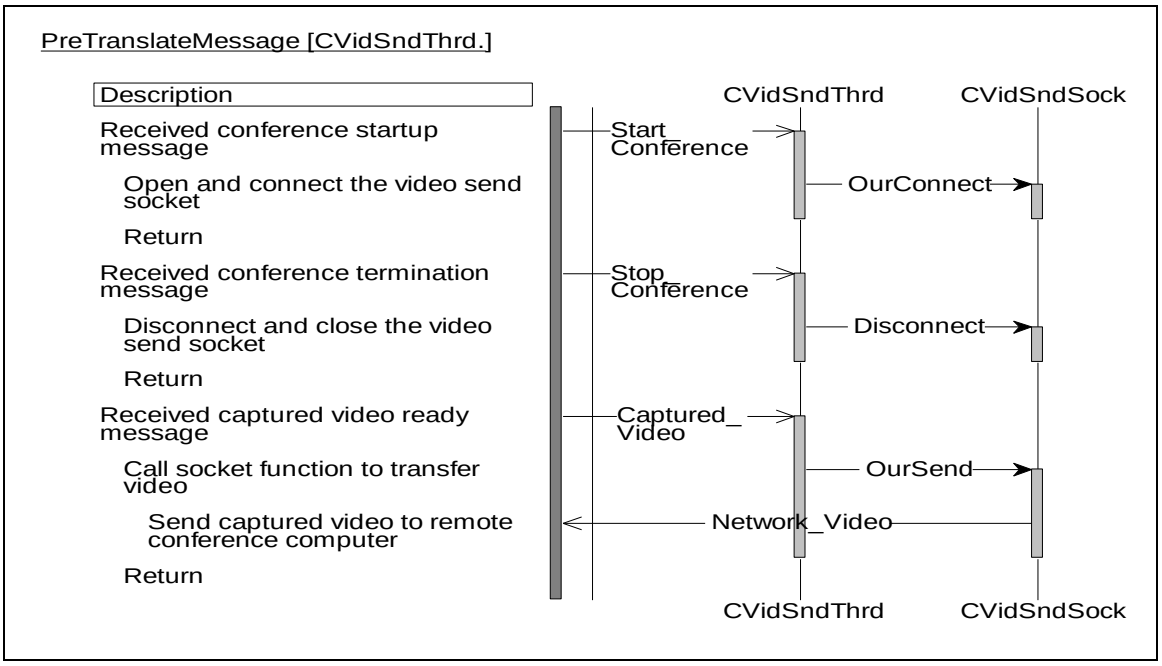


Figure 26. Video Send Thread Message Processing

7.5.10 Video Receive Thread Message Processing

The Video Receive Processing thread, responsible for receiving video from the remote conferencing node, operates asynchronously. It communicates with the other LifeLink threads using messages. Figure 27 illustrates the message processing sequences of the CVidRcvThrd::PreTranslateMessage operation, which is a part of the thread's message processing loop.

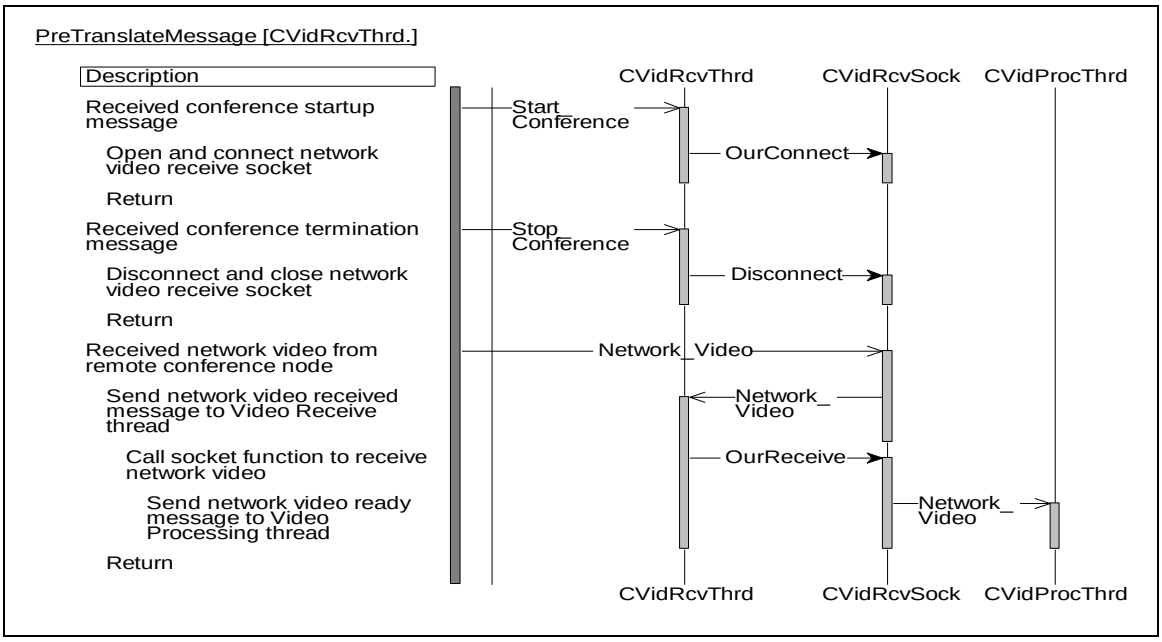


Figure 27. Video Receive Thread Message Processing

7.5.11 Vital Statistic Data Threads Processing

The transfer of medical vital statistic data between the ambulance and the hospital is accomplished using a pair of threads. One thread can be blocked reading data from the RS232 serial port, and the other can be blocked reading data from the network socket. Figure 28 illustrates the processing of the ReadPortThreadProc operation, and Figure 29 illustrates the processing of the ReadSocketThreadProc operation.

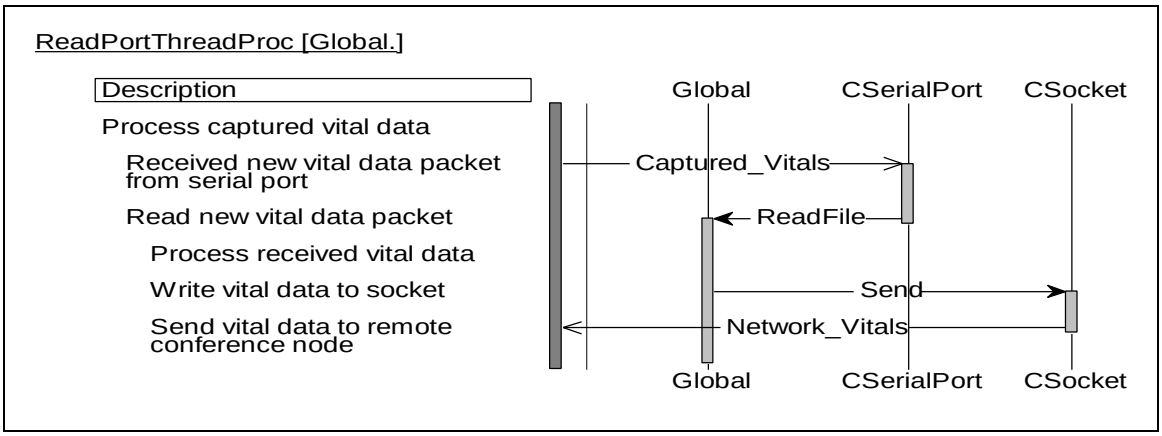


Figure 28. Serial Port Read Thread Processing

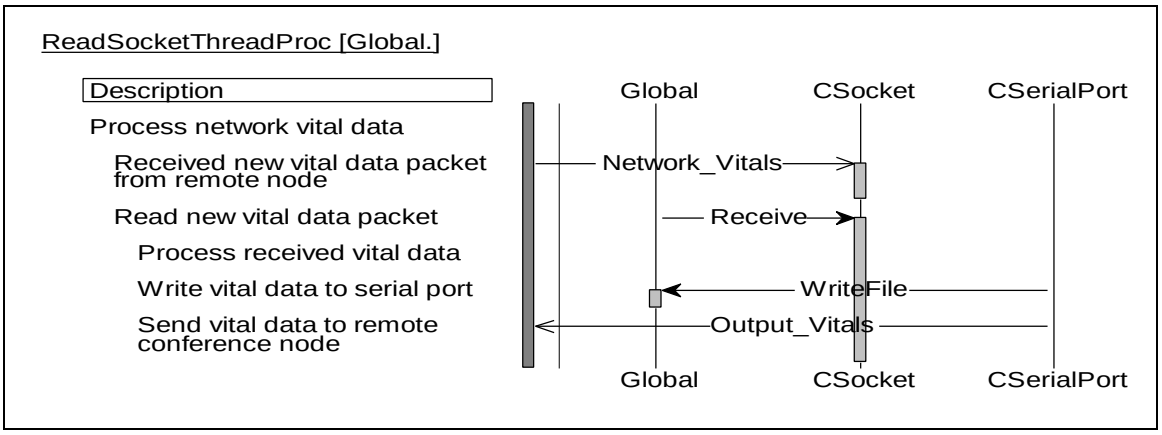


Figure 29. Socket Read Thread Processing

7.5.12 Command Socket Message Processing

The Command Socket is used to send messages to and receive messages from other computers in the network running the LifeLink application. Figure 30 illustrates the processing of messages received from a remote node.

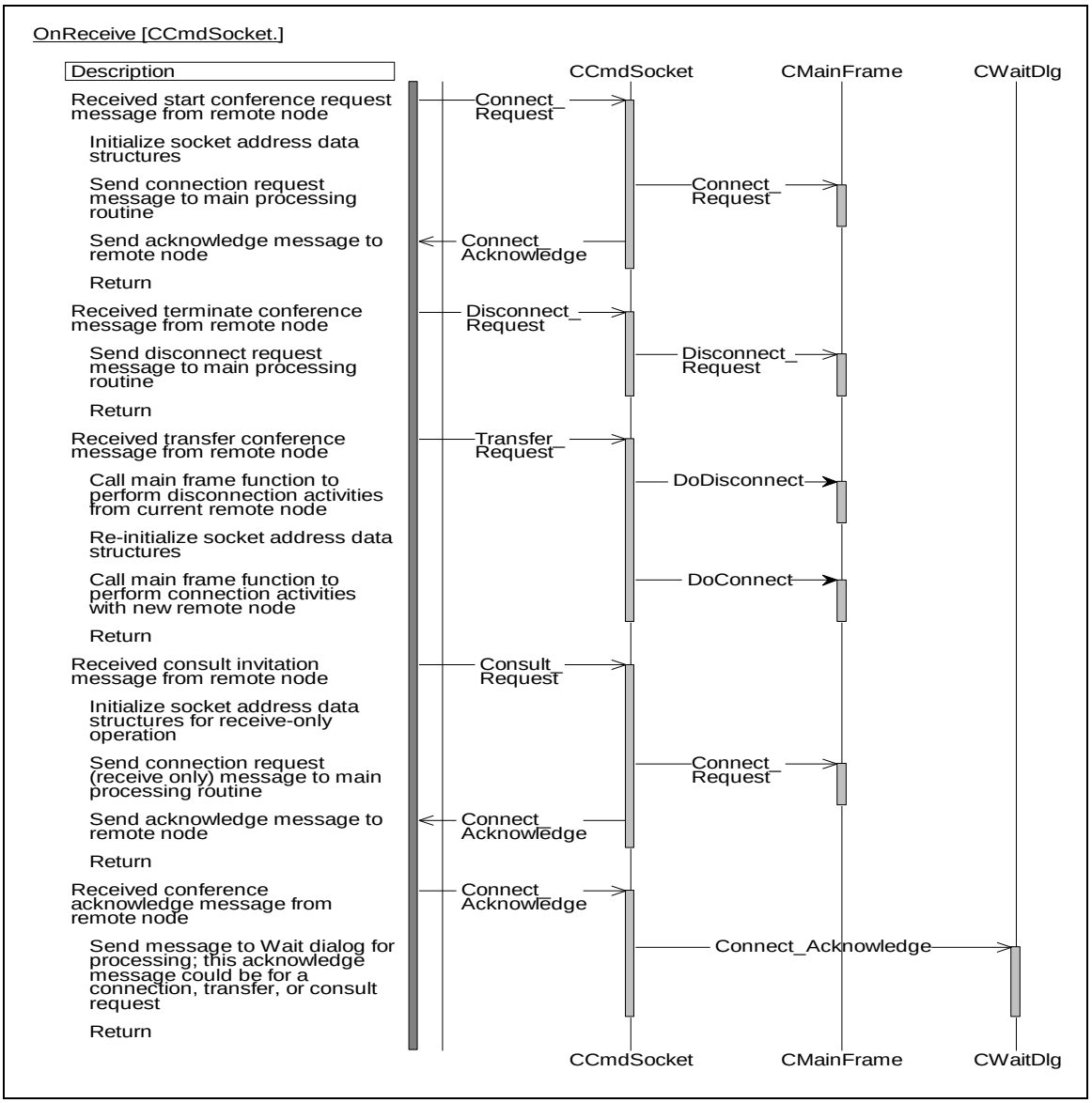


Figure 30. Command Socket Message Processing

8. Traceability Matrix

The traceability matrix for the LifeLink System is presented in this section. It lists the requirements of the system that were presented in Sections 2.0 through 6.0 of this document. Along with each requirement is the source of the requirement, the design element to which it was assigned to, the level at which it will be tested, and the method that will be used to verify the requirement. During development of the Acceptance Test Plan (ATP), sections of the test plan will be referenced to the TEST LEVEL column of this table to cross-reference to the ATP.

The requirements in the traceability matrix are organized by requirement number. Each requirement in the matrix has a unique requirement identification (ID) label that maps the particular requirement to a subsystem with the LifeLink System. The ID labels are defined as:

LL-GEN-XXX LifeLink General Requirement

LL-SYS-XXX LifeLink System Requirement

LL-AMB-XXX LifeLink Ambulance Subsystem Requirement

LL-FBH-XXX LifeLink Fiber Hub Subsystem Requirement

LL-TOC-XXX LifeLink TransGuide Operation Center (TOC) Subsystem Requirement

LL-HOS-XXX LifeLink Hospital Subsystem Requirement

REQUIREMENT ID	REQUIREMENT DESCRIPTION	PROPOSAL PARAGRAPH	DESIGN DOCUMENT PARAGRAPH
LL-GEN-001	The system shall provide an Ethernet communications network, two way audio and videoconferencing, and one way vital statistic data telemetry from an ambulance to a hospital node.	2.5.1	2.0
LL-GEN-002	One controlling hospital node can conference with one ambulance at a time.	2.5.1 (Derived)	2.0
LL-GEN-003	A full-duplex videoconferencing session with an ambulance may be transferred to another hospital.	2.5.1	2.0
LL-GEN-004	The system shall use optical fibers in the TransGuide infrastructure as the backbone of the communications system.	2.5.1 2.5.2.6.1 2.5.2.6.4	2.0
LL-GEN-005	The system shall support vital statistic data telemetry at a RS-232 serial link with a rate of 38.4 kbps between the ambulance and hospital involved in the conference simultaneously with a videoconferencing session.	2.5.1 2.5.2.6.5 (Derived)	2.0
LL-GEN-006	Additional hospital nodes may consult in a conference where the controlling hospital node directs the consult node to receive the audio and video from the ambulance.	(Derived)	2.0
LL-SYS-001	Each end of the videoconference shall provide a full-screen view of the received video with a smaller view containing the local image that is being transmitted.	2.5.1 (ref. change order)	2.0
LL-SYS-002	Each end of the videoconference shall provide a status window indicating the identity of the remote node.	2.5.1	2.0

REQUIREMENT ID	REQUIREMENT DESCRIPTION	PROPOSAL PARAGRAPH	DESIGN DOCUMENT PARAGRAPH
LL-SYS-003	The computer at each end of the videoconference shall be configured to perform automatic operating system startup and application startup.	2.5.2.4.1 (Derived)	2.0 3.3.1 6.2.1
LL-SYS-004	In the event of a temporary loss of communications, the system shall present a "frozen" image of the last good video presented to viewers which will prevail until the transient blockage is removed.	2.5.1 2.5.2.5	2.0
LL-SYS-005	The system shall use a wireless, spread spectrum communications channel for communication between ambulances and roadside fiber hub terminals.	2.5.1	2.0
LL-SYS-006	The system shall provide voice contact between the controlling physician and the ambulance LifeLink system operator via a single headset provided at each end of the videoconference.	2.5.1 2.5.2.6.3 2.5.2.6.5	2.0
LL-SYS-007	The system shall provide for use of standard Simple Network Management Protocol (SNMP) techniques for network management of all Ethernet configurable devices including spread spectrum radios from one central control node.	2.5.1	2.0
LL-SYS-008	The videoconference shall provide: A minimum resolution of CIF (352x240 pixels), Scalability to full screen, Display of the transmitted image, Operation within the radio bandwidth.	(derived)	2.0

REQUIREMENT ID	REQUIREMENT DESCRIPTION	PROPOSAL PARAGRAPH	DESIGN DOCUMENT PARAGRAPH
LL-SYS-009	If an ambulance initiates a conference while out of range of the radio communications network, the conference will automatically establish when the ambulance enters radio contact.	(derived)	3.3.3.1
LL-SYS-010	If an ambulance drives out of radio contact during a conference and re-enters radio contact within the timeout period, the conference will resume without ambulance system operator intervention.	(derived)	3.3.3.1
LL-SYS-011	If an ambulance drives out of radio contact during a conference and remains without radio contact for a time exceeding the timeout period, the conference will terminate without ambulance system operator intervention.	(derived)	3.3.3.1
LL-SYS-012	If a second ambulance attempts to initiate a videoconference with a hospital node which is already in a conference session, the system will notify both the hospital and the second ambulance. The second ambulance will continue to attempt connection, and a new videoconference session will start when the hospital terminates the existing videoconference.	(derived)	6.2.3
LL-AMB-001	The ambulance mobile communication link shall utilize a spread spectrum Ethernet bridge radio.	2.5.1 2.5.2.6.1 2.5.2.6.2	3.1.7
LL-AMB-002	The ambulance subsystem shall include an industrial computer.	2.5.2.6.2 (ref. change order)	3.1.1

REQUIREMENT ID	REQUIREMENT DESCRIPTION	PROPOSAL PARAGRAPH	DESIGN DOCUMENT PARAGRAPH
LL-AMB-003	The ambulance computer shall be able to provide necessary connections and ports for the videoconferencing system.	2.5.2.6.2	3.1.1.1
LL-AMB-004	The ambulance computer shall be able to provide a connection for the spread spectrum Ethernet bridge radio.	2.5.2.6.2	3.1.1.4
LL-AMB-005	The ambulance computer shall be able to provide necessary connections and ports for connection to vital statistic equipment.	2.5.2.6.2	3.1.1.2
LL-AMB-006	The ambulance subsystem shall provide a videoconferencing camera and lens capable of providing a video resolution matching or exceeding the capabilities of the videoconferencing codec.	2.5.2.6.2 (Derived)	3.1.2
LL-AMB-007	The ambulance subsystem shall provide a videoconferencing camera and lens able to provide a default field of view directed at the patient under transport.	2.5.2.6.2 (Derived)	3.1.2
LL-AMB-008	The ambulance subsystem shall include a headset containing a microphone and speaker which enable voice communications as part of the videoconferencing session.	2.5.2.6.2	3.1.6
LL-AMB-009	User interface to the LifeLink ambulance computer shall limit (to a practical extent) the actions required to originate or terminate a videoconferencing session.	2.5.1 2.5.2.6.2 (Derived)	3.3.3.1
LL-AMB-010	The ambulance subsystem shall include a power system interface capable of operation during ignition power.	(Derived)	3.2

REQUIREMENT ID	REQUIREMENT DESCRIPTION	PROPOSAL PARAGRAPH	DESIGN DOCUMENT PARAGRAPH
LL-AMB-011	The ambulance subsystem shall include a power system interface capable of providing momentary power when ignition power is lost.	(Derived)	3.2
LL-AMB-012	The ambulance subsystem shall include a power system interface with an emergency kill switch.	(Derived)	3.2
LL-AMB-013	The ambulance subsystem shall include a power system interface capable of alerting the computer of a loss of ambulance ignition power.	(Derived)	3.2
LL-FBH-001	The roadside fiber hub terminal subsystem shall include a spread spectrum Ethernet bridge located on each camera pole in an environmental box.	2.5.2.6.1.3	4.5
LL-FBH-002	The roadside fiber hub terminal subsystem shall provide network continuity between each TransGuide Fiber Hub and the TOC with WDM devices on the protect fiber pairs.	2.5.2.6.1.2	4.1
LL-FBH-003	The roadside fiber hub terminal subsystem shall use existing TransGuide camera poles and roadside fiber hub terminals.	2.5.2.6.1.3	4.0
LL-FBH-004	The roadside fiber hub subsystem shall provide a communications system capable of supporting data transmission between a radio registered to the subsystem radio and the TOC.	(derived)	4.0
LL-TOC-001	The TOC subsystem shall include a computer matching the following specifications: Provide capability to serve as the SNMP host.	2.5.1 2.5.2.6.1.4 (Derived)	5.5

REQUIREMENT ID	REQUIREMENT DESCRIPTION	PROPOSAL PARAGRAPH	DESIGN DOCUMENT PARAGRAPH
LL-TOC-002	The TOC subsystem shall include a computer matching the following specifications: Provide capability to serve as a videoconferencing node.	2.5.1 2.5.2.6.1.4 (Derived)	5.6
LL-TOC-003	The TOC subsystem shall provide a communications system capable of supporting the required Ethernet connectivity between the TOC and the respective hospitals.	2.5.2.6.1.4	5.4
LL-HOS-001	The hospital subsystem shall include one PC.	2.5.2.6.5	6.1
LL-HOS-002	The hospital PC shall provide necessary connections and ports for connection to fixed location vital statistic monitoring equipment.	2.5.2.6.5	6.1.1.2
LL-HOS-003	The hospital PC shall support 10BaseT Ethernet connectivity.	2.5.2.6.5	6.1.1.3
LL-HOS-004	The hospital PC shall provide unobstructed access to other LITC facility equipment or walkways.	2.5.2.6.5	6.0
LL-HOS-005	User interface to the LifeLink hospital computer shall limit (to a practical extent) the actions required to answer, transfer, or terminate a videoconferencing session.	2.5.1 (Derived)	6.2.2 6.2.3.2 6.2.3.3

APPENDIX A:
AMBULANCE SUBSYSTEM DOCUMENTATION

APPENDIX B:
VITAL STATISTIC DATA MONITORING EQUIPMENT

1.0 VITAL STATISTIC DATA MONITORING EQUIPMENT

The SAFD ambulances are normally equipped with some type of vital statistic monitoring equipment. The LifeLink System videoconferencing link includes a means for also transmitting this information to the hospital. Two different vital statistic monitoring systems are either currently being used by the SAFD or under evaluation. They are the ProPaq Encore and LifePak 11 systems. Although these units are not part of the LifeLink System, the Lifelink System does provide a transparent RS-232 serial telemetry link enabling the ambulance vital statistic monitoring equipment to transmit this information in real-time to compatible vital statistic data display equipment at the hospital. The LifeLink System does not perform any special processing of the transmitted data, but does provide one extended RS-232 link between onboard vital statistic equipment and the remote hospital display monitor. Power for this vital statistic monitoring equipment is not provided by the LifeLink System, since these are portable units with internal batteries. This capability enables the hospital personnel to review the data while the patient is en-route. The interface characteristics of the 2 vital signs instruments are summarized in the table shown below.

Interface Port Characteristic/Description	Physio Control LifePak 11 Defibrillator	Protocol Systems, Inc. ProPaq Encore
Supported Data Rate (bps)	300, 1200, 2400, 4800, 9600, 19200, and 38400	38400
Default Data Rate (bps)	38400, for direct connection 2400, for modem connection	Initial rate set at 19200, after communications link is established, data rate switches to 384001
Data Transfer Mode (Block or Continuos)	block mode	Continuous stream
Data Block Size (bytes)	129 (128 data + 1 checksum)	
Interface Standard Utilized	RS-232	RS-423
Data Format: bits per word, start bits, parity, stop bits	8bits per word, 1 start bit, No Parity, 1.5 stop bits	8bits per word, 1 start bit, No Parity, 1 stop bit
Connector Type	Circular 9 Pin Connector	RJ-12 Phone Jack Type 623
Electrical Isolation	No2	Yes
Handshaking Mode	ASCII Control Characters	No Hardware Handshaking
Transfer Initialization Mode	User Initiated Via Front Panel	RTS (Request To Send) Line Goes True

1 The standard Protocol ProPaq Encore system begins transmissions at 19.2 kbps and then switches to 38.4 kbps if both the transmitting and receiving devices can operate at the higher rate. In order for the ProPaq Encore to work with the LifeLink System, this feature must be disabled by the manufacturer. The LifeLink System requires that the ProPaq Encore transmission occur at a constant 38.4 kbps.

2 The Physio Control LifePak 11 Defibrillator does not guarantee electrical isolation when directly connected to the LifeLink System serial port connector. Therefore, for patient safety, a Black Box Model SP340A RS-232 Opto-Isolator module has been placed in the link between the vital statistic data monitor and ambulance computer RS-232 ports. This module must remain in place in order prevent possible injury to a patient connected to the ambulance vital statistic data monitor.

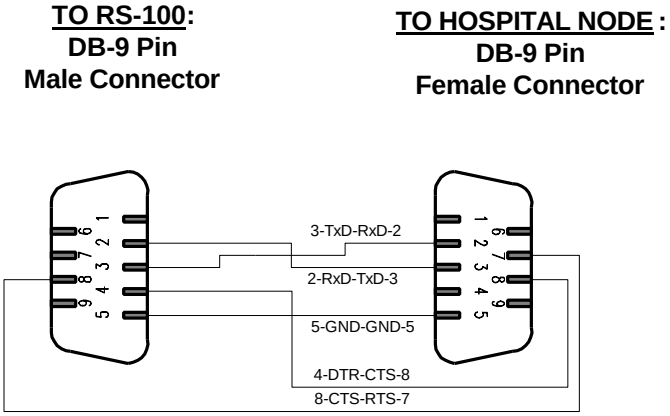
2.0 LIFEPAK 11

The SAFD is currently utilizing the Physio-Control LifePak 10 vital statistic monitoring equipment on some ambulances and is evaluating the next generation of Physio-Control vital signs equipment for use in their ambulances in the future. The next generation of vital signs equipment includes a LifePak 11 Diagnostic Cardiac Monitor and a remote RS-100 Receiving Station instrument. The LifePak 11 Diagnostic Cardiac Monitor is a portable, battery-powered instrument that can deliver defibrillation, synchronized cardioversion, or pacing therapies. It can be used as a stand-alone defibrillator but must be connected to a LifePak 11 Defibrillator/Pacemaker to deliver synchronized cardioversion and pacing. The LifePak 11 Defibrillator/Pacemaker provides isolated ECG delivered through the hard paddles or the defibrillation electrodes. The RS-100 Receiving Station is a portable battery powered unit that receives, prints, and stores ECG patient reports generated and transmitted from the LifePak 11 Diagnostic Cardiac Monitor.

The LifePak 11 Diagnostic Cardiac Monitor stores, prints, and transmits patient reports via telecommunications to a Physio-Control RS-100 Receiving Station. The LifePak 11 monitor has two communication interfaces which include an RJ-11 port for a direct dial-in connection to the Public Switch Telephone Network (PSTN) and an RS-232 port which is intended to connect to an external cellular modem, or directly to the RS-100 Receiving Station. The RS-232 port is configured for a modem-to-modem connect rate of 2.4 kbps to minimize modem handshake and connection time but can support a maximum of 38.4 kbps data rate when connecting to a Data Terminal Equipment (DTE), such as a personal computer (PC) or laptop computer. For operation with the LifeLink System, the LifePak 11 Diagnostic Cardiac Monitor RS-232 port must be configured to provide a 38.4 kbps data rate to the computer located in the ambulance. The RS-232 connector on the LifePak 11 is a 9-pin circular connector. Physio-Control part number 3005999-06 is required to connect the LifePak 11 Diagnostic Cardiac Monitor's RS-232 port to the LifeLink Signal Distribution Enclosure.

The RS-100 Receiving Station receives, prints, and stores patient reports via telecommunications with a LifePak 11 Diagnostic Cardiac Monitor. The RS-100 Receiving Station can also forward patient reports to another receiving station or an external mass storage device. Typically, the RS-100 can store up to 50 12-lead ECG reports or 30 recorded ECG reports. Printing of patient reports is performed via a thermal print-head recorder that provides a 100mm wide strip chart recording. Transmission of patient reports can be performed via an external modem, internal modem, or direct connection between a LifePak 11 Diagnostic Cardiac Monitor and an RS-100 Receiving Station. The RS-100 Receiving Station has two communication interfaces which include an RJ-11 port for a direct dial-in connection to the Public Switch Telephone Network (PSTN) and an RS-232 port which is intended to connect to an external cellular modem, or directly to a LifePak 11 Diagnostic Cardiac Monitor. The RS-232 port is configured for a modem-to-modem connect rate of 2.4 kbps data rate to minimize modem handshake and connection time but can support a maximum of 38.4 kbps data rate when connecting to a Data Terminal Equipment (DTE), such as a personal computer (PC) or laptop computer. For operation with the LifeLink System, the RS-232 port has been configured

to provide a 38.4 kbps data rate to the computer located in the hospital. The RS-232 connector on the RS-100 Receiving Station is a DB-9, 9-pin connector. The figure below shows the cable required to connect the RS-100 Receiving Station to the hospital computer RS-232 port.

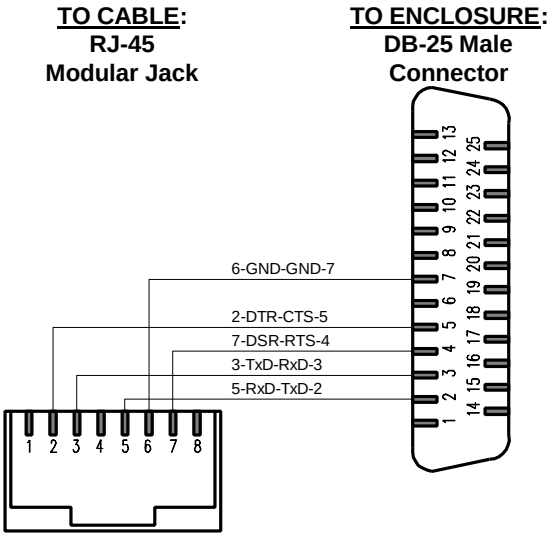


3.0 PROPAQ ENCORE

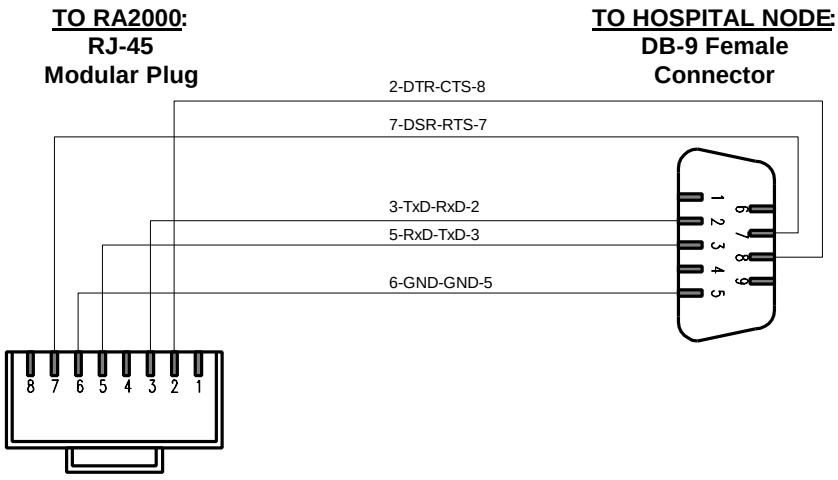
The SAFD plans to evaluate the Protocol Systems ProPaq vital statistic monitoring system as an alternative to the Physio-Control LifePak system that it currently uses. The ProPaq vital statistic monitoring system is composed of the ProPaq Encore 205EL diagnostic cardiac monitor and the Acuity Monitoring System. The ProPaq Encore is a multi-parameter vital signs monitoring instrument intended to provide monitoring of neonatal, pediatric, and adult patients in health care facilities, as well as intra- and inter-facility transport. The ProPaq Encore is configurable with heart/pulse rate, ECG, non-invasive blood pressure, invasive blood pressure (up to two channels), temperature, nellcor pulse oximetry, capnography, impedance respiration, and apnea. The Acuity Monitoring System is composed of a Sun Sparc workstation with monitor and keyboard for user entry, and the Remote Annex 2000 terminal server.

The ProPaq Encore provides a communications interface via an RS-423 port with an RJ-12 connector which is intended to connect to an RJ-45 port on a Remote Annex 2000 terminal server. The RJ-12 connector is a 6-pin telephone modular connector type 623. Several RJ-45 ports are available on the Remote Annex 2000 terminal server to support multiple ProPaq Encore units. The Remote Annex 2000 terminal server then connects to the Acuity Monitoring System which includes a Sun Sparc computer/workstation with monitor. The Acuity Monitoring System displays the patient vital signs data received from the various ProPaq Encore units. The Acuity Monitoring System monitors the Request-To-Send (RTS) signal level and when in an active state, marks the start of establishing communications with the ProPaq Encore. The normal connect rate between the Acuity Monitoring System and the ProPaq Encore starts at 19.2 kbps data rate, but since the ProPaq can support a 38.4 kbps data rate, the Acuity Monitoring System would normally switch to the higher data rate after the communications link has been established.

In order to enable the ProPaq Encore vital statistic data monitor system to work with the LifeLink System, SwRI had Protocol Systems to set the data rate at a constant 38.4 kbps. Protocol Systems part number 008-0110-01 Propaq Acuity Cord TIA568 is required to connect the Propaq Encore 206EL RS-423 port to the LifeLink Signal Distribution Enclosure. The figure below shows the adapter required to convert the RJ-45 end of the cable to a DB-25 male for connection to the LifeLink Signal Distribution Enclosure.



The Acuity Monitoring System includes a Sun Sparc workstation and a Remote Annex 2000 terminal server. The Remote Annex 2000 is a multi-port terminal server providing a central communications point for multiple ProPaq Encores or other vital signs equipment typically distributed throughout a hospital. The Acuity Monitoring System, which includes a 21" color monitor, provides a central control point from which to observe the various vital signs data collected from the remote ProPaq Encore diagnostic cardiac monitors. The hospital computer connects to an RJ-45 serial port on the Remote Annex 2000 terminal server and supports a 38.4 kbps data rate as required. The figure below shows the cable required to connect the Remote Annex 2000 terminal server to the hospital computer RS-232 port.


TO RA2000:
RJ-45
Modular Plug
TO HOSPITAL NODE:
DB-9 Female
Connector
2-DTR-CTS-8
7-DSR-RTS-7
3-TxD-RxD-2
5-RxD-TxD-3
6-GND-GND-5
8 7 6 5 4 3 2 1
1 2 3 4 5
6 7 8 9

APPENDIX C:
ROADSIDE FIBER HUB SUBSYSTEM DOCUMENTATION

APPENDIX D:
TOC SUBSYSTEM DOCUMENTATION