

Hazmat Cam Wireless Video System

2006 Sharing Solutions for Emergencies and Hazardous Environments

Kevin L. Young

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Hazmat Cam Wireless Video System

Kevin L. Young

Idaho National Laboratory, 2525 Fremont Ave/MS 3840, Idaho Falls, ID 83415-3840, KevinL.Young@INL.GOV

Abstract – *This paper describes the Hazmat Cam Wireless Video System and its application to emergency response involving chemical, biological or radiological contamination. The Idaho National Laboratory designed the Hazmat Cam Wireless Video System to assist the National Guard Weapons of Mass Destruction - Civil Support Teams during their mission of emergency response to incidents involving weapons of mass destruction. The lightweight, handheld camera transmits encrypted, real-time video from inside a contaminated area, or hot-zone, to a command post located a safe distance away. The system includes a small wireless video camera, a true-diversity receiver, viewing console, and an optional extension link that allows the command post to be placed up to five miles from danger. It can be fully deployed by one person in a standalone configuration in less than 10 minutes. The complete system is battery powered. Each rechargeable camera battery powers the camera for 3 hours with the receiver and video monitor battery lasting 22 hours on a single charge. The camera transmits encrypted, low frequency analog video signals to a true-diversity receiver with three antennas. This unique combination of encryption and transmission technologies delivers encrypted, interference-free images to the command post under conditions where other wireless systems fail. The lightweight camera is completely waterproof for quick and easy decontamination after use. The Hazmat Cam Wireless Video System is currently being used by several National Guard Teams, the US Army, and by fire fighters. The system has been proven to greatly enhance situational awareness during the crucial, initial phase of a hazardous response allowing commanders to make better, faster, safer decisions.*

I. INTRODUCTION

Terrorism, major accidents and natural disasters throughout the world present emergency responders with unimaginable challenges. Because chemical, biological or radiological weapons of mass destruction may be involved, or dangerous conditions may persist, access to an incident "hot zone" is severely limited by prudent safety concerns. Trained emergency responders usually enter the dangerous area alone with only limited voice communications back to the incident commander and other terrorism experts.

Now, wireless video puts these support teams on the scene. The Hazmat Cam Wireless Video System (commercialized under the name Visual First Responder - VFR™) sends secure, real-time video images from emergency responders in the hot zone to a command post a safe distance away.

Real-time video during a hazardous response increases responder safety, reduces the number of entries into a dangerous area and shortens the time needed to safely resolve a hazardous situation. Real-time video enhances the ability to get the job done because there is less chance of a communications mistake between the emergency responders and the incident commander.

Incident commanders can request a closer look at objects of interest, read labels on containers and peer into spaces inaccessible to recon team eyes. By using the

camera to look around corners or through doorways or windows, the commander can assess potential risks to recon teams before they enter the space being observed.

In early 2001, the National Guard expressed to the Idaho National Laboratory (INL) the need for a wireless video system capable of performing under their unique mission requirements. The hand-held camera needed to be rugged, light, waterproof, and capable of transmitting an encrypted video signal out of a variety of building structures.

At the time, existing wireless video systems for HAZMAT response teams suffered from degraded picture quality while the camera was in motion, a lack of adequate transmission range, were heavy to carry, and did not have video encryption. The rapidly developed INL Hazmat Cam Wireless Video System, or more simply Hazmat Cam, overcomes or greatly reduces each of these problem areas and is described in detail below.

II. SYSTEM DESCRIPTION

The Hazmat Cam Wireless Video System is the *first* wireless video system incorporating encrypted video, 900 MHz transmit frequency, waterproof camera housing, and a triple-antenna true-diversity receiver. The system, without repeater, is shown in Figure 1.

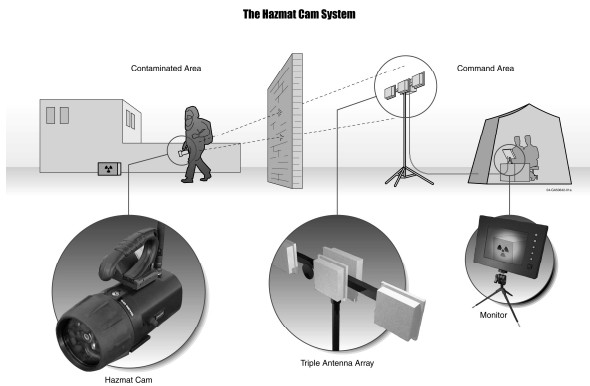


Figure 1 - The Hazmat Cam Wireless Video System

The camera transmits at 250 mW providing a transmission range of 2,200 feet line-of-site to the triple-antenna true-diversity receiver. At the receiver, the signal is decoded and displayed on the included 6.4 inch LCD field monitor or any monitor capable of displaying a composite video signal. The video output could be simultaneously recorded to VHS tape, Video CD, DVD, etc. and, if an Internet connection is available, viewed real-time from anywhere in the world. Access through the Internet is controlled through username and password login.

The original system design includes an optional transmitter-receiver pair called the Extension Link. This repeater increases the transmission range to five miles line-of-site and allows the signal to be routed around signal blocking structures such as large liquid storage tanks.

II.A. Better Image Resolution and Low-Light Capabilities

The Hazmat Cam imaging sensor is based on a Sony charge-coupled device (CCD) array with a resolution of 480 lines – comparable to broadcast quality. The high resolution and the camera's wide-angle 36 mm lens keep objects in focus from infinity to as close as two inches, allowing viewers to see an entire room and then move in close to read inspection tags on fire extinguishers or labels on solvent containers.

With a very low LUX value of 0.5, the camera performs well in most lighting conditions, from bright to relatively dim. It has a clip-on flashlight to illuminate dark areas and under or behind objects of interest. A built-in, pulsed, red laser pointer helps users aim the camera to view specific objects or indicate an object of interest to command post observers.

II.B. Lower Transmit Frequency for Better Signal Penetration Through Structures

The Hazmat Cam transmits a frequency modulated (FM) analog video signals at 900 MHz rather than 2.4 GHz used by competitive products because lower frequency signals pass through structural objects, such as building walls, better than high frequency signals for a given transmit power. This capability is depicted in Figure 2.

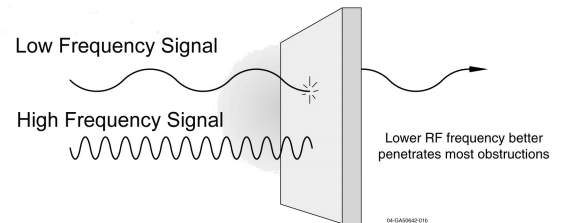


Figure 2 - Low Frequency Signals Penetrates Objects Better Than High Frequency Signals

II.C. Video Encryption for Secure Communications

A primary design requirement for developing the Hazmat Cam was video encryption. The Hazmat Cam employs law enforcement grade video encryption. The encoder and decoder pair, known as the MicroView Lock II, is made by the English company, Ovation. The encryption system uses full cut-and-rotate scrambling for every line of video. The encoder's small package size made it easy to add to the camera design. Figure 3 shows the encryption device installed on the Hazmat Cam circuit board.

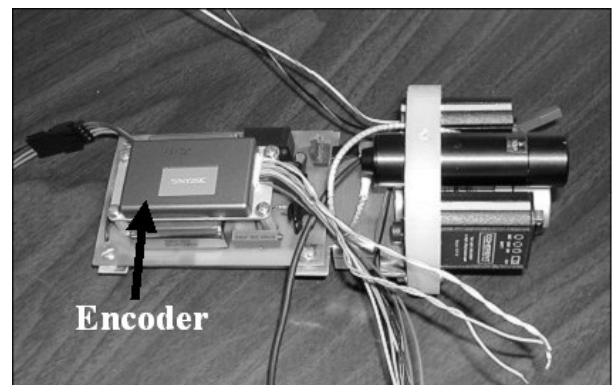


Figure 3 - Hazmat Cam Encoder Module

Only the properly paired decoder located on the output of the true-diversity receiver can interpret and display the transmitted video signal. It keeps unauthorized people from intercepting and viewing

transmitted images. This could be critically important in a terrorist incident where two bombs have been planted. If the terrorists intercepted video images from the emergency responders they would know when to detonate the second bomb to inflict the most damage. Also, police or military want crime, terror or disaster scenes secure and do not want live video from the scene intercepted and broadcast to the public. This doesn't mean, however, that the transmission can't be shared among cooperating agencies. Agencies on the scene with properly keyed decoders can all receive the same video transmission. The encryption system can be bypassed for situations where encryption is not required or desired making it easier to share the transmitted signal.

II.D. Rugged and Waterproof Design

The Hazmat Cam components are housed in a lightweight, waterproof and durable ABS plastic dive flashlight housing with a lantern grip made by Underwater Kinetics. With rechargeable lithium ion batteries, the entire package weighs only 2.75 pounds. Figure 4 shows a block diagram of all the major camera system components.

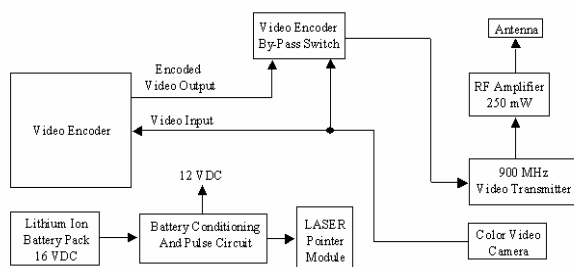


Figure 4 - Camera System Block Diagram

The lantern-style grip improves system ergonomics while the built-in pulsed laser instantly tells the operator where the camera is pointed. A standard tripod mount allows the completely self-contained camera/transmitter to be positioned unattended and continue to send video images while the operator leaves the area or attends to other matters.

The camera design is extremely durable and shock resistant – all critical components are mounted on a 1/2-inch thick low-density polyethylene disk integrated into the housing. With a proprietary circuit card to extend battery life, the camera has an expected runtime of 3 hours with the laser pointer on, and 6 hours with the included extra set of batteries, more than enough time for most emergency responder reconnaissance activities.

II.E. True-Diversity Reception

Wireless video systems often suffer from "rolling" and distorted images caused by video signals reflecting off of objects. This typically causes ghost images, flopping, or shaky pictures. This interference is due to signal multipathing -- when the signal interferes with itself after bouncing off structures, buildings, file cabinets, even people – on its way to the receiver. Because users of any handheld wireless camera are constantly moving, the problem is compounded.

The Hazmat Cam Wireless Video System uses a true-diversity receiver to greatly minimize the effects of multipathing. Instead of one receiving antenna, the Hazmat Cam's true-diversity receiver uses three. Three eight dB gain patch antennas are mounted horizontally on a T-bar approximately 75 cm apart. Each antenna is scanned 1,000 times a second by the receiver so the system can choose from a true diversity of signals and lock onto the strongest one. As the handheld camera is moved around, the transmitted signal in front of one antenna may drop out due to multipathing. When this happens, the true-diversity receiver simply switches to one of the other two antennas. This switch occurs seamlessly to the viewer. Figure 5 is a graphical representation of how a true-diversity receiver minimizes the effects of multipathing.

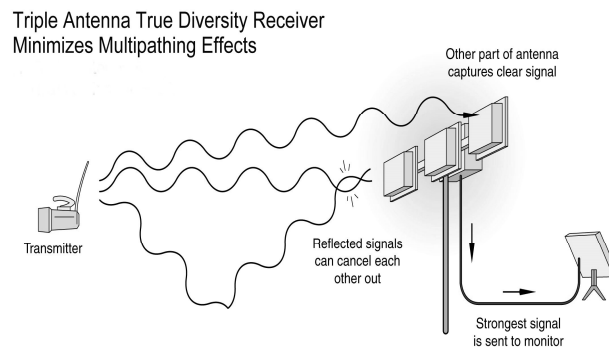


Figure 5 - The Effects of Multipathing are Minimized by a True-Diversity Receiver

This is a key technology when working with a mobile transmitter in a field of reflective objects. Compared to single-antenna receivers, the Hazmat Cam triple-antenna, true-diversity receiver allows the command post to be located further from the hot zone in real-world situations for safer and more secure operations.

Tested in demanding circumstances, the Hazmat Cam has provided high-quality video from steel office building basements, inside a closed steel shipping container, deep in a West Virginia tunnel, below decks on a 150-ft fishing

vessel at a Seattle pier, and within the concrete rubble of a collapsed building training facility in Oklahoma City.

II.F. Hazmat Cam In Use Today

In November of 2003, the Hazmat Cam Wireless Video System was licensed to View Systems, Inc. of Baltimore. View Systems, Inc. currently sells the system under the name Visual First Responder™. The system has been tested and used by several agencies in a variety of locations.

A joint US Air Force and National Guard emergency response team tested the Hazmat Cam during a search and extraction training exercise at the US's largest collapsed structure training facility in Oklahoma City. High quality video was received from several locations within the rubble pile. Another wireless video system tested during the exercise was not rugged enough to complete testing in this harsh environment. Figure 6 shows the Hazmat Cam in use during the search and extraction exercise in Oklahoma City.

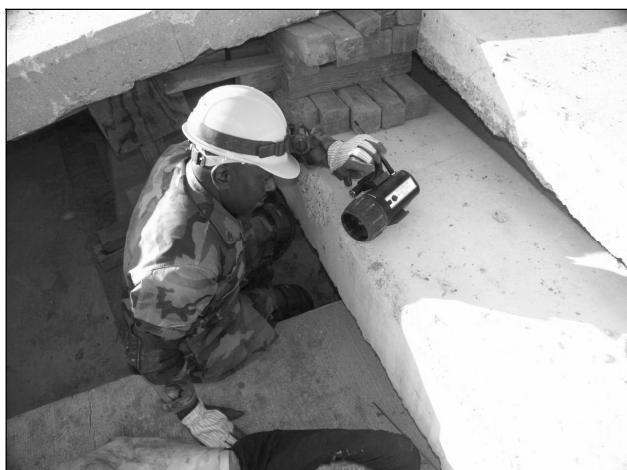


Figure 6 - Hazmat Cam In Use During Search and Extraction Exercise

One of the first “real-world” uses of the Hazmat Cam occurred at the INL during the summer of 2003. The Hazmat Cam allowed hazardous waste experts at the INL to safely view a potentially dangerous storage drum that was bulging due to internal pressure from an unknown chemical reaction. The live video feed from the wireless camera during the initial drum inspection by firefighters eliminated the need for a second inspection by hazardous waste storage experts. A mitigation plan was quickly formed based on the visual information and the potentially hazardous situation was easily and quickly resolved with minimal risk to the response team.

During a training exercise, the Georgia National Guard WMD-CST used the Hazmat Cam to transmit an excellent live video image from the basement of a large steel-reinforced concrete building back to a command

post approximately 1,000 feet from the building. Figure 7 shows the Hazmat Cam in use during this exercise.



Figure 7 - Hazmat Cam Transmitting From Basement of Steel-Reinforced Concrete Building

The Seattle Fire Department tested the Hazmat Cam inside a three-deck, 150-ft steel, commercial fishing vessel. Using the Extension Link repeater to route the signal above deck, the system was able to send clear, stable video from all three decks to a command post on the pier.

II.G. Future Hazmat Cam Improvements

At the time of licensing, the INL and View Systems, Inc. established a Cooperative Research and Development Agreement (CRADA) to continue improving the capabilities of the Hazmat Cam Wireless Video System. Some of the capabilities under evaluation include flash memory recording on the camera to record video even if the transmitted signal can no longer make it back to the command post; the integration of small, battery powered wireless LAN nodes as repeaters to increase range in difficult RF targets; a selectable dual-powered amplifier; and improved video compression and streaming over the Internet.

III. CONCLUSIONS

In the four years following the 9/11 attack on the World Trade Center in New York City it has become clear that emergency responders were hampered by poor communications within their command structure. Commanders, receiving only fragmentary voice input about conditions on the floors above had the impossible task of making life and death decisions with too little solid information. The attacks also demonstrated to the nation that terrorists are capable of the most horrendous

acts. The threat of chemical, biological or radiological attack must be taken seriously.

We can be better prepared. The Hazmat Cam Wireless Video System provides increased tactical awareness and safety during a response to a hazardous incident by allowing the incident commander and other response experts to remain safely outside the hazard zone while viewing real-time, broadcast-quality video of what the initial entry team is seeing. The system's lightweight, waterproof video camera – easily carried by emergency responders – transmits video signals over 2,200 ft (5 miles with a repeater) to a battery-powered receiver and monitor for remote viewing of hazardous areas.

A unique combination of system flexibility, rugged design, video encryption, true-diversity reception, and relatively low transmission frequency all help to deliver secure, clear, interference-free images to the command post under conditions where other video systems fail.

The Hazmat Cam has been tested and used by National Guard WMD Response Teams, fire departments, HAZMAT teams, and local, state and federal law enforcement authorities. It has provided high-quality video from steel office building basements, a West Virginia tunnel, below decks in a 150-ft fishing vessel, and the concrete rubble of a collapsed building training facility.

Today, the likelihood for a terrorist act against the United States involving chemical, biological or radiological agents is at its greatest. The INL Hazmat Cam gives our emergency responders a new communications tool to help them do a better job with an increased level of safety when terrorists, accidents or natural disasters strike.

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