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EXPERT SERIES

HOW TO MAKE the Most of Megapixel Imaging

HOW TO MAKE THE MOST OF MEGAPIXEL IMAGING

Megapixel cameras and associated devices are revolutionizing the video surveillance world. Given a proper match of system design and application, the technology's advanced capabilities are enabling superior results for both security and management purposes. Learn key insights and tips about megapixel imaging and optimizing its deployment. **BY ALLAN B. COLOMBO**

MEGAPIXEL (MP) TECHNOLOGY has essentially changed the face of video surveillance by providing images that are larger, clearer, and better suited for analytic applications. Those who have experienced the difference between MP and standard definition (SD) are sure to appreciate the above statement more than those who have used SD (analog) cameras all of their professional lives. But this is a new day, a new age, and digital is at the forefront of virtually every advance made in science and technology. Why should video surveillance be any different?

For one thing, digital signaling is far more forgiving then analog where it comes to induced electromagnetic interference, which can occur where wires from a variety of services run parallel for some distance. Digital signals also can be compressed into a relatively small package and sent along a metallic or fiber cable, or a wireless connection for a virtually unlimited distance using network technology. And then there's the issue of the solid-state imaging chips that create MP-quality versus SD images. There really is no comparison when you look at the images they produce side by side.

In order to put megapixel cameras to good use, it's important to have a basic knowledge of analog/SD and how MP technology differs. For those who have installed only analog cameras, unless we examine these fundamental differences, making the analog-to-digital jump can be somewhat intimidating.

In this white paper, brought to you by Illustra from Tyco Security Products, manufacturer of IP cameras, network-based storage solutions, advanced VMS (video management systems) and other digital video equipment, we'll touch on the differences between SD and MP technologies. We'll also discuss how megapixel and high definition (HD) cameras do what they do and the differences between them. We'll talk about how MP-seasoned security integrators successfully install those cameras, and speak to a number of popular applications where HD megapixel cameras have made a significant difference in overall image quality.

THE MEGAPIXEL ADVANTAGE

Historically speaking, the average analog camera has never produced the quality, detailed images that business owners and law enforcement have really wanted, especially where it comes to identification for the purpose of lawful arrest and prosecution. The images that SD analog cameras generate all too often lack detail and they are blurry when they are enlarged, which is due to pixelization where the number of pixels per inch (PPI) is not sufficient to handle an image's resolution/physical size. In the past, this was especially a problem when images were gleaned from a time-lapse tape recorder and then blown up in size. The advent of DVRs, in combination with better quality analog cameras, has improved analog image quality but not enough to provide the kind of graphic detail and analytical data that forensic experts need and want, but MP cameras do.

Oddly enough, both analog and megapixel cameras use a digital imaging chip to convert reflected light from objects in the camera's FOV (field of view) into a digital signal. In the case of an analog camera, the ensuing digitized image is converted into an analog signal that complies with NTSC (National Television System Committee) standards. It then is sent up a coaxial cable to the head-end where it is converted back to digital by way of a hybrid DVR/HVR (hybrid video recorder) or an encoder. A MP camera signal, on the other hand, remains digital from imager to head-end without conversion, which allows the VMS to make the best use of the resulting images in a variety of ways that we will touch on throughout this white paper.

Another significant factor that ties directly to image usability is the num-

Comparison of Image Size, Resolution and Megapixel Rating

FORMAT	RESOLUTION	MEGAPIXEL RATING
NTSC/2CIF	704 X 240	0.17
VGA	640 X 480	0.31
NTSC DA/4CIF	704 X 480	0.34
HD/720p	1280 X 720	0.9
1.3MP	1280 X 1024	1.3
2MP	1600 X 1200	1.9
HD/1080p	1920 X 1080	2.1
3MP	2048 X 1536	3.1
5MP	2560 X 1920	4.9
10MP	3648 X 2752	10.39

The image size of a megapixel camera has a direct bearing on megapixel rating that is assigned to the camera. This chart provides a comparison of imager sizes (in pixels) with the megapixel rating of the camera.

ber of pixels contained in the camera imager. The greater the PPI rating of the chip, the more detailed and acceptable the image will be for both visual examination and digital processing. For example, a common VGA camera using SD creates an image size (resolution) of 640 X 480 when converted from analog to digital. The number of pixels contained on the camera's imager can be computed by multiplying these two numbers together, or 640 X 480 = 307,200 pixels, or 0.3MP. Compare this to a camera that generates an image size of 2592 X 1944 for a total of 5,038,848 pixels, which is considered a 5MP camera. Another example that illustrates the power of megapixel technology, a 10MP camera has an image size of 3648 X 2752 for a total of 10,039,296 pixels. Obviously, a 10MP camera is better than a 5MP because it contains more pixels, that is assuming both imagers are the same size (format).

Another issue that makes MP cameras more effective than analog when detail is an issue is the technical standard upon which the camera operates. SD cameras, for example, use the NTSC standard, which is based on the interlaced scanning of 480 rows of light-sensitive elements, such as pixels. MP cameras, however, uses progressive scanning, which can have an image with 720 or 1080 rows using the HD standard.

The difference between progressive and interlace scanning is that the latter entails a process where the camera scans every other line of a reflected image comprised of 480 rows of pixels returning to the top left of the chip to scan those lines/rows that were previously passed over. A camera that uses progressive scanning, on the other hand, systematically scans the entire image line for line, top to bottom, without skipping a single line, which is what the overwhelming number of MP cameras do. Add to this the fact that megapixel cameras forgo the digital-to-analog-to-digital conversion process, and you have a much better quality image to work with.

THE DIFFERENCE BETWEEN MP AND HD/MP

By definition, any camera you see on the market that produces an image resolution of a million pixels or more qualifies as a MP camera, but that's not where the story ends. These days, with the term "HD megapixel camera" being bantered about by so many people, many of us think that "all" MP cameras are the same, that MP and HD are synonymous, but this is not the case.

A MP camera without the HD designation may use the same aspect ratio as a SD analog camera, which is typically 4:3. HD MP cameras, however, use an aspect ratio of 16:9 that complies with the newer HD consumer broadcast standard. By definition, the aspect ratio of a camera is the same as a common CRT or solid-state display: it's a mathematical ratio determined by the width and height of the image that a camera produces. The thing to know is that some MP cameras, unless they carry the HD designation in the specifications, produce an image that complies with the older SD standard, which again is 4:3. Others can

Museums are especially challenging because of the priceless pictures and other items of antiquity that reside on display. High-resolution MP technology can be used in such a manner that a single camera can be used to monitor a relatively large number of such as museum displays or a casino's gambling machines. A detection zone can be assigned to each item and the VMS programmed in such a manner that a verbal warning not to touch can be issued on a display-by-display basis as in a museum setting.

be configured internally to provide a variety of aspect ratios, such as 4:3, 5:4, and HD, which is 16:9.

To be clear, there is a distinct advantage to using MP cameras with an aspect ratio of 4:3 in an existing analog CCTV system. This is because they will easily replace older analog SD cameras because they have the same aspect ratio. Thus, MP 4:3 images can be displayed on older SD-compliant CCTV composite video monitors.

There also are distinct advantages to HD megapixel cameras with a 16:9 display. First of all, a growing number of solid-state displays are designed to accommodate the HD standard of 16:9. Second, in most cases it's better to have more width than height simply because SD displays have always experienced wasted space above the intended target. A good example of this is the images created by an outdoor SD/analog camera. In most instances a significant portion of the camera view involves empty sky. Using the 16:9 aspect ratio, you are able to place more emphasis on the area around the intended target with less wasted space above it.

HD also provides frame rates and image size specifications that greatly improve the understanding we have of the megapixel cameras that security integrators install. For example, the two resolutions specified by the HD standard are 720p and 1080p – each number correlating to the horizontal aspect of the image. Thus, the 720p designation entails an image size of 1280 X 720 whereas a 1080p image is 1920 X 1080. In terms of how many megapixels there are in each one, the 720p has 1280 X 720 = 921,600 pixels (which don't technically comply with our MP camera definition) and the 1080p has 1920 X 1080 = 2,073,600 pixels, which is essentially a 2.1MP camera.

IP MP camera technology allows for camera configuration never possible with analog. For example, when we think about the aspect ratio of a HD 16 X 9 video, this is a wide scene FOV. What if I want my camera to look down a long narrow aisle as in a retail store? Certain cameras allow the 16 X 9 frame to be rotated into a 9 X 16 aspect ratio, which is a perfect solution to apply all the camera resolution capability to the desired long and narrow, vertical view.

Another great advantage in IP MP is region of interest encoding. All MP cameras encode and compress the data to maintain a balance of video quality, and to economize on the bandwidth and disk space used to transmit over the network and store recorded video in disk. Camera settings allow for compression to be increased, economizing on bandwidth and storage at the tradeoff of some overall video quality. For example, in the case of a bank where a MP camera is monitoring two teller windows, regions of interest can be drawn around the cash drawers, which would maintain the highest quality in these regions (lowest compression) while the less important areas outside these drawn regions have a higher compression level. The result is the best quality is applied where it is needed and at the same time increased compression economized bandwidth and storage to get the

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maximum value out of the surveillance system.

In addition to MP cameras that comply with the HD 720p and 1080p standard, 4K and 8K Ultra HD now is moving into position within the video surveillance market, promising to further improve image quality and increase the number of features and benefits that law enforcement and their owners enjoy. MP cameras built upon the 4K Ultra specification produce a resolution of 3840 X 2160 (2160p), which is equal to an 8.3MP camera (3840 X 2160 = 8,294,400 pixels), which is four times better than 1080p HD. An 8K Ultra camera is rated at 33.2MP (7680 X 4320 = 33,177,600 pixels), which is 16 times better than 1080p HD. The question is, were will we go from here in the years to come?

Ultra resolutions have their place in an overall system but at the tradeoff of higher cost of ownership across the entire system. It is best to assess each individual camera deployment and expected results before deciding what resolution is needed.

APPLICATIONS FOR HD/MP CAMERAS

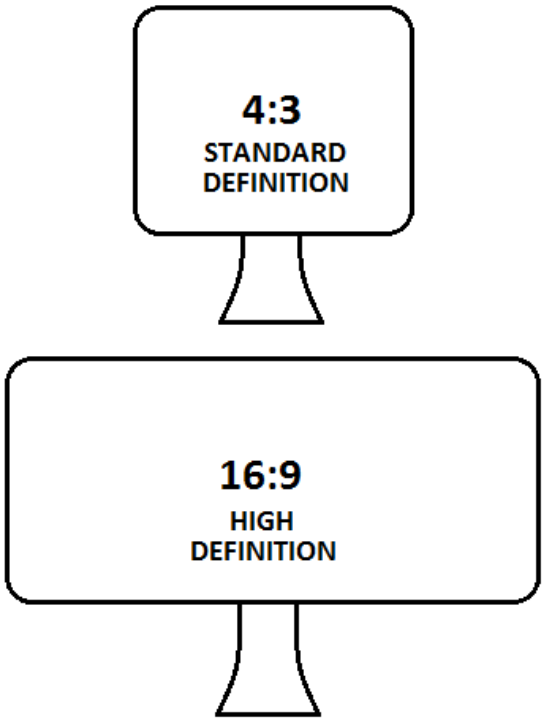
There are all sorts of applications where HD MP cameras work well. The following is a list of possible applications for HD/MP technology along with a few installation insights, but keep in mind that this list is by no means conclusive.

Agricultural/Industrial/Commercial: All three can be great applications for HD MP cameras. HD/MP technologies make it possible to secure large swaths of land with a single camera. Because the resolution is so good using MP technology, the end user is able to electronically zoom in on an event that is in progress some distance away without the resulting images being blurred on playback, which is typical of cameras designed around lower resolutions.

The VMS can actually be used to tour the grounds in real time on multiple displays for those who may be watching while they go about their business. Not only that, a typical VMS will allow the end user to play back portions of the video while the system continues to save images to a digital recording system, such as a NVR. This assures that every bit of video data is retained in the system if it should be needed at a later time.

Retail/Banks: Probably the biggest challenges to security integrators are to a) secure the public while on company property, b) assure the wellbeing of employees, and c) prevent shrink. In the case of retail, the directive is to stop internal theft and shoplifting. In the case of a bank, the objective is to document transactions as well as events that occur, such as a robbery. Outside either type of facility HD MP cameras are great for parking lot theft prevention, especially in high-crime areas. And where there typically is one camera per register/bank clerk, a single high-resolution MP camera

SD/HD Aspect Ratio Comparison



High Definition (HD) offers a wider view of the target with less wasted space above it than Standard Definition (SD) cameras.

will usually suffice, which represents a huge savings to the property/business owner. Multiple windows can be individually displayed as well as recorded through the VMS by the digital recording system at the head-end.

The bottom line is that unless the clients and their vehicles are safe, many of them will refuse to return to do business there. Thus, protecting visitors and employees during night time hours can be especially difficult. Toward this end, many of today's HD MP cameras come with solid-state illuminators built into them that will generally help to illuminate scenes up to 100 feet or more. For greater coverage, adequate exterior lighting is required.

Although HD MP cameras are always a good choice, it must also be said that quality analog cameras will suffice in some areas of a bank or retail store. In retail, for example, a camera in each aisle is common as well as facing entrances, exits and cash registers. In banks, high-resolution analog cameras also can be placed at entrances, although 720p HD (0.72MP) cameras would be better as a typical analog camera is only 0.3MP. And for money rooms, nothing less than HD MP cameras will suffice.

Commercial/Industrial/Government: HD MP cameras lend themselves well for these three applications. HD/MP technology is a must where it comes to license plate identification as well as facial recognition (more on this subject later in the article). Many factories – with or without a manned security force – use HD MP cameras to monitor manufacturing processes and assembly lines in real-time while recording each and every event. These cameras also are used to log the comings and goings of vehicles by day of the week and time of day using license plate numbers. The most common way to capture license plate data is to position one or more MP cameras overlooking the entrances/exits so they have a clear, uninterrupted view of motor vehicles entering and exiting the facility's parking lot. When linked to a valid database of motor vehicle drivers, it's possible for the VMS to track individuals as well as determine when an undesirable person is onsite.

Because most HD MP cameras have a wide FOV, and because of the exceptionally high resolution images they generate, security can establish one or more kill zones within the expanse between the outer perimeter and the main building(s). Movement within these areas can be monitored by the VMS, activating a series of events that will result in several simultaneous actions.

The system can send a text message to one or more security personnel, it will turn on outdoor lights at strategic locations, and it will communicate the situation to any number of other stakeholders. At unmanned facilities a siren or a voice recording can be made play in the hope of frightening off an unwelcome intruder. In a managed system, a live operator can be alerted and connected to the VMS through an Internet connection for real-time interaction with the target. The VMS can follow the source of movement after opening a zoom window, handing

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the target off camera to camera if necessary, all the while maintaining a recording of the original image as well as any zoom windows.

Library/Museums/Airports/Casinos: Museums are especially challenging because of the priceless pictures and other items of antiquity that reside on display. High-resolution MP technology can be used in such a manner that a single camera can be used to monitor a relatively large number of such as museum displays or a casino's gambling machines. A detection zone can be assigned to each item and the VMS programmed in such a manner that a verbal warning not to touch can be issued on a display-by-display basis as in a museum setting. Airports are another application where HD MP cameras excel, especially in the area of traffic control.

As mentioned previously, the VMS can be programmed to immediately notify security personnel and other stakeholders when someone has crossed into a predetermined (outlined) detection zone. This may include specified time duration so as to protect against false alarms. The VMS also can tell when an item has suddenly dropped out of the picture, as in the case of a priceless painting. In an airport, the VMS can detect when an item has suddenly appeared, alerting security when it remains in place for a preprogrammed period of time as might occur with a bomb. The same VMS also can count heads and detect someone walking in the wrong direction, as in the case of an outgoing jetway.

In general and in all cases above, where monitoring an area for situational awareness – people coming and going or tracking traffic flow through a store – cameras with a very wide FOV are the ticket. High-resolution (5MP) fish-eye cameras can monitor 360° at all times. A fish-eye mounted on a 10- or 12-foot ceiling will easily monitor a circular area more than 50 feet across and record in all directions at once. For example, a camera in the center area of a bank will see customers as they enter through the doors, cross the space and queue in at the teller windows or customer service area. Any area of the view can be extracted, dewarped and viewed as if it was a separate camera. For an event at the teller window the same camera is also monitoring people entering the doors at the same instant – one camera looking in all directions.

Last, but not least, is the issue of video analytics. As cameras increase in power, the scene analysis capability will move from the server and into the camera. This not only lifts burden off the VMS, but it allows the camera to make smarter decisions. A simple in-camera or "edge" analytic example is using a p/t/z camera to detect objects and move the camera to automatically track the object as it moved through the field of view. One example is outdoors in a parking area. The camera could be instructed to detect vehicles moving through the area at night when no vehicles should be present. The camera could automatically pan to track the vehicle and zoom in to record details such as the license plate. Other uses of edge analytics might be logging video at a cash register when no

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customer is present. The video can be cross referenced by date and time with point-of-sales exception reports to quickly determine if refunds or credits are being issued when no customer is at the register.

THE NETWORK CONNECTION

The other aspect associated with MP and HD MP cameras is the fact that they connect to a PC or a computer network, such as a LAN (Local Area Network) or WAN (Wide Area Network). It's immensely important that you understand network technology when installing an IP-based MP camera system to some degree otherwise you may need to solicit outside help from an IT expert.

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Unlike analog cameras that use RG59/RG6 coaxial cable to convey composite video signals from each camera to the head-end, however, MP and HD/MP technologies use a UTP (unshielded twisted pair) cable that complies with either the Category-5e or -6 cable standard. The fact is, unless you have a firm understanding of UTP, it's virtually impossible to successfully install an IP/MP camera.

One advantage to using IP-based HD MP cameras is the fact that you do not have to install additional transformers or cable to power them, as is the case with their SD/analog counterparts. Instead, a PoE (Power Over Ethernet) switch can be used to provide power over the same Cat-5e/-6 cable that sends and receives data. The switch itself acts to route data to and from each camera, limiting the amount of data that is allowed to impinge on other parts of the network.

Despite the fact that IP cameras use Cat-5e/-6 cable with eight-position modular plugs, most cameras have a composite BNC output on the back so technicians can use a small test monitor to determine FOV issues.

Some IP cameras also come with internal Web servers, which allow the end user to gain access to additional settings and benefits not available or accessible through the NVR. By placing the intelligence in the camera at the edge of the network, you realize additional benefits, such as the ability to lock and unlock doors, open and closed motorized gates, turn lights on and off at remote locations, and communicate with others using bi-direction audio with video. In addition, some models come with internal temperature sensors as well as the ability to send E-mail alerts along with image clips over an Internet connection.

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