

WHITE PAPER:

A New Alternative to Video Transmission Over Ethernet For Industrial Security Applications

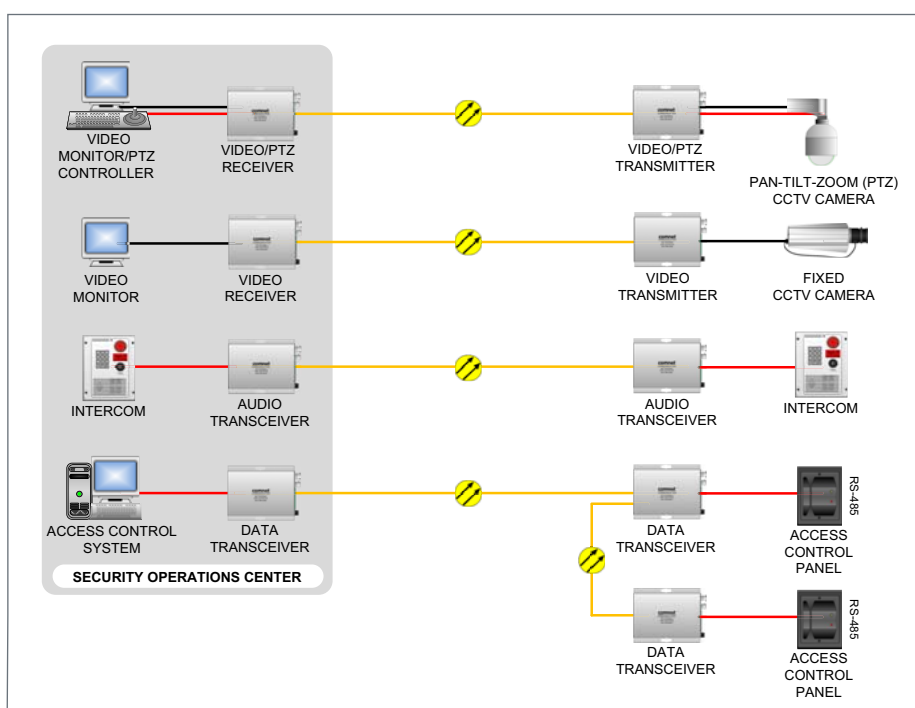
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A New Alternative to Video Transmission Over Ethernet For Industrial Security Applications

The industrial security market has been witnessing the gradual transition to video, audio, and data transmission over Ethernet since the beginning of this decade. This change has impacted numerous other markets as well, including the transportation, factory automation/industrial control, and utility/electric power transmission and distribution markets. Prior to the introduction of video over IP (or Internet Protocol), a separate network of analog or digitally encoded video was typically utilized for hauling the video from the edge of the network back to the monitoring location. Audio for telephony or a communications intercom system; RS-232, RS-422, or RS-485 serial data, commonly used for CCTV camera pan-tilt-zoom (PTZ) control or the card access element of the system, was transmitted from the field devices back to the control center on other dedicated and parallel networks (*see figure 1*). The transmission media of choice was usually optical fiber for reasons of robustness and bandwidth.

*Figure 1 –
Classical Video, Data &
Audio Parallel Network*

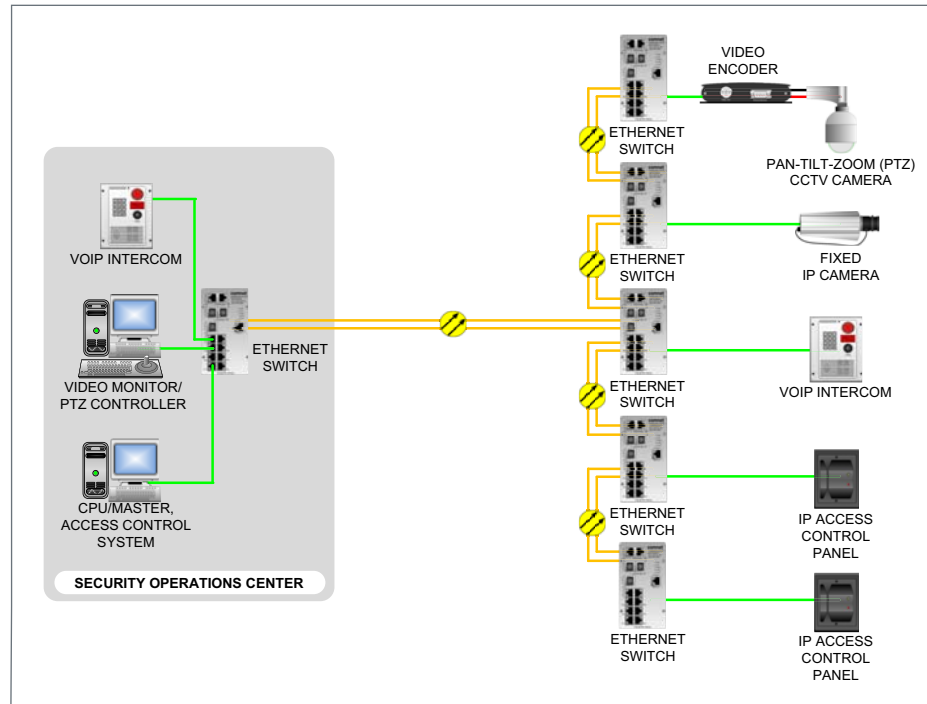


These technologies and system design approaches are still very viable solutions for hauling high-quality, full-motion video, audio, and data, and when optical fiber is employed as the communications media, extremely long transmission distances and electrically noisy environments are easily accommodated.

The difficulty of installing and maintaining two or more parallel and technically diverse networks, one for video, one for audio, and another for serial or other data, has motivated many users to consider the use of Ethernet as their preferred communications networking system. The relative ease of integration of the key components of the system onto a common platform has largely made Ethernet the networking solution of choice in the many markets, including the industrial security market.

With the advent of Ethernet, it now became practical and cost-effective to consolidate the video, audio, and data elements of a security communications subsystem onto a single network (*see figure 2*). Although in theory this should be the ideal platform for the typical local or wide area communications network utilized for industrial security and other surveillance applications, in practice several key and recurring issues are frequently encountered by the systems integrator and end-user responsible for the installation, maintenance, and operation of the system.

*Figure 2 –
Ethernet-Based Linear
Insert & Repeat Network*



When analog video is to be deployed onto the network, a video encoder is required to convert the camera video output into an electrical signal that is compatible with transmission over an Ethernet-based network. These encoders employ signal compression technology to reduce the bandwidth occupied by the video, so as to increase the number of potential video, audio, or data signals that may share the finite bandwidth available on the network. Present video compression standards include MPEG-2, MPEG-4 and H.264, with MPEG-4 currently most widely used. The H.264 standard is newer and offers the advantage of enhanced video quality with the benefit of reduced bandwidth. MPEG-2 was originally developed for use by the commercial television broadcast industry, and although capable of superb video quality, its bandwidth requirements are large. As such, it has not been widely accepted for use within those communications networks employing Ethernet. Regardless of the compression standard utilized, hardware decoders or decoding software compatible with the encoded video are required for viewing the video.

One major issue involves the relative lack of MPEG-4 or H.264 video encoders that are environmentally hardened when these devices are installed in an out-of-plant operating environment. In this kind of environment, issues such as ambient operating temperature, voltage transient protection, vibration, mechanical shock, and humidity with condensation must be considered to ensure that the video encoders or other field equipment are capable of providing long-term reliability and stable performance. The market is full of suppliers that build quality encoders designed for deployment in benign, conditioned operating environments, such as when the equipment is fielded in an adequately heated and cooled communications equipment room. However, those manufacturers that build hardware capable of withstanding the extended operating temperature range, humidity with condensation, and electrical voltage transients and noise encountered in an outdoor or out-of-plant environment are few and far between, and the equipment is costly as a result.

The MPEG-4 and H.264 video compression standards are suitable for transmission over Ethernet. As these standards rely upon video compression, the video in these standards is not transmitted in real time, and exhibits a certain amount of latency depending upon the compression standard utilized. Some users may encounter potential legal issues with video transmission systems that are not real-time. Other users may have operator issues with the time lag or delay between executing a pan-tilt-zoom command, and the actual execution of the command as viewed on the CCTV monitor.

Full-motion 30 frames per second true broadcast-quality video with zero latency is not achievable considering the current state of Ethernet-based systems, and significant system bandwidth is required to achieve acceptable video quality. The high system bandwidth requirement imposed by the video ultimately limits the total number of video

channels and other signal sources that may be inserted onto the Ethernet platform. Many end-users have been disappointed with the video quality of their video-over-Ethernet system, especially when the video is viewed on highly revealing wall monitors. In addition, some video surveillance or monitoring applications mandate the use of high-resolution cameras, and much of the resolution provided by these cameras may be lost when the video is compressed to MPEG-4 or H.264 and inserted onto the network.

Although Ethernet is based upon the industry accepted IEEE 802.3 standard, and in theory any manufacturer's Ethernet equipment should be completely interoperable with any other manufacturer's equipment, in practice this is very frequently not the case. Interoperability issues require the involvement of a trained IT professional to resolve, and in some cases, resolution is not possible. Trained IT or technical personnel are required for the initial installation, set-up, and long-term maintenance of the system, and the long-term cost associated with this are obvious, and frequently not within the budget of many users. They must be considered as part of the overall life-cycle cost of owning and operating the system.

In response to these issues, ComNet Communications Networks recently introduced a new and unique approach to a common platform for the transmission of high-quality video and data over conventional fiber optic-based networks. This product line, identified as FVT/FVR-SHR, allows the user to insert up to eight independent video and eight independent data channels on one optical fiber in either a self-healing ring or linear insert-and-repeat topology. Depending upon the equipment selected, the following system configurations may be created:

- A) A single channel of analog full-motion 30 frames-per-second video and one serial data channel may be inserted at a given field node and repeated back to the central monitoring location.
- B) Four channels of analog full-motion 30 frames-per-second video and four serial data channels may be inserted at a given field node and repeated back to the central monitoring location.
- C) Four channels of analog full-motion 30 frames-per-second video only may be inserted at a given field node and repeated back to the central monitoring location. No serial data channel transmission capability is provided in this variant of the equipment.
- D) Eight channels of analog full-motion 30 frames-per-second video and eight serial data channels may be inserted at a given field node and repeated back to the central monitoring location.
- E) Eight channels of analog full-motion 30 frames-per-second video channels may be inserted at a given field node and repeated back to the central monitoring location. No serial data channel transmission capability is provided in this variant of the equipment.

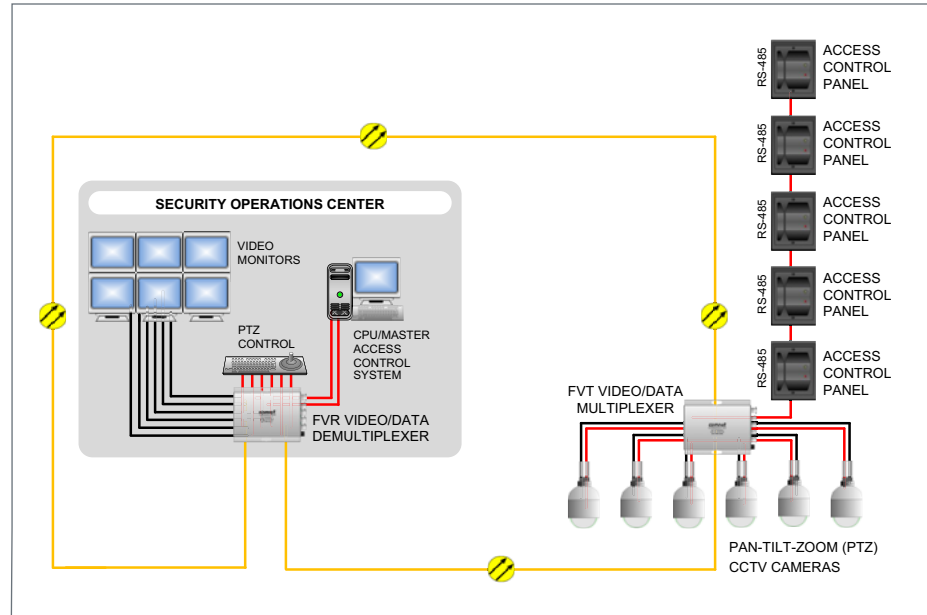
Alternately, any combination of field devices may be used to haul a maximum of eight video channels and eight serial data channels back to the central monitoring center. For example, (one) four-channel field device and up to four single-channel field devices may be optically connected to haul a total of eight video and eight serial data channels back to the monitoring center.

Although the system in the current product offering is input-limited to a maximum of eight video channels and 8 data channels, there is essentially no limit as to the number of de-multiplexers that may be inserted anywhere within the network. As such, video outputs may be dropped anywhere the user wants to monitor the video, satisfying the frequent requirement that multiple users have access to the video and camera PTZ control function.

At the video monitoring locations, up to 8 simultaneous video outputs and up to 8 full-duplex serial data channels are available. The serial data channels may be used for CCTV pan-tilt-zoom (PTZ) control, or any other terminal or communications device or application utilizing RS-232/RS-422, or 2 or 4-wire RS-485 data, such as a card access system, etc.

The system may also be utilized as an optically redundant point-to-point 8-channel video and 8-channel serial data multiplexer/de-multiplexer system. In this topology, two optical fibers are required; one optical fiber is utilized as the primary transmission path, and the other or alternate fiber provides a redundant or secondary optical path in the event

*Figure 3 –
Optically Redundant Point-to-Point 8
Channel Video and 8 Channel Serial Data
Multiplexer/De-multiplexer System*



that the primary optical path is severed or lost (*see figure 3*). This is ideal for those applications requiring a very high level of communications reliability and availability.

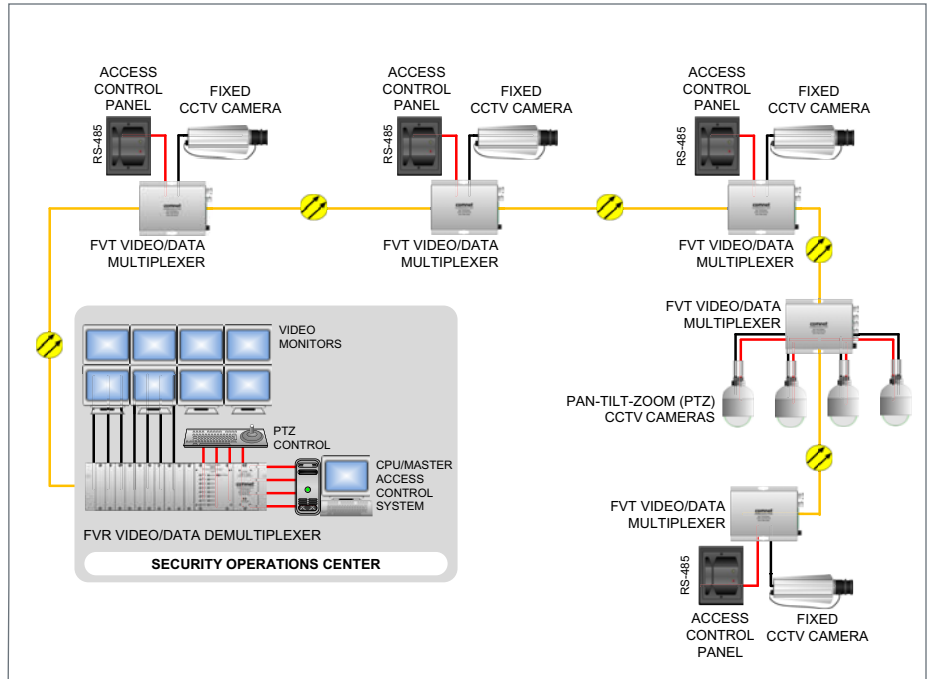
Either linear insert-and-repeat/daisy-chain or self-healing ring topologies are supported with multimode or single mode fiber (*see figures 4 & 5*). In contrast to the majority of self-healing ring communications systems that rely upon two optical fibers for fault-tolerance and redundant operation, by using wave division multiplexing technology (WDM), the ComNet system utilizes only one optical fiber, thereby reducing the installed cost of the system as well as reducing the complexity of the cable plant. Transmission distances between field nodes of up to 2 km are supported with multimode optical fiber, and transmission distances between nodes of up to 55 km are supported with single mode optical fiber, making the system ideal for monitoring applications where considerable distances may exist between cameras or other potential surveillance and security-related locations. Such long transmission distances are frequently encountered when petrochemical pipeline or electrical substation monitoring and surveillance are required.

The video performance exceeds the requirements of EIA/TIA Standard RS-250C for Medium-Haul Transmission performance, although the crucial signal-to-noise ratio (SNR) parameter is better than 67 dB and is consistent with broadcast-standard RS-250C for Short-Haul performance. As such, the system is capable of providing performance that is essentially equivalent to true broadcast quality video, with none of the fatiguing artifacts, latency, or less-than-ideal video quality that may plague MPEG-4 or H.264 compressed video. SNR is the most significant figure of merit in terms of qualitatively and quantitatively evaluating and rating the performance of a video transmission system, regardless of the transmission media used.

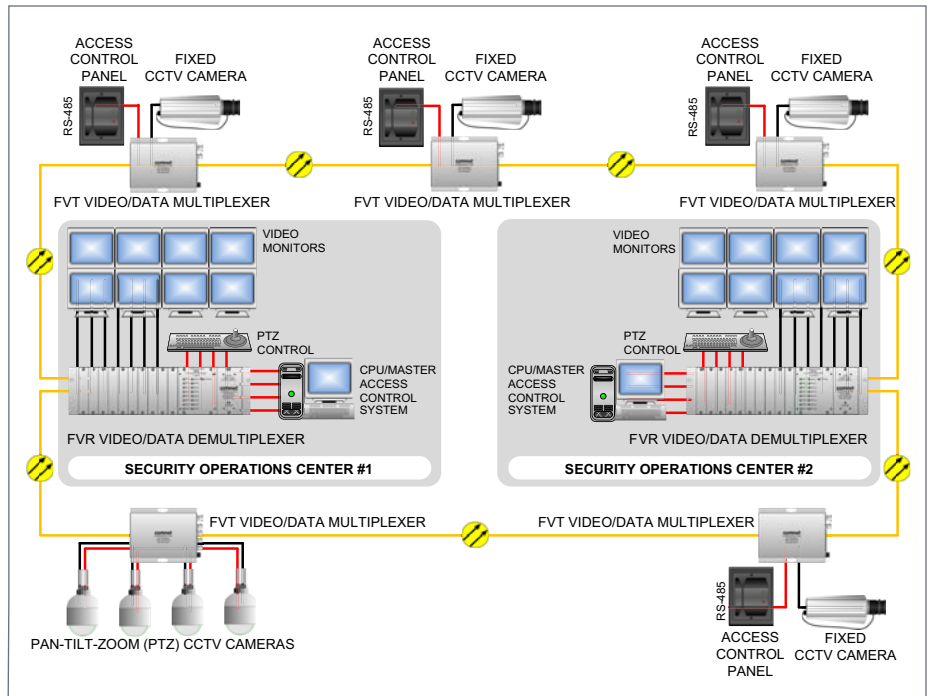
The small form factor of the multiplexer or de-multiplexer units allows shelf mounting in field equipment cabinets where the amount of real estate allocated to the communications or other equipment may be limited. When installed in a ComNet card cage unit, the equipment may be directly mounted in any standard 19-inch equipment rack.

These multiplexers and de-multiplexers are environmentally ruggedized for direct deployment in unconditioned out-of-plant environments as typically encountered in many industrial security, transportation, and utility installations. A commonly utilized and accepted industrial specification for defining the environmental requirements for out-of-plant installations is NEMA TS-1/TS-2, and the ComNet FVT/FVR-SHR product is fully compliant with this specification. The ambient operating temperature range is -37 to +74 degrees C, and the equipment is fully protected against voltage surges and transients on the power and signal rails. The maximum humidity specification is 95% with condensation, when provided with the conformal coating option.

**Figure 4 –
Linear Insert & Repeat Network
Utilizing FVT/FVR Video/Data
Multiplexers & De-multiplexers**



**Figure 5 –
Self-Healing Ring Network
Utilizing FVT/FVR Video/Data
Multiplexers & De-multiplexers**



The previous generation of video insert-and-repeat equipment employed an all analog-based technology known as Frequency Division Multiplexing, or FDM. In an FDM-based system, laborious calculations were required by the user to ascertain the actual multiplexer and de-multiplexer hardware requirements based upon the desired signal-to-noise ratio, the number of video inserts and drops, the video channel count to be transported, the transmission distance between nodes, and so forth. The ComNet FVT/FVR-SHR series utilizes an all-digital, Time Division Multiplexing (TDM) design approach that eliminates any user computations, and provides for zero video degradation regardless of the number of video inserts, video channels, or video drops within the system. It is a true plug-and-play solution. 10-bit digital video encoding is provided for the best video quality attainable, making truly transparent transmission possible. The system video inputs and outputs are standard NTSC/PAL/SECAM composite/baseband video, allowing the FVT/FVR-SHR equipment to be directly used with any analog-based CCTV equipment available worldwide.

The need for difficult-to-source and costly environmentally-hardened video encoders and related video decoding hardware or software is completely eliminated, along with the need for hardened Ethernet managed switches. The uncompressed video is transmitted in real-time with zero latency. The deployed cost advantage of the ComNet system becomes immediately apparent, and when compared to traditional Ethernet video/data insert-and-repeat networks, the ComNet FVT/FVR-SHR system offers considerably simpler ease of installation and system integration. Unlike Ethernet-based networks, trained IT or technical personnel are not required for the installation or maintenance of this system, reducing the initial installation cost as well as the life-cycle cost. Relatively non-technical personnel easily handle the integration and long-term maintenance of the equipment. Since the video encoders, managed switches, and other Ethernet-related hardware are eliminated, the overall reliability and simplicity of the system are significantly enhanced.

Several industrial security users have recently considered a change in their system architecture, due in large part to the relative scarcity and high cost of field-hardened MPEG-4 and H.264 video encoding equipment. Instead of deploying hardened video encoders collocated with the CCTV cameras at the edge of the network, the ComNet FVT/FVR-SHR multiplexing equipment is installed at the very edge of the network, at the CCTV camera locations. The video is hauled back from the field on one optical fiber in either an optical self-healing ring for high system reliability, or an optical linear insert-and-repeat configuration, to an environmentally-conditioned hub location, thereby allowing the use of non-hardened, inexpensive, and widely available video encoders. The output from these encoders is then inserted onto the Ethernet network in the conventional manner. Inexpensive, non-hardened terminal servers would be used for converting the CCTV camera pan-tilt-zoom control serial data to Ethernet, also for insertion onto the network.

The FVT/FVR-SHR may also be utilized as an inexpensive yet extremely high quality optical backbone. In this approach, the video and control data from distant CCTV cameras are connected through conventional point-to-point fiber optic transmission links. These links terminate at those locations where the FVT/FVR-SHR video multiplexers are installed, and the video and data are then inserted onto an Ethernet network in the scenario described above, or hauled directly back to the security management center for monitoring and control.

Summary

The difficulty of installing and maintaining two or more parallel and technically diverse networks, one for video, one for audio, and the other for serial or other data, has motivated many users to consider the use of Ethernet as their preferred communications networking system. The relative ease of system integration of the key components of the system onto a common platform has largely made Ethernet the networking system of choice. Although Ethernet is based upon the industry accepted IEEE 802.3 standard, and therefore in theory any manufacturers' Ethernet equipment should be completely interoperable with any other manufacturers' equipment, in practice this is very frequently not the case. Interoperability issues require the involvement of a trained IT professional to resolve, and in some cases, resolution is not possible. Trained IT or technical personnel are required for the initial installation, set-up, and long-term maintenance of the system, and the long-term costs associated with this are obvious, and frequently not within the budget of many users. They must be considered as part of the overall life-cycle cost of owning and operating the system. When analog video is to be deployed on to the network, a video encoder is required to convert the camera video output into an electrical signal that is compatible with transmission over an Ethernet-based network. Hardware decoders or decoding software compatible with the encoded video are required for viewing the video.

In response to these issues, ComNet is offering a new and unique approach of a common platform for the transmission of high-quality video and data over conventional fiber optic-based networks. Up to eight independent video and eight independent serial data channels may be inserted onto one optical fiber in either a self-healing ring or linear drop-and-repeat topology. 32 video and 32 data channel capability is currently at a high level of development and will be available to market in the near-term. Unlike Ethernet-based systems, trained IT or technical personnel are not required for the installation or maintenance of this system, reducing the initial installation cost as well as the life-cycle cost of the system. True plug-and-play installation and operation now becomes possible with equipment that occupies only a small footprint, facilitating those installations where space is at a premium. Relatively non-technical personnel can easily handle the integration and installation of the equipment. Since the video encoders, decoders or decoding software, managed switches, and other Ethernet-related hardware are all eliminated, the overall reliability and simplicity of the system are significantly enhanced.



ComNet offers an extensive line of environmentally hardened fiber optic video and data transmission equipment as well as a line of Ethernet networking equipment that is uniquely designed to meet the needs of the Industrial Security, Intelligent Transportation, and industrial control markets.

Berman is responsible for directing and promoting the application of ComNet products in markets that can benefit from their use. In many cases he educates System Designers and customers on all levels about the benefits that ComNet products and technology bring to their projects. Bruce Berman has a Bachelor's Degree in Communications from the State University of New York at Geneseo.