WHITEPAPER

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Video Monitoring of Process Control and Automation Systems Nobody is doing it yet, but the potential is available

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1.0. Overview

Video monitoring is a proven technology in the water and wastewater industries, especially in the U.S. After the terrorist attacks in New York City and the Pentagon on September 11, 2001, the U.S. Homeland Security Agency deemed that water and wastewater treatment plants were potential targets, and required that security be increased.

Water plants in the U.S. installed video monitoring equipment to watch over their fences, entry points, remote facilities, lagoons and properties, Figure 1. In many cases, they connected the security video to their HMI/SCADA systems using industrial networks, wireless and cellular network connections.

The main reason for connecting to HMI/SCADA was that it was far less expensive to use existing networks than it was to install dedicated CCTV or broadband cable.

Longwatch pioneered the use of industrial networks for connecting video to Wonderware, Rockwell, GE Fanuc iFix and other HMI/SCADA systems; consequently, it has dozens of installations across the U.S. in water plants. Emerson and Invensys also offer video security monitoring systems connected to HMI/SCADA. Simply dropping a video window onto an HMI/SCADA screen is now a common practice.

With hardware, software and communications problems solved, intriguing questions come up: Why not use video to monitor process control and automation systems? Why can't video be another sensor? Why not use video to allow operators to see what is happening in the plant? Answer: Nobody is doing any of this, but it is certainly possible. This article explores the possibilities of using vision to help operators monitor and control plant operations.

2.0. Video on HMI/SCADA

Traditional video monitoring in a gas processing plant involves remote analog cameras connected via CCTV coaxial cables to a bank of monitors in a guard shack. Not only is this an expensive solution, it requires eternal vigilance by security personnel (to make sure they don't miss anything). If conventional video monitors are installed in a control room, they take up valuable panel space, and they also require constant observation.

Figure 1: *Water treatment plants pioneered the use of video in HMI/SCADA systems. Here, a water plant in the U.S., displays video clips transmitted over the plant's industrial network on a Wonderware HMI system.*

A modern digital camera system improves on this installation in four ways: First, it allows multiple cameras to be connected to a single cable or wireless connection; second, it uses an existing industrial network to transmit the images, thus eliminating the need to run additional cable; third, it puts the video images directly onto an HMI/SCADA screen, so operators can monitor what is happening in a process unit or an assembly line; and fourth, modern digital cameras and video processing software can identify intruders and anomalies in the image, and alert the operator. Figure 2 illustrates how such a system works.

A modern camera system continuously records high-resolution video on a "Video Engine" for up to 30 days at the camera site (commonly called "recording at the edge"). The system can be programmed to send live video to an SCADA/HMI system, or to take "video clips" at specific times of the day, when requested by the control system, or if local events occur, such as a process alarm, an intrusion or if the camera itself detects an anomaly. For example, a digital camera can identify an errant crane hook passing in front of the lens on an offshore platform, Figure 3. The operator might have a different video image on the HMI, but the system can be configured so that it switches to the offshore camera, alerts the operator, and shows the video.

The quality of the video depends upon the bandwidth available. On a high speed, gigabit Ethernet network or a high-bandwidth 3G cellular connection, high resolution video can be transmitted. Conversely, on a low-speed radio network, short video clips may have to suffice. Longwatch video systems require a minimum of 9600 baud (1KB per second) bandwidth to transmit video images.

Typically, an analysis is made of the communication system to determine if enough bandwidth is available to accommodate video packets without interfering with higher priority messages, such as process monitoring or control signals. If so, the Longwatch Video Engine is configured to ensure that it does not use any more bandwidth than is permitted. Many industrial communications systems are Ethernet-based, meaning that a video system can connect to virtually any existing system.

For Ethernet-based networks, the Longwatch Video Engine connects via an Ethernet port and has an individual IP address; similarly, the Longwatch Video Control Center computer in the control room has an IP address. Video images are sent in packets from the remote site, reassembled in the Video Control Center computer, and presented on the HMI screen. The Longwatch advantage in this configuration is that there is local video recording that provides a level of fault tolerance (the video is preserved even if the network is unavailable). In addition, the Longwatch system buffers the network messages so that bandwidth is preserved even during a flurry of plant or system events.

High-resolution video stored at the remote site can be retrieved at any time and either transmitted to the control room or loaded onto a thumb drive or portable recorder. Video clips are stored in a Video Historian on a PC in the control room. This combination of video storage allows operators and engineers to view any event or series of events.

What can you do with this capability? Following are some brief scenarios, describing possibilities for using video in a process or manufacturing plant.

3.0. Process Control

Monitoring a process control system has been described as hours of sheer boredom interrupted by moments of panic. Operators sit at HMI consoles, staring at bar graphs and animated representations of batch reactors and distillation columns, and rarely—if ever—"walk the plant." They are completely isolated from the process, and rely on their HMI screens to tell them what is happening. When an upset occurs, they have to figure out the problem remotely. If a storage tank is leaking, a valve is stuck, a pipe burst, or a batch has gone awry, the HMI screen may not be able to give them enough information.

Video can. With video, an operator can call up a video image of the process in question, then pan, tilt and zoom the camera to see what is happening. An operator can even read local gauges and indicators. Once the problem is discovered, the operator can view video from seconds, minutes or days before the incident occurred to determine why it happened. Maybe someone hit the valve with a forklift truck three days ago. Perhaps the operator forgot to add an ingredient to a batch.

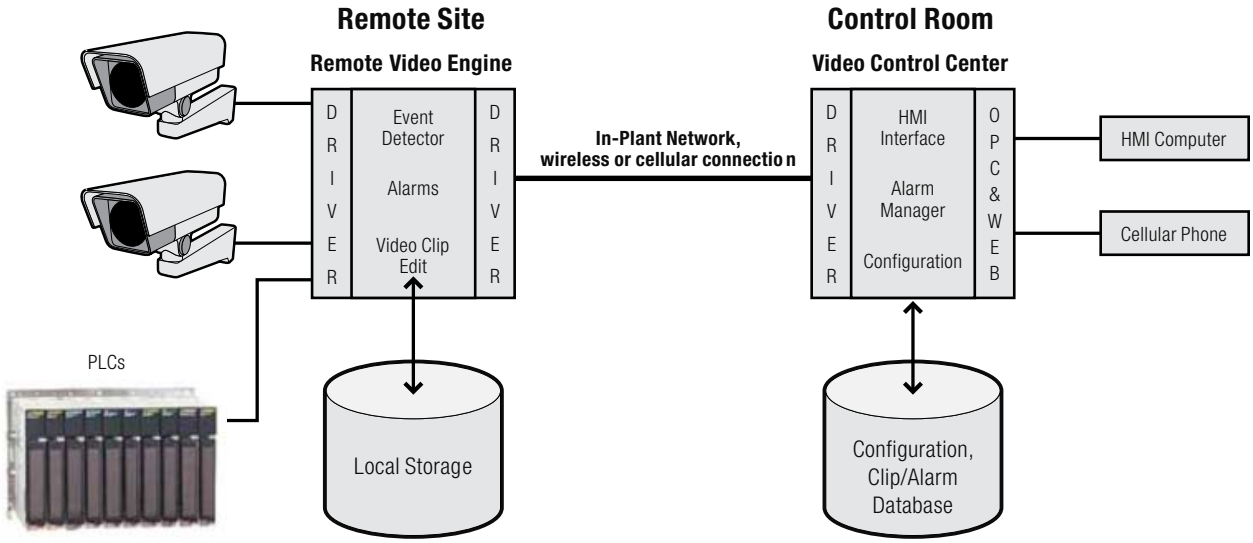

Figure 2: *In the Longwatch video surveillance system, up to 12 cameras at a remote site connect to a local Video Engine, which acquires and stores their continuous high-resolution images for up to 30 days. The Video Engine transmits "video clips" when requested by the control system, a local alarm, or when it detects an intruder or anomaly in the image. Video clips are transmitted as Ethernet packets over the in-plant network, wireless system, or a cellular network to the Video Control Center in the control room. The VCC stores the video clips within the Video Historian and provides these video clips to an HMI, cellphones, email, via the Internet, and to other systems on the network.*

Using video and a video historian to document a batch sequence allows a plant to collect evidence that a process step was completed for regulatory compliance, quality control, and diagnostic purposes. One way to do this is to program the ISA 88 batch recipe to request a video clip of the process from, say, 30 seconds before the ingredient is added until the operator presses "Step Complete" on the console, Figure 4. This clip can be sent to the HMI live, while the process step is being carried out, and then logged into the Video Historian along with time of day, recipe number, step number, and other real-time information.

Multiple cameras can be installed to monitor a particularly difficult problem. If operators don't know exactly what's happening or where, several cameras can be brought in on a temporary basis to monitor the situation. Once the problem is identified and solved, the cameras can be moved to the next trouble spot. The cameras and their Video Engine can plug into any convenient plant network.

Remote plant units, such as pipelines, wellheads, storage tanks, wastewater lagoons and pumping stations are well suited for video monitoring. Even if a remote unit—such as a wellhead—is not connected to the plant's SCADA system, cameras can be positioned to read local gauges and readouts, and transmit video via wireless or cellular networks. This lets operators check operations and conditions without visiting the site, thus saving significant time and money.

Figure 3: *Smart digital cameras and video analytics software can detect and track an intruder. Here, a camera on an offshore platform spotted a crane hook moving across its field of view, put a red box around it, and tracked the hook until it disappeared from view.*

Cellular data transfer offers an economical solution for remote process areas. For about $60 per month, cellular data services provide a fast, bidirectional interface. Operators can pan, tilt and zoom remote cameras to read gauges or inspect the equipment, and watch high-resolution video live. Cellular coverage is increasing rapidly across North America, although it can be sparse in remote areas, such as Wyoming with its hundreds of gas wellheads. In that case, a radio system can be installed that has enough power to reach the central distribution location. Many wellheads are being equipped with solar or gas-powered generators to supply power for local controls and radio communications; the video system can piggyback on any of these power and communication systems.

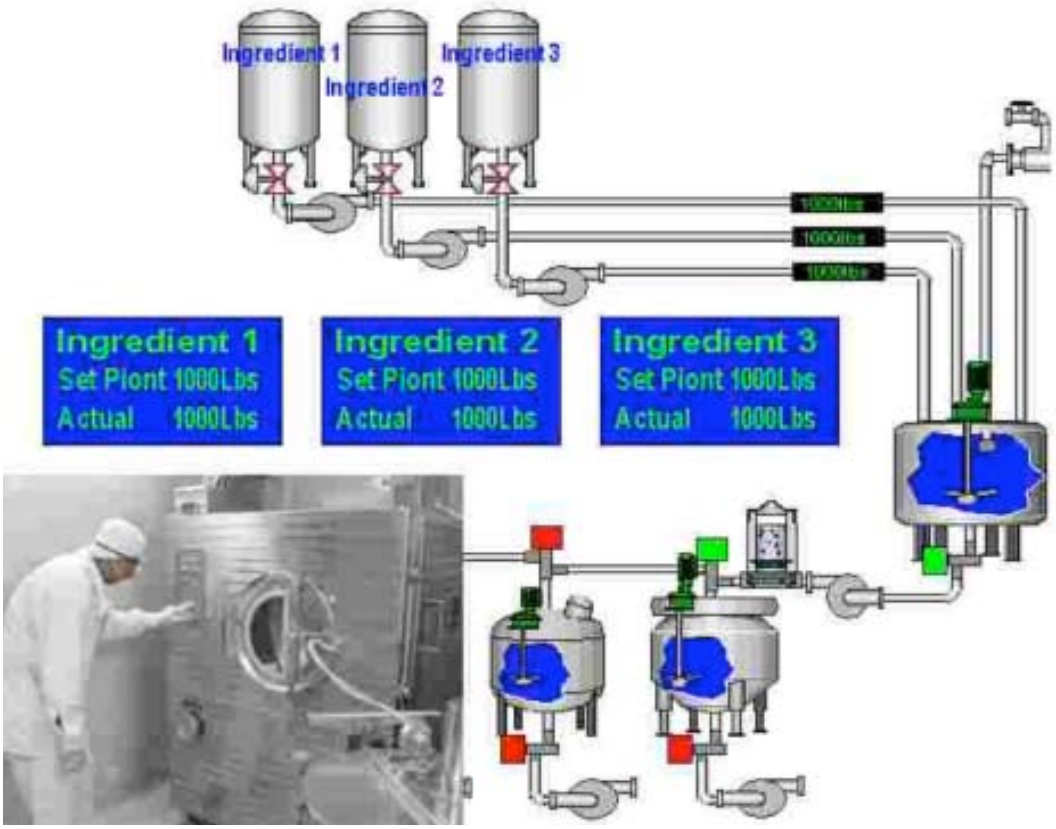

Figure 4: *To assure that operators add the correct ingredients to a batch, video can be used to monitor the operator, and then record the video clip in a Video Historian. Here, the video clip is displayed on a Wonderware HMI screen, along with the process graphic.*

4.0. Checking Instrumentation

Instrumentation is fairly reliable, but when it fails the operator may not know it. Also, instrumentation can't detect everything. If a valve seal or pipe is leaking and it does not get detected by instrumentation, then visual inspection is the only possible detection method. If the instrumentation can cause a leak or a tank overflow, by the time the problem is discovered valuable and/or hazardous chemicals may be on the ground or polluting water.

At one power plant, operators could not understand why a tanker was not unloading properly. The HMI screen said the pumps and valves were working, but the level in the receiving tank was not increasing. On-site inspection revealed that one of the pumping hoses had come loose, and the plant had pumped 10,000 gallons of fuel oil into the river instead of the tanker. The plant has since installed a video monitoring system. The key benefit is that the video enables the operator to act quickly, avoiding the costs of clean up and EPA fines. It also provides more goodwill with their neighbors.

To check instrumentation and systems, one solution would be to perform a "test clip" prior to every tank transfer, unit startup, batch run or at the beginning of each shift. This is the equivalent of "walking around the plant," because simply looking at a video clip makes it possible to see obvious faults in the process unit. The human eye is very good at spotting problems.

Even if the operators don't look at the video clip, modern digital cameras and Longwatch comparative analytic software can spot anomalies in the image, such as escaping steam, a pool of liquid, intruders, and so on. Video might be able to spot a problem long before local sensors can sound an alarm.

Another key differentiator with video: Video will not show a switch to be in the "off" position when it is in the "on" position and it will not show that a door is open when it is closed, but it is possible for an instrument to give false readings in these cases.

Integrated control room based visual inspections based on video, video clips and video analytics introduces a new and extremely powerful sensor yielding enhanced levels of reliability and confidence. It offers almost 100% reliability, and it is the equivalent of having operators out in the plant watching remote process locations 24x7.

5.0. Monitoring Assembly Lines

Because vision systems are programmed to analyze part quality, the Longwatch Video Historian can document those inspections. It might not work well with a system that processes 50 parts a second, but inspections of big, expensive, complex parts are possible. It might be worth it to a manufacturer to be able to prove that certain manufacturing steps were done correctly. Video output from a vision system can be connected to a Video Engine, transmitted to the control room, and stored in the Video Historian along with time of day, part number, customer, etc.

If a machine is having problems of some kind—say, ejecting parts randomly once a day and triggering an alarm—a plant could install multiple cameras around the machine. The cameras could look at various parts of the machine, and a Longwatch Video Engine would record live video. Then, when a part is ejected, the Video Historian would save all the video from 30 seconds before from all cameras, and engineers could review the high-resolution video at a remote HMI. Since all the video can be archived in the Video Historian, video from multiple part ejection events can be compared side by side.

As with process plants, cameras could monitor remote or unattended areas of the plant, such as parts and material storage areas, power generating stations, pumping stations, transformers, and other areas rarely

visited by maintenance personnel. For example, a huge problem involves theft of copper and brass. Cameras that record the comings and goings of people in the area would deter theft and provide evidence for prosecution if a theft occurred.

Assembly line workers are accustomed to seeing time management people observing them with stopwatches in hand, recording how many seconds it takes to perform certain operations. Video does it better. With video records stored in the Video Historian, time management personnel can compare up to four workers at a time doing the same job, and determine why one worker is so much faster than the others.

6.0 Shutting Down Plants

When layoffs occur, the people who remain are tasked with picking up the work that was being done by others. Only in a few cases is the work eliminated as well. So, the "survivors" have to deal with "survivor guilt" and a lot more work. In a plant or factory, how do you cover all that floor space and monitor all that equipment with fewer people?

Why not use video to replace people? Assuming the average worker has a fully-burdened annual cost of $80K, you could add about 20 cameras in the factory and still have money left over. Don't worry about the burden on the recently-trimmed-down IT staff: A Longwatch system uses the existing plant network without adding much overhead. The system will bring video back to the operators in the control room. If an alarm occurs in the plant, Longwatch will deliver the message and the video that shows what happened before and after the alarm.

Thus, a Longwatch system multiplies the number of eyes an operator has, without burdening the operator with much more work to do. Integrated into the existing network and the existing HMI, Longwatch is a low-impact, high-value solution that delivers "virtual operators" in a downsized environment.

Closing a plant eliminates significant operating costs. But when the plant closes, the equipment and building remain. The value of this idle asset is at risk of theft and vandalism. Video surveillance to deter and identify theft and vandalism is a classic application. Certainly, a company can contract with a "traditional" video surveillance supplier to get a system. But doing so has two significant drawbacks.

The first is the recurring cost of monitoring the video. Surveillance companies charge high monthly or annual fees to watch the video and respond to alarms. The second drawback is the inability to view the entire collection of assets. If your plant is relatively small, this isn't much of a problem. A closed-circuit coax network can be used to connect cameras and related equipment. But if your business includes remote assets (like pumping stations, waste treatment facilities, storage yards, etc.) then getting video from those sites is a different story. Traditional video systems have great difficulty reaching those areas, and only do so with a significant investment in specialized networking.

A modern video monitoring system can use existing networks, wireless or cellular technology to collect information from all remote cameras.

7.0. Unmanned Operations

Many facilities function without operators today. Offshore platforms, wellheads, pipelines, compressor stations, and other facilities operate with only routine visits from maintenance personnel. Some of these operate far from electrical power, and rely on solar power or natural gas fired generators. The problem is: Not only are they unmanned, they are unwatched. With solar power or battery power, a cellular-equipped camera system can monitor just about anything, anywhere, 24 hours a day.

Video systems make it possible for an operator at a central control room to monitor equipment across the plant or across the world. From an HMI system, an operator can pan, tilt and zoom remote cameras to inspect the premises, read gauges, and look for problems. Smart video systems can detect intruders and spot problems automatically, alerting remote operators. Someday, video may make entire unmanned plants possible.

8.0. About Longwatch

Founded in 2004 by a team of industry veterans, Longwatch, Inc. is dedicated to enhancing the safety and security of the Nation's water, utility and energy distribution systems by delivering a powerful, yet cost-effective solution.

The Longwatch solution is designed to deliver real-time video surveillance of remote facilities over existing SCADA communication networks. This proprietary, patent-pending technology will dramatically improve an operator's ability to monitor and verify alarms at remote sites utilizing existing communication infrastructures.

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