

A User's Guide To Digital Video

by Conrad Steffen and Donald Cogswell

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Introduction

by Conrad Steffen

The surveillance industry has come a long way, since the days of the catwalks and two-way mirrors. As late as 1990, most surveillance departments were still writing incident reports by hand on yellow legal pads. Although the personal computer was around, many of those relegated to the surveillance department “*old timers*,” didn’t know how to work them.

Since well before my time, surveillance directors have struggled to define their department’s job description beyond “*protecting the corporate assets*.” Company executives knew very little about gaming, and even less about surveillance. Each surveillance director I’ve either worked with, or known, runs their department their own way.

Although some so-called experts have written books on how to run a surveillance department, the fact is that running a surveillance department is a little like raising a child. There is no single right way to do it. However, certain aspects of rearing a child and a surveillance department are a must. For the surveillance industry, some of those “*musts*” have included: the need to know the games you were watching, how to spot a cheat, what “*rubber-necking*” meant, making sure you don’t accidentally tape over your evidence, and getting tape-change done on time.

The musts in parenting have changed very little in the last twenty years, the musts for surveillance departments however will be like night and day. Technology and the dissemination of information will be the cause of this radical change. Computers with word processors, databases, and the Internet, have already had a profound effect on society and the way we live our lives and do business. It is a foregone conclusion, by the end of the decade, the replacement of VCRs with DVR’s, full-view 360° cameras, and video analytics, or smart video, will complete the metamorphosis.

Most surveillance directors are forty-something+, and they have never had formal training in the areas of, video compression science, networking, and information technology, as a whole. These forces are behind what will shape the next generation of surveillance departments. Corporate execs lack the specific knowledge to make informed decisions and rely on their surveillance people to provide the answers. The surveillance directors are deluged with information from a myriad of vendors and left to decipher the fact from the fiction.

As one who has been a surveillance director, I feel for those struggling to come up with the miracle cure. We have written this book with that in mind. It is well beyond my individual area of expertise to draft this alone, so I want to thank all those who contributed to this book, each in their core competence, which made this undertaking possible.

While this book won’t tell you who and where to buy from, it is a great source of information to assist you in the selection process and making informed decisions. It will educate you to ask all the necessary questions and be able to sift through the smoke and mirrors.

Introduction

by Donald Cogswell

I have grown up in an era where I remember my first Christmas' under the tree were not bicycles or building blocks, but video games and a personal computer. My dad used to tell me the joke of *"when I was your age and we were punished our parents made us come in the house, these days when y'all get punished we send you outside the house."*

As a kid I looked forward to the summers, so I could work on making my own video games and learning about the latest hacks. I had a mouse in my hand instead of a baseball, but I loved every minute of it. Sometimes my colleagues chastise me and say, *"speak English damn it, stop speaking in acronyms!"* I guess they hate when I speak "IT," and I forget it's not a spoken language to all.

I have been fortunate enough to start my career around some of the country's finest programmers in the banking industry before moving over to data security, networking and communications. The visionaries I surrounded myself with cautioned me, that while we are moving into the age of the Jetsons, we can't forget we are still living with the Flintstones. So we have to remember that whatever we design, Fred, Barney, Wilma and Betty are the ones going to be using it. My mentors would say, *"technology is a wonderful tool, but not if the masses can't use it."*

I watched product after product that were incredible in what their capabilities were, fall flat on their face because the users got frustrated and gave up. It was designed by software engineers for engineers. Too often, software and hardware developers cannot empathize with the masses. They assume everybody has a PhD in technology.

When I was introduced to the security industry in the 90's, what I encountered was puzzling to me. I guess I watched too much TV and thought this was the place for cutting edge technology; to my surprise what I found was an industry in the dark ages. Why, because the industry icons were not schooled in Information Technology and the customers they were selling too knew less then they did. It was the blind leading the blind.

In talking to surveillance directors the frustration was evident. They were being called upon by management to be the guru of this coming age of digital technology and had about as much knowledge in that skill set as they do in nuclear physics. Whatever education they were able to find was usually skewed to one side to facilitate a manufacturer's products, even though it may have been so far off the mark.

In writing this book, we have tried to take the mystery out of digital video. There is no black magic and the underlying technologies are well known and developed. There are endless research papers developed by the world's leading companies on the subject. We have tried to translate the information into layman's terms. I can only say do your homework and ask the right questions and don't take anything for granted, the cost of a poor decision, well could result in your early retirement!

Chapter 1

A Brief History of the DVR

Whether you are new to digital video surveillance or experienced; this guide will provide you with valuable and comprehensive information on DVR technology and digital video surveillance systems. You will quickly learn that all DVR's and surveillance solutions are not alike. Quality, performance and reliability vary widely. It's not what the manufacturers and integrators do tell you, rather what they omit. The object of this guide is to make sure the products and solutions you specify meet your required specifications and overall objectives.



DVR technology for security began in the early-to-mid 90's with mechanical-type devices. They typically were operated by remote controllers and buttons or dials on the DVR box itself. Easy to operate, their functions and keys were similar to a device users were already familiar with; the VCR. Unfortunately, due to technological limitations, early DVR's were not reliable, had limited features, offered poor quality video recording and were not powerful enough or designed properly to provide solutions that could address managing large amounts of cameras and video.

Customers required more capable and reliable systems, which resulted in the introduction of PC-based DVR's.

The PC-based DVR brought enhanced features and were programmable, but the early models were plagued by inherent reliability problems and still did not have the requisite robustness in order to manage anything of substantial size.



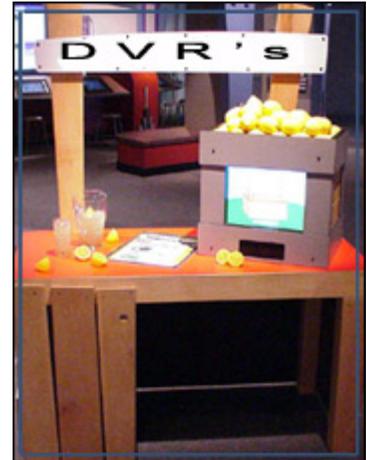
Today, both PC based and non-PC based DVR's and related solutions are much improved over their early predecessors. Considerable advances in digital video technology and equipment have opened as many doors to users as they present challenges and quality issues for manufacturers.

Chapter 2

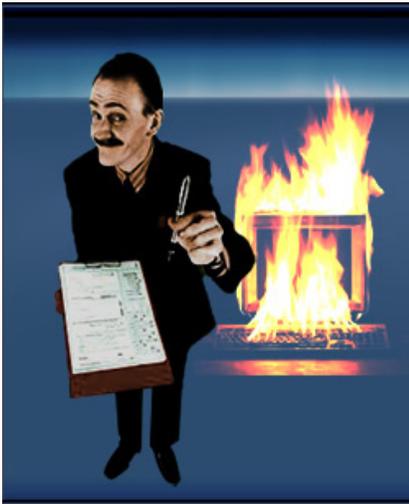
Common DVR Myths

Many people have the misconception that a PC-Based DVR is merely a PC with video capture (encoder) cards, display (decoder) cards and some off-the-shelf software. This explains the presence of hundreds of DVR and security companies that have literally sprung up overnight.

While these companies may hold themselves out to be “*manufacturers*” and security specialists - beware - few can deliver what they promise. In later chapters, we will discuss some of the “*sleight of hands*” to throw the unknowing off the track- in the quest of anything to make a sale.



At a recent security industry trade show we attended there were hundreds of exhibitor booths with DVR's on display. In fact, it was difficult to find a booth without one. Many possessed attractive literature and some phenomenal marketing claims. However, many were unable to provide a live demonstration of their equipment and just limited it to a “*canned*” and “*controlled*” demonstration. Others, when trying to show the features listed in their sales brochures upon specific request, experienced problems.



A true DVR, meant for security, is a sophisticated system composed of specialized hardware, software and sub-assemblies with built-in checks and balances. It all must work in unison to create a robust and reliable solution. There is no margin for error. Down-time costs money.



Building a DVR surveillance system requires a dedicated team of software and hardware engineers, programmers and system designers, plus support personnel. They take years to develop and go through extensive testing.

So when a salesman tells you how their company manufactures the product and is doing all these wonderful things and it's a 2 or 3 person organization, well let's just say it sounds a little hard to digest.

The fact is the majority of even the household names in the security business are ill equipped to manage the task. The obvious question is what seems to be the problem?

The obstacle for security companies is the mere fact that digital surveillance is an "IT" business. Information Technology is a world away from the culture that has been developed by these security companies, over decades. It is no longer analog cameras plugged into a VCR; rather, it's IP, networking, fiber infrastructure, data management, encryption, security, firewalls, routers, bandwidth issues, etc.



It's a completely different business and architecture that not in any way resembles the legacy analog technology. It requires different personnel, different skill sets, different cultures, etc. It's the Flintstones® trying to operate in the Jetsons® age.

This may account for why 90% of the product peddled by the major security companies is nothing but private label solutions, to some extent, using third party technology. This explains the myriad of installation debacles prevalent over the last few years. When a problem arises, the reliance to resolve issues goes back to the true suppliers, which in many cases are half a world away in a foreign language.

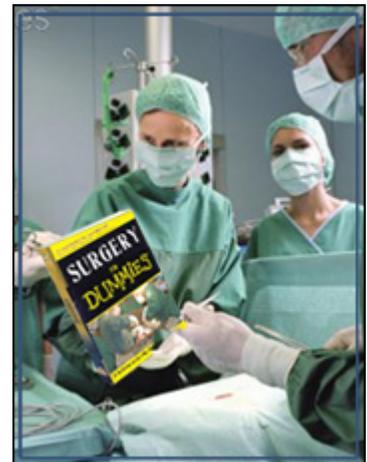


This conundrum holds true on both sides of the fence. The surveillance buyer is ill equipped to understand the nuances and what expectations they should have. They are relying on the manufacturers to provide them with the appropriate information.

Unfortunately, if the information is incorrect, how are you supposed to know?

Even professionals are confused as to what is and is not possible; what is and is not acceptable; what is coming down the road; and what technologies accomplish the goals required.

The amusing thing is sales people, installers and others from the old school are used to half day courses on learning a security product and often figure... ok, I will take a half day course in networking and PC's and learn this stuff. It is much to their chagrin when they find out people attend school for years, just to learn the basics of IT.



When people approach us and ask can you teach me the basics in a morning session, my response is usually no problem and in the afternoon we can follow that up with a half day session on performing brain surgery.

Chapter 3

What is a Security DVR

Unlike a VCR, the DVR has many advanced features and can also be operated and viewed remotely via local network **(or even an Internet connection, which most regulators prohibit.)** A Digital Video Recorder differs from a VCR in several important ways, some more obvious than others.

Instead of recording video and audio data to a tape, the DVR records to a computer's hard drive or removable media such as a CD or DVD.

Computer hard drives:

- Are more reliable (no tape jamming, degaussing or signal loss)
- Can store far more recorded material (weeks, months, years)
- Offer better video quality (tape wear causes signal loss)
- Are automated (no need to worry someone forgot to push the record button or change tapes)
- Protect data effectively
- Are automated (no need to worry someone forgot to push the record button or change tapes)



Cassette tapes:

- Are bulky
- Are vulnerable to loss of data
- Have to be replaced frequently to maintain good quality
- Can easily be tampered with and data manipulated



There really isn't much more of a choice any more, as the primary manufacturers of VCR's have ceased production as of the end of 2005. Even videocassettes are becoming harder to locate.

Video and audio stored on a DVR can be:

- Accessed quickly and efficiently
- Viewed or retrieved locally or remotely
- Viewed simultaneously by multiple users
- Tied to alarm systems
- Authenticated for court admissibility



Chapter 4

PC-Based Vs. Non-PC-Based

One of the most frequently asked questions about DVR's is: Which is better a PC-Based or Non PC-Based DVR solution?

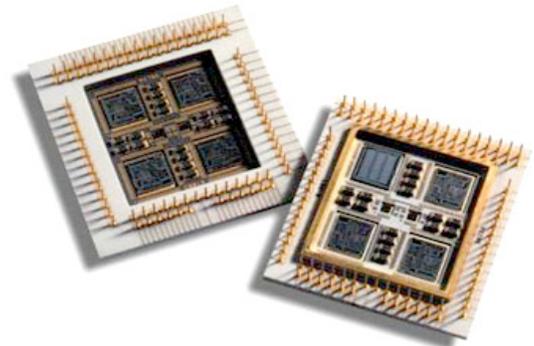
There isn't much that a non-PC based DVR solution cannot do today, which a PC-Based DVR can. The difference has more to do with the *"footprint"*. PC interfaces tend to be more user-friendly and less *"mechanical."*

PC-Based DVR's tend to be more flexible and easier to manage. PC-Based solutions also tend to allow for upgrades of compression technology, which can be vital to the end user. Remember, in the IT world, you blink and they are onto the next technology.



ASIC Chip

Non-PC-based solutions tend to use *"ASIC"* (Application Specific Integrated Circuits) technology, which does not allow for upgrading of a technology platform, similar to your microwave oven. ASIC, is a chip that is custom designed for a specific application rather than a general-purpose, such as a microprocessor. ASIC, unlike an FPGA, has fixed functionality and is not reprogrammable.



In the PC environment, the latest technology utilizes DSP's (digital signal processors). A DSP is a specialized digital microprocessor used to efficiently and rapidly perform calculations on digitized signals that were originally analog in form, such as audio and video. The big advantage of DSP lies in the programmability of the processor, allowing parameters to be easily changed.

Chapter 6

All DVR's and Solutions are not Alike

DVR's are not all alike. In fact, many are as dislike as automobiles. In the world of DVR's you can find the equivalent of a \$10,000 Kia and a \$100,000 Mercedes Benz plus everything in between. Both may be capable of getting you from point "A" to point "B" but that's where the similarities often end.

Using the vehicle analogy, if you buy a light weight truck it may be a fine vehicle for hauling small loads. But, if you load it up with 10,000 pounds of cargo and drive up and down hills all day you shouldn't expect a very long useful life out of the transmission or engine. It's not that it's a poor product, rather that's not what it was designed to do. Not unlike exotic and sophisticated foreign cars, many



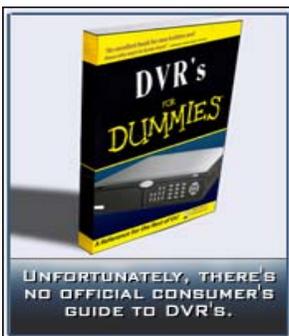
DVR's can be just as complex and temperamental.

Every ounce of computing power is critical. Digital video recording is a process intensive, multi-tasking application which can tax even the most robust systems. Along with processing power, a good DVR depends on equally robust related parts and assemblies. The famous saying in information technology is *"you are only as fast and efficient as your slowest and weakest component."* If your system is not beefed up from end-to-end, from hardware to software, it will be underpowered, will under perform and it's going to break. Even worse, it simply will not deliver any reasonable quality or cause

instability from the outset and probably never meet gaming requirements. I would not want to be the one that approved the purchase of a system that was just installed to only find out gaming has rejected it.



Unfortunately, there's no official consumer's guide to DVR's. It's difficult at best for most buyers to evaluate products on a fair comparison, or to even know; what are reasonable expectations.



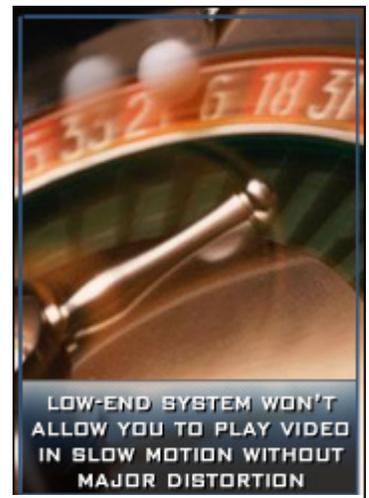
Hobby and consumer class products often parade as commercial and business grade. Don't be fooled. You can buy a blender for your home for \$25.00 but it is not the same as the \$500.00 model at your local bar which may be responsible for making hundreds of perfect daiquiris and Margaritas every night, day-after-day.

Remember, surveillance you are either monitoring or recording 24/7 so that \$25 blender equivalent won't do the job for very long, if at all.

Components become even more of an issue as you get into the large casino systems. Caveat emptor – let the buyer beware – all DVR's are not alike.

For buyers who do not have a lot of experience with DVR's, separating the quality from junk can be a daunting task. Often salesmen and brochures will conveniently fail to mention the things that their system won't do. Often the buyer doesn't realize it until:

- The quality of the recorded video is poor under normal operating conditions.
- There is no ability to playback video in slow motion without distortion and choppiness.
- When you move the PTZ, the recorded video is blurry or blocky.
- You never looked at the video remotely over the network before you bought it and now you realize the remote video quality is sub-par at best.
- The recording and display speeds are not as promised.
- The number of days of storage is far less than specified.
- When you blow-up the video to full screen, the image is fuzzy.
- When you playback recorded video and freeze frames you see double.
- The DVR overheats itself as well as the room.
- The noise created by the system is deafening.
- The DVR's are unstable and continue to reboot or shut down unexpectedly.
- You just decided to expand and purchased additional systems from the same company and they don't work with the old ones because the software or hardware is not compatible since they have no longer use the same supplier or technology platform.
- You can't practically control the DVR remotely from a workstation, as the way you thought it would operate.
- There is no way to burn disks of multiple cameras from different DVR's on a single disk.
- There is no way to synchronize playback video from multiple DVR's on a workstation.
- The networked video at the workstation is not real-time because its bandwidth intensive.
- Certain functions only work under limited or ideal conditions and render other features inoperable.
- There is no one – (at least locally) - to support the product that is technical.



Chapter 7

DVR Card Differences

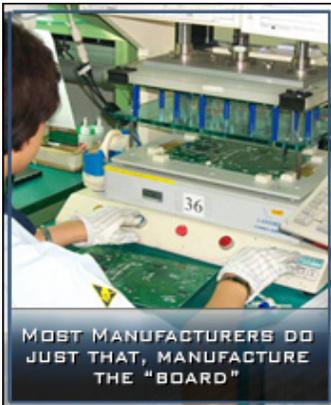
At the heart of any DVR solution is the video capture card, also known as a DVR board or encoder. This component, more than any other, will determine the effectiveness and quality of the DVR system. The encoder is the “*engine*” which powers the vehicle. This video capture card contains, a hardware or software based Codec, which performs the vital operation of capturing, compressing and decompressing packets of video data. **Codec**, which stands for “***compression-decompression***,” will be discussed in greater detail later in this guide.



There are consumer quality, economy cards and components and industrial/commercial grade ones too. There are some with the current technology and others with decade old technology.

Most video capture board and encoder “manufacturers” do just that, manufacture the “board” - that green thing with a bunch of neat looking colorful soldered components.

In reality, these companies are just assembly plants. This is common throughout much of the consumer electronics industry where nearly all companies create products assembled from other companies' components, including all the household names you are familiar with.



So what is it then that makes the difference between, a top notch product and an average to sub-standard one?

We mentioned earlier that the video must be compressed and decompressed. This function requires “*processing*.” Processing is performed by a processor. The processors for decoders are similar in nature to a PC and come in various speeds and abilities. Just as in an Intel processor for a PC you have a Celeron and a P4, etc. Then within those architecture categories are different levels of processing power, such as 1.4MHz to 3+MHz; different bus rates; etc., so goes processors for encoders and decoders. For the gaming environment, the most powerful processors are required to meet acceptable regulatory standards.

In many cases there are multiple processors on a single encoder card in order to maximize performance. Some will have one processor for each channel of video; the more efficient ones are capable of encoding multiple channels of video on a single processor. Once you have the power of the encoding processors, you then require a powerful and efficient compression algorithm to perform the function.

Chapter 8

Bottlenecking

Perhaps the most pressing challenge relating to DVR card performance is bottlenecking.

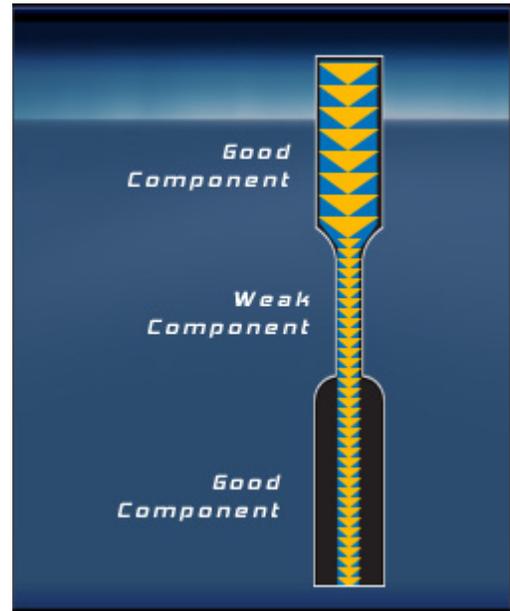
What is bottlenecking?

Say you have 100 garden hoses connected to each other, 99 of which can pump water at 3 gallons per minute, and one hose somewhere along the line, which can only pump water at 1 gallon per minute. In spite of all your 3 gallon-per-minute hoses, the entire system of hoses will only allow 1 gallon of water per minute to pass through.

The same is true in processing video data. *“You're only as fast as your slowest component.”* Put a bunch of good high-performance components on a DVR encoder board and one component is not matched or as fast as the others, and you have a slow, underperforming system.

This brings us to a critical understanding with respect to performance. Many times manufacturers will provide a demonstration and show a limited number of channels of video performing at a certain level. Since the bottleneck will cause the solution to hit a wall at some point they limit the demonstration to stop before that critical point, where system degradation can be observed. So one needs to be careful to see what happens when you use the full capacity of the system.

Bottlenecking is but a single of multiple aspects of where the system may max out before its *“alleged”* capacity.



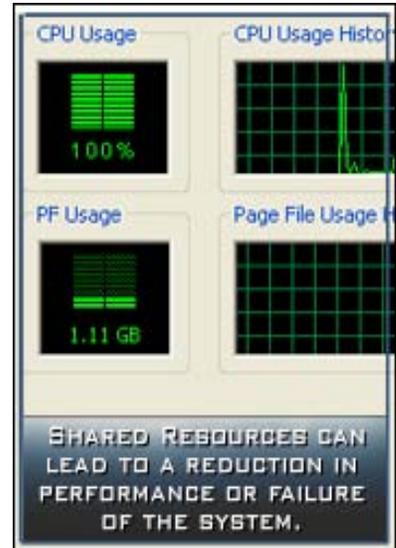
Chapter 9

Shared Resources

Shared resources refer to the condition that occurs when one component is asked to perform multiple tasks simultaneously. Each task a particular component performs drains a portion of that part's total resource and this is why we mentioned that quite often multiple processors or other components are used so that resources are not drained when trying to operate the DVR system at its maximum capacity. In some instances, regardless of how many components are used, the underlying technology is just not powerful enough to drive that many components on a single board or the technologies are not compatible and do not function properly. As an analogy, you can buy the latest Intel processor but only the newer motherboards are capable of handling its architecture. If you try to run the processor it may not function or only function at the maximum capacity of the older architecture. All the pieces have to be compatible.

Beware; manufacturers will quote a specification for their equipment at its ***“maximum”*** performance level, under ideal conditions.

The quoted specification usually assumes the components are doing nothing else at the same time, but rather a single, simple function and not sharing resources. Manufacturers will merely show you functions or features as a single task and not demonstrate the same across multiple channels, knowing that the quality or stability is not otherwise possible. Welcome to sleight of hand 101.



DVR's, encoders, decoders and servers are more often than not called upon to multitask. The problem is that not all hardware architectures and components are up to the task. The logical question would be why doesn't everyone just use the best and most powerful components? The answer comes back to what we stated above; the underlying architecture might be quite outdated and not compatible with the latest components. Some components don't work well with others even though each might be the best in their respective category.

What you may ask is the result of shared resources on the DVR? The answer is the same whether it's shared resources or bottlenecking, the most common problems are ***“dropped frames,”*** choppy, robotic and poor quality recorded images. Which in some cases leads to significant instability and eventual failure as the system is running at 100% of capacity and still not keeping up.

Chapter 10

Frames / Images Per Second

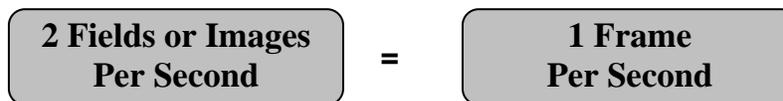
Let's give you a quick lesson in translation and calculation of video "speed" or "frame rates."

Some manufacturers use different expressions when identifying the speed capabilities of their product. It will become increasingly apparent why this is misleading.

- Thirty (30) "frames-per-second"(abbreviated as "fps") is "real-time," "real-motion" video in the NTSC (North America) video standard.
- Twenty-five (25) "frames-per-second"(abbreviated as "fps") is "real-time," "real-motion" video in the PAL (International) standard.

This is not to be confused with "fields-per-second" (also abbreviated as "fps"). Unfortunately, two (2) fields equal one (1) frame. So when a manufacturer states "30 fps" on their literature are they talking fields or frames? Are they talking about each channel of video or total capacity of the system? Are they talking about the system limitation or the operating capability?

Another acronym used by manufacturers is "ips" (images-per-second). Similar to fields-per-second, there are two (2) images-per-second to each frame-per-second; so two (2) images or two (2) fields equal one (1) frame. Therefore, in order to obtain a real-time, real-motion image you require sixty (60) fields or images per second, per camera.



When comparing a DVR's fields (FPS), images (IPS) or frames-per-second (FPS); display, recording or playback performance claims; be careful to take into consideration all the factors that will apply to your particular application. Once again, manufacturers' claims may be based on "optimal" conditions and have little to do with reality and what you are trying to achieve. So always check to see if the total number of FPS/FPS/IPS quoted is for the entire DVR capture card or is it on a per channel basis. Is it for display and record? You simply have to test it anyway, as claims are just that; claims. Besides if you don't the regulators will.

It's kind of like the MPG sticker on a new car. Do you know anyone that ever got that kind of mileage? Not unless they were going downhill, in neutral, with a strong tail-wind!

Remember also what you are viewing live has nothing to do with the recorded quality, they are separate and distinct. So watching a live picture has little value, although if the live video is poor you are already in trouble.

Chapter 11

Image Resolution

Image resolution describes the detail an image holds. The term applies equally to digital images, film images, and other types of images. Higher resolution means more image detail. Image resolution can be measured in various ways. Resolution quantifies how close lines can be to each other and still be visibly *resolved*. Resolution units can be tied to physical sizes (e.g. lines per mm, lines per inch) or to the overall size of a picture (lines per picture height, also known simply as lines, or TV lines).

A television or raster image display with 525 scan lines makes a picture with somewhat less than 525 TV lines of resolution. The term resolution is often used as a pixel count in digital imaging. But when the pixel counts are referred to as resolution, the convention is to describe the pixel resolution with the set of two positive integer numbers, where the first number is the number of pixel columns (width) and the second is the number of pixel rows (height), for example as 640 by 480.

Another popular convention is to cite resolution as the total number of pixels in the image, typically given as number of megapixels, which can be calculated by multiplying pixel columns by pixel rows and dividing by one million. Other conventions include describing pixels per length unit or pixels per area unit, such as pixels per inch or per square inch.

NONE OF THESE PIXEL RESOLUTIONS SUCH AS 704 X 480 OR 640 X 480 ARE RESOLUTIONS THAT DEFINE QUALITY, EVEN THOUGH THEY ARE WIDELY REFERRED TO AS SUCH; THEY MERELY SERVE AS UPPER BOUNDS ON IMAGE RESOLUTION.

A **pixel** (short for **picture element**, using the common abbreviation "pix" for "picture") is one of the many tiny *dots* that make up the representation of a picture in a computer's memory. Each such information element is not really a dot, nor a square, but an abstract sample. Pixels in an image can be reproduced at any size without the appearance of visible dots or squares; but in many contexts, they are reproduced as dots or squares and can be visibly distinct when not fine enough.

A pixel is not a little square. A pixel is generally thought of as the smallest complete sample of an image. The definition is highly context sensitive; for example, we can speak of printed pixels in a page, or pixels carried by electronic signals, or represented by digital values, or pixels on a display device, or pixels in a digital camera (photosensor elements). This list is not exhaustive, and depending on context there are several synonyms that are accurate in particular contexts. We can also speak of pixels in the abstract, or as a unit of measure, in particular when using pixels as a measure of resolution, e.g. 2400 pixels per inch, 640 pixels per line, or spaced 10 pixels apart.

The more pixels used to represent an image, the closer the result can resemble the original. The number of pixels in an image is sometimes called the resolution, though resolution has a more specific definition.

Chapter 12

Bitrate

Many customers specify a standard for video quality, which in fact specifies no quality at all. Huh??? Ever heard the terms CIF, 2CIF, 4CIF or D1?

CIF (Common Intermediate Format) is used to standardize the horizontal and vertical resolutions in pixels of YCbCr sequences in video signals. A CIF is commonly defined as one-quarter of the 'full' resolution of the video system it is intended for (listed below as 4CIF). Note that this full resolution does not match what is currently referred to as D1 video (based upon Sony's D1 format).

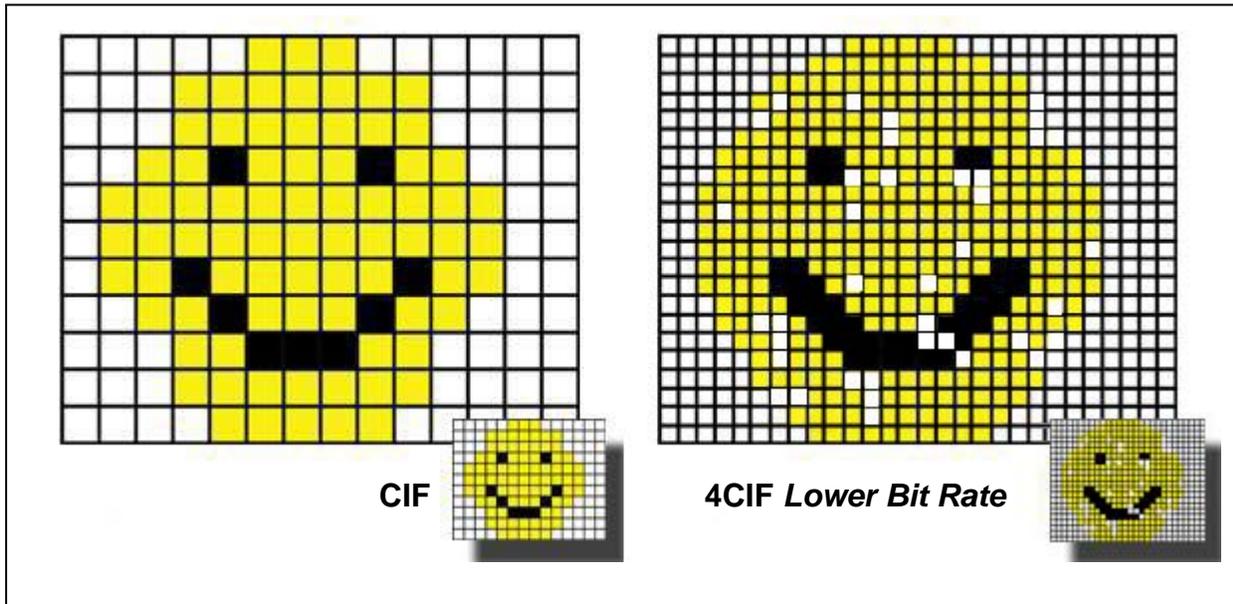
Video Resolutions (in pixels)		
Format	<u>NTSC</u> - based	<u>PAL</u> - based
CIF	352 × 240	352 × 288
4CIF	704 × 480	704 × 576
D1	720 × 480	720 × 576

NTSC is the video system or standard used in North America and most of South America. In NTSC, 30 frames are transmitted each second. Each frame is made up of 525 individual scan lines.

PAL is the predominant video system or standard mostly used overseas. In PAL, 25 frames are transmitted each second. Each frame is made up of 625 individual scan lines.

The problem with these standards is that these “resolutions” speak nothing of the quality of the video. 4CIF simply means that in the NTSC format there are 704 pixels that will be filled with some amount of data across each of 480 lines. CIF means, there are 352 pixels which will be filled with some amount of data across each of 240 lines. How much data has yet to be determined, which is the bitrate.

While a 4CIF image *“can”* produce a better quality image than a CIF image because the more pixels used to represent an image, the closer the result can resemble the original; it does not necessarily have to be the case. 4CIF does not mention the amount or quality of the data to be displayed in the pixels. These are *“empty”* pixels. Pixels need to be filled with data. Data is referred to in terms of “bits.” Accordingly, a CIF image filled with more bits than a 4CIF image can produce better visual and audible results.



In telecommunications and computing, **bitrate** (sometimes written **bit rate**, or as a variable R_{bit}) is the number of bits that are conveyed or processed per unit of time. In digital multimedia, *bitrate* is the number of bits used per unit of time to represent a continuous medium such as audio or video. It is quantified using the **bit per second (bit/s)** unit or some derivative such as Mbit/s.

While often referred to as *“speed”*, bitrate does not measure *distance/time* but *quantity/time*, and thus should be distinguished from the *“propagation speed”* (which depends on the transmission medium and has the usual physical meaning).

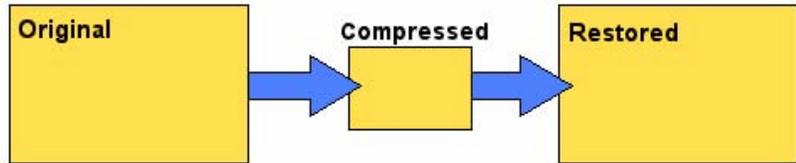
In digital video, bitrate represents the amount of information, or detail, which is stored per unit of time of a recording. The bitrate depends on several factors:

- the original material may be sampled at different frequencies
- the samples may use different numbers of bits
- the data may be encoded by different schemes
- the information may be digitally compressed by different algorithms or to different degrees

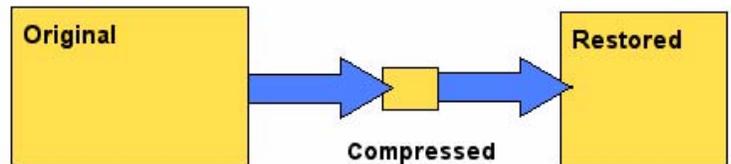
Generally, choices are made about the above factors in order to achieve the desired trade-off between minimizing the bitrate and maximizing the quality of the material when it is recorded or played.

In digital video to reduce the bitrate a “lossy” compression is utilized. A lossy compression is a compression method that discards some of the information or data to make a video or audio program occupy less storage space or less transmission bandwidth.

LOSSLESS



LOSSY



If lossy data compression is used on audio or visual data, differences from the original signal will be introduced since data has been discarded. If the compression is substantial, or lossy data is decompressed and recompressed, this may become noticeable in the form of compression artifacts, which appear in the form of blocky mosaic images. Whether, these

affect the perceived quality, and, if so how much; depend on the compression scheme, encoder power, and the characteristics of the input data, the viewer's perceptions, and the viewer's familiarity with artifacts.

Ostensibly what we are saying is quoting a specification as 4CIF doesn't mean a thing. Further, even quoting a specified bitrate at a particular resolution, also means nothing, because of the amount of variables as described above.

Many times the encoding power or compression scheme is insufficient regardless of the bitrate to generate “usable” video, because of it being applied with outdated technology.

So what is a customer to do? We will discuss some overall general rules of thumb and concepts; but, they are by no means the Holy Grail.

In order to view good quality 4CIF recorded video the following bitrate estimates may apply using the specified codecs:

- H.264AVC:** 1 – 2 Mbps
- MPEG4 (Part 2):** 2 – 4 Mbps
- MPEG2:** 3 – 6 Mbps

Just because you use the above bitrates does not necessarily mean you will have acceptable quality video. These are general numbers for the particular codec and do not account for all the other potential issues we have discussed in this guide.

The higher the bitrate the more storage it requires and the slower the download and transmission time. This comes back to the truck that needs to pull 10,000 pounds. The bigger file sizes created by the high bitrates require a lot more resources to move them along.

What does this mean in terms of how much hard drive space is required? Again, it's an estimate based upon our evaluation and testing of various systems in the marketplace and speaking with professionals who have also tested the same equipment. There could be significant variations depending upon multiple factors, but for the highest possible quality this is a good rule of thumb.

H.264AVC: ½ – 1 GB per hour

MPEG4 (Part 2): 1 – 2 GB per hour

MPEG2: 1.5 – 3 GB per hour

This is assuming the bitrates mentioned above, with "acceptable" video quality at 25/30 frames per second (PAL/NTSC). Remember this is the highest quality, which may not be required in all instances.

There are several other things that would skew in the favor of the newer codecs and make them even more attractive. H.264AVC uses what is known as a Variable bit-rate (VBR). VBR allows a codec to change its bit-rate dynamically to adapt to the "difficulty" of the audio and video being encoded. In the example of a swinging PTZ or other rapid movement, a higher bit-rate to achieve good quality is required, while less active scenes can be coded adequately with fewer bits. For this reason, VBR can achieve lower bit-rate for the same quality, or a better quality for a certain bit-rate. Hard drive capacity can be substantially increased. The older codecs use a Constant bit-rate (CBR). Therefore, there are no efficiencies regardless of the scene activity; the bitrate is constant to whatever it has been set to in the firmware.

As we cover all these topics it becomes more evident why the move to digital surveillance has been slow. Fact is, it's not so easy to comprehend, plus the underlying technology required to provide video to a high standard was just not there until the last couple of years. It was a combination of the lack of powerful enough components and efficient compression technology.

Chapter 13

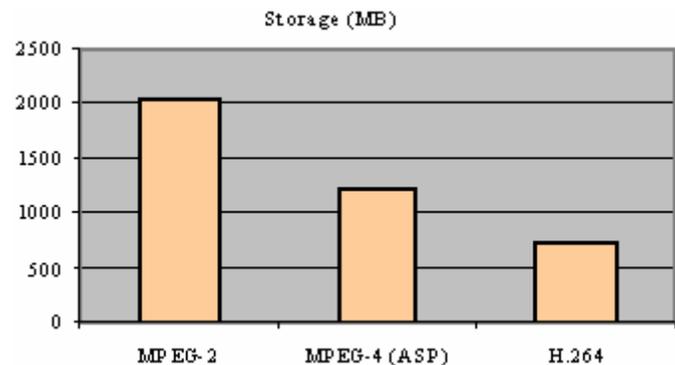
Storage

So why do we need to understand bitrate and compression?

Ultimately, in order to accurately determine how much hard drive space you will need with your DVR you need to take into consideration the codec technology being implemented, image resolution size, the bit-rate/compression ratio, the amount of video activity, is the bitrate variable or constant, and if motion detection (setting the DVR to only record activity when the camera detects motion in its field of view) is being utilized. Next, calculate the number of cameras and how many frames per second you want to record on each.

Advanced DVR systems, will allow you to independently control each channel for:

- Image resolution
- Bit rate (constant/variable)
- Display frame rate
- Record frame rate
- Motion detection



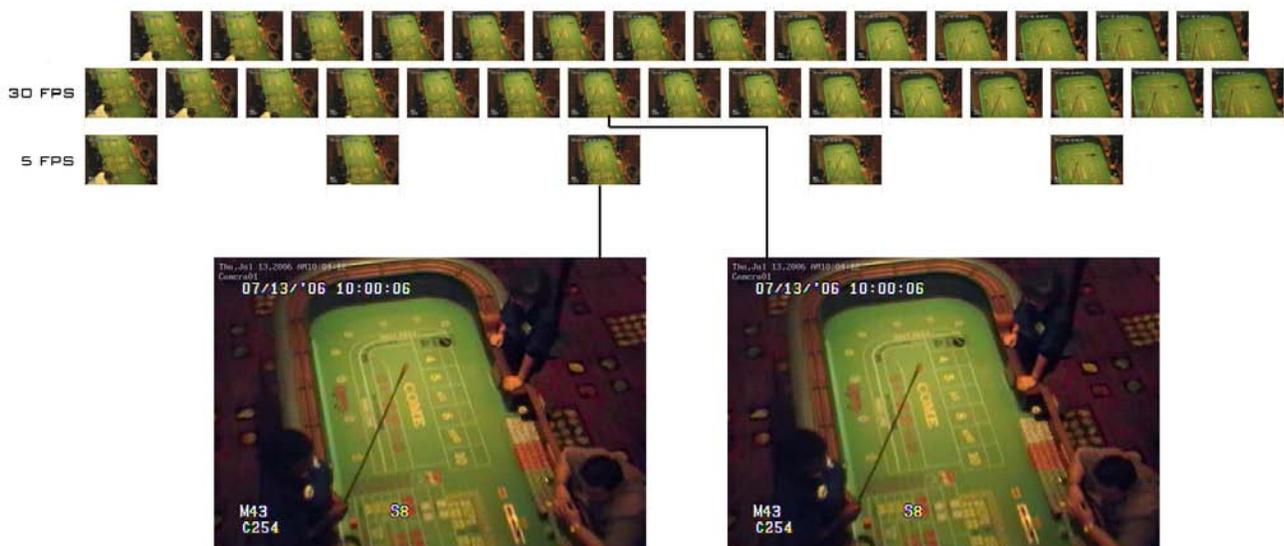
When evaluating storage requirements remember to evaluate the quality of the video based upon the most intense circumstances. Bitrates can be reduced significantly, if there is minimal motion, but when it comes time to maximum motion, the image can be distorted.

Chapter 14

Video Quality Vis-à-vis Frames-Per-Second

The number of frames per second has nothing to do with the image quality. While 30 frames per second is real time in NTSC, it is made up of 30 individual snapshots of sort. So while a video recorded at 5 frames-per-second has 1/6th the number of images, it does not have 1/6th the quality; it merely has fewer snapshots (that is of course if everything else is equal – such as bitrate, resolution, etc.) Remember, it is nothing but a succession of still images.

So why is there a need to record in real time? After all human beings don't move that quickly, or do they? We are not recording speeding cars. One answer is from a prosecutorial standpoint, what happened in between, if you are not looking at the whole picture. If you are recording in real-time, there is no room for hypothecations by the defense lawyers. Further, a more detailed picture can make it easier to identify sleight-of-hand movements. You are also going to find that older technologies have trouble with slow motion and smooth playback under those conditions, so higher frame rates tend to compensate for some of the shortfalls, but not all. In reality unless it's mission critical applications 5 frames per second is more than enough to accomplish the task, which is what many bank and institutions use; some even less.



A still shot from a recording at 30 FPS will look the same as one at 5 FPS

Chapter 15

Size Matters

A file is a collection of data. File size refers to how much data is contained in this single unit of measure. The larger the file size, the more bandwidth (the amount of data that can be transmitted in a fixed amount of time) and computer resources are required to display, record and transfer a file.

Conversely, a smaller file, of the same amount of data, will use fewer computing resources, display and record more effectively and will transfer across networks more efficiently.



The size of a file of video data can be affected by image size (resolution), bitrate, motion, compression and various other factors, as previously discussed. Ultimately this can affect the amount of video you will be able to store on the DVR's hard drive and overall performance when viewing and recording multiple cameras simultaneously. As cautioned previously, beware of performance claims; they are usually referring to results achieved under the most optimal conditions.



As a rule, the higher the compression ratio, the smaller the file size. The smaller the file, the less sharp the image, the quicker the transmission speed, the less storage space and processing power required. Conversely, a lower compression ratio results in a larger file size, sharper image with a slower transmission speed and more storage space and processing power required.

A good way to understand compression is to think of the printer attached to your computer. If you print with a higher resolution the quality is better but it takes longer to print because:

- there is more processing power required
- more memory to buffer
- more dots per inch to process
- more ink (data) to lay down

Using a lower resolution which generates lower quality is faster because:

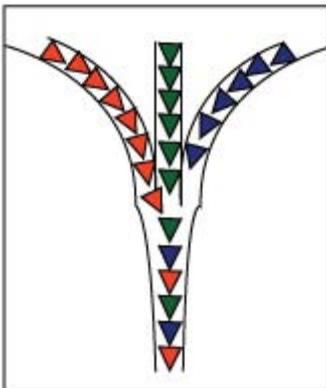
- there are fewer dots to process
- less memory to buffer
- less ink to lay down

This reverts back to a previous issue of speed claims. When they say your printer prints 20 pages per minute, it's usually not based on the highest resolution or with full pages of ink coverage, but the maximum possible on low resolution with the manufacturer's definition of "normal" print coverage. Again, like the MPG ratings!

The fact is, older compression technologies produce larger file sizes, since they are not as efficient as the newer technologies. Accordingly, they require more processing power, which begs the question; can it generate enough power to provide a working solution with such large file sizes? The answer in most cases is a resounding, no. This is why many manufacturers will use multiple pieces of hardware with fewer channels of video to try to compensate for the shortfalls.



Newer compression technologies can compress video more efficiently and therefore result in less power required across the board. This is why in many cases older technologies are more expensive than the latest; because the storage requirements can be as much as 3x greater, as well as the amount of equipment.



Large file sizes bring several interesting challenges for your DVR solution. One primary concern is the majority of DVR users want to be able to watch video remotely. So the video must be transmitted across a network. As such, bandwidth becomes a major concern and in some cases a mathematical improbability for older technologies.

We return to the garden hose analogy. If the garden hose can only accommodate one gallon of water per minute (e.g. your network connection) and you are trying to pump water from a source (e.g. the video data stream) which requires 3 gallons per minute we have ourselves a physics problem.

The water (video data) backs up (latency). Now let's add to the conundrum, what if you wanted to receive water from another source at the same time (video data from multiple DVR's simultaneously) – the result is the throughput has been further cut. In terms of video what you end up with is chopped up and sometimes frozen images.

The bit rates below are for uncompressed color frames at 30 frames per second NTSC:

CIF 36.5 Mbps

2CIF 73.0Mbps

4CIF 146.0Mbps

What do these numbers mean? A single 4CIF uncompressed image is 146Mbps. Typical network cards can only accommodate a maximum of 100Mbps. Therefore, a single camera would ostensibly surpass the capacity of the network. So what happens when you have to transmit multiple cameras? The answer is, it cannot handle it. While there have been improvements in network cards which now approach Gigabit speeds (1000Mbps), there is still the issue of the capacity of the encoding and decoding cards. They simply cannot handle the task. The processing power is too great. Therefore, in order to transmit camera images compression technology is utilized.

Chapter 16

Codec Algorithms

Raw uncompressed video as you see uses a tremendous amount of data. In the gaming environment we want to transmit and store, many simultaneous camera images on as few a servers as possible. In order to accomplish this task practically and efficiently the data requires compression before it can be transmitted or recorded.

Compression is performed when an input video stream is analyzed and information that is indiscernible to the viewer is discarded. Each event is then assigned a code – commonly occurring events are assigned a few bits and rare events will have more bits. These steps are commonly called signal analysis, quantization and variable length encoding.



The more the images are compressed, (meaning more information has been discarded), the lesser the quality. The challenge becomes to have the maximum amount of compression yet retain a certain standard of quality. Obviously, at some point if the video is compressed too much you end up with unusable video.

Older technologies, which use “simple” codecs, cannot do this efficiently. The newer codecs are “*complex*” and can intricately analyze an image resulting in better video transmission, smaller file sizes and superior image quality. Newer codecs can efficiently compress video more than 100x.

		Standards		
		MPEG-2	MPEG4	H.264
Features	I, P, B-frames	✓	✓	✓
	Interlace	✓	✓	✓
	Coding	Huffman	Huffman	Huffman or Arithmetic
	Block size	fixed 16x16	fixed 16x16	variable down to 4x4
	¼ pixel		✓	✓
	GMC		✓	
	Loop Filter (aka deblocking filter)			✓
	Slice-based motion prediction			✓
	Multiple reference frames			✓
	MB AFF (improved interlaced management)			✓
	RDO (Rate Distortion Optimisation)			✓
	WP (Weighted Prediction)			✓
	Switching pictures (for fast change channel)			✓

Encoding Standards Applications

Codec	Goal	Quality / Bit rates	Comments
MPEG -1 International Standard (1992)	Achieving plausible video and audio recording and transmission at approx. 1.5Mbps for VideoCD at CIF standard.	VHS quality at 1.5Mbps. Typical resolution CIF.	Nearly every computer supports MPEG-1 files. Typically used for lower resolution video, but can be used for any resolution. Progressive only.
MPEG-2 International Standard (1994)	High bit rate and broader generic applications, including TV, Broadcast, VOD, consumer electronics, including coding of interlaced video and HDTV.	High quality, typically full D1 resolution (MPEG-2 is used for Broadcasting and DVD) at 6-8 Mbps.	Application: Digital TV, HDTV, DVD, digital cable, satellite and terrestrial broadcast.
MPEG-4 Part 2 Visual H.263 (1998)	Covers very low bit-rate applications. In addition to video coding, Includes generic multimedia framework for animation, textures, 3D meshes.	DVD quality at 4 Mbps. VCR quality at 2 Mbps Provides 1.5 times better compression as compared to MPEG-2 standard, given the similar video quality level.	Application: Digital television; Interactive graphics applications (synthetic content); Interactive multimedia (World Wide Web, distribution of and access to content).
MPEG-4 Part 10/AVC H.264 (2003)	All video requirements from High quality HDTV to low bit rate for cellular networks and a myriad of solutions from security to IPTV.	DVD quality at 2-3 Mbps. VCR quality at 1-1.5 Mbps Provides 2.5-4 times better compression as compared to MPEG-2 standard, given the similar video quality level.	The most advanced standard with fidelity extension ranges approved in April 2004 as the new High Definition TV Standard. New extensions allow for advanced broadcasting and video editing. Open standard adopted by all major industry participants (Intel, Microsoft, Apple, Cisco, Motorola, IBM...)

There are 2 types of compression; hardware and software. It is actually a case of compression and decompression.

When using hardware compression there are minimal loss of efficiencies, as all the work is being done on the DVR capture card by hardware components designed for that specific function. That is of course if you have all the right components.

Software compression utilizes software to instruct the computer's processor and memory to perform specific operations. As encoding and decoding functions are very intense, the

processor and memory are taxed to their limits and beyond. It becomes further exacerbated when the computer is asked to perform multiple tasks simultaneously and there is just not sufficient power to perform. As the processor is being stressed it generates heat and accompanying noise. This leads to concerns of overheating and instability.

This is why we talk time and again about the system being designed to perform the function it is being asked to do; which explains why many DVR's are only capable of performing certain minimal tasks. Meaning, trying to record and display high quality real time images on multiple cameras simultaneously is not going to happen on low-end DVR's running software compression.

Codec Comparison

The Codec, which stands for **co**-mpression **dec**-ompression," is a program or algorithm that lies at the heart of the DVR/video capture encoder card. The quality of the codec being run on your video capture card can make or break your system's visual and overall performance.



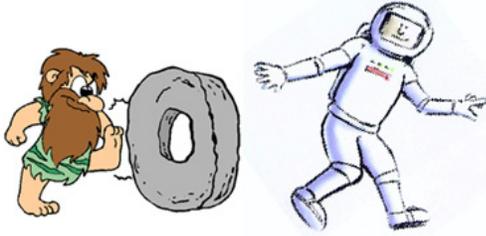
Poor Codec Compression Vs. Good Codec Compression

Not unlike computer processors and other digital technology, codecs have evolved rapidly over a relatively short period of time and continue to evolve and improve as we write these words.

The algorithm underlying the older codecs such as MPEG4, MPEG2 and wavelet is the

Huffman Algorithm, which dates back to the 1950's. The more current H.264 codec uses both the old Huffman algorithm and the new Arithmetic technology.

One of the headaches legacy security companies have is, they are accustomed building a black box that they can sell for years. Not so the case in IT. It is a continuous process that requires constant updating and modification to stay current; which is why many leave it to the IT savvy companies to produce, while they merely market.



In the information technology ("IT") world we often speak of 180 days as one lifetime. Think about when you buy a PC - how long is it before the next greatest model is on the market? Every Christmas there is something new and usually at some point in between there are other advancements. So think about using an algorithm that dates back 50 years. Processing speeds of DSP's have increased almost 50% in the last year alone.

MJPEG

One of the oldest Codecs still in use. MJPEG (Motion JPEG) is usually found in the least expensive and lowest performance DVR's. While capable of providing decent image quality, MJPEG is inefficient, resource intensive and requires massive amounts of storage space. It hogs bandwidth, which impedes network transmission. It has little use in an enterprise environment.

MPEG2

MPEG2 is a very common codec and has been in widespread use for more than a decade. It has a good reputation as a stable codec and, up until a few years ago, was the choice of most broadcast professionals. While smaller in file size than MJPEG it is still larger and more difficult to transmit across networks than newer codecs. MPEG2 dates back to the mid 1990's.

MPEG-4

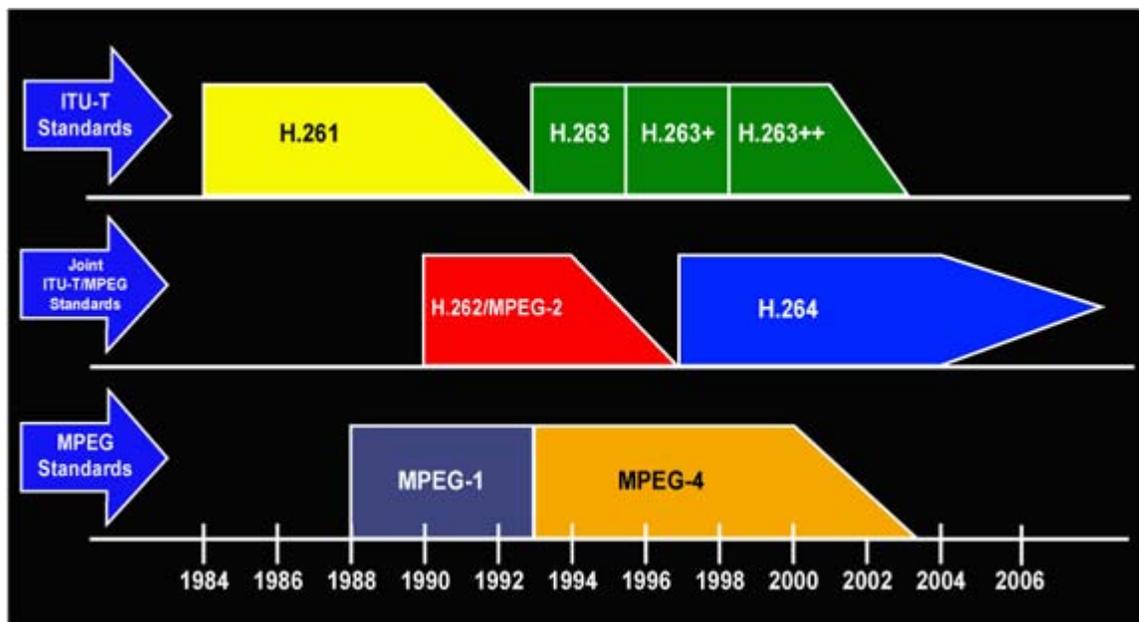
MPEG-4 (Part 2) is an object-based compression. In MPEG4, individual objects – rather than a scene of objects - are tracked separately and compressed together to create a data packet. This results in more efficient compression than MPEG2 or MJPEG and it is scalable, from low bit rates to very high. MPEG4 is approximately twice as efficient as MPEG2. MPEG4 dates back to the late 1990's.

H.264

Most recently H.264AVC, also known as **MPEG-4 Part 10 (Advanced Video Coding)**, has emerged as the leading codec for commercial video compression technology. Offering still significantly greater compression than its predecessors, H.264 provides up to 25% better compression than the current MPEG-4 ASP (Advanced Simple Profile). It also has the best image quality, smallest packet size, provides DVD-quality video and transmits video more efficiently over networks than any of the previous technologies. Unlike the previous codecs it is able to negotiate rapid complex images and provide razor sharp quality. H.264AVC is the first of what is known as a complex codec. The following chapter compares the different compression technologies.

Be very skeptical of people who say they have a proprietary codec and that it's not MPEG or whatever. Codecs are incredibly complicated to develop and are created by consortiums of some of the world's leading companies. The amount of years it takes to develop these applications with the number of people and companies involved make it highly unlikely anyone can develop a proprietary codec.

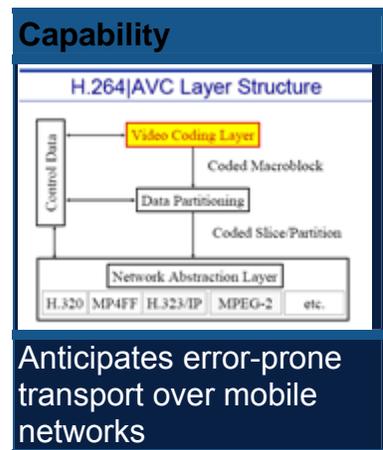
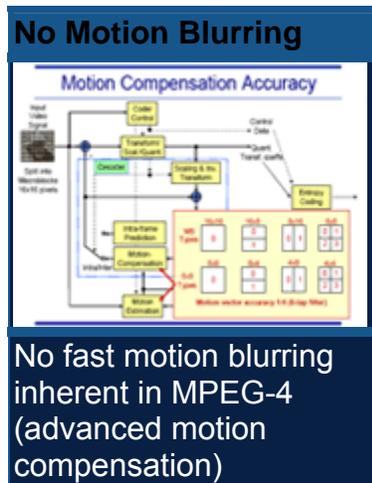
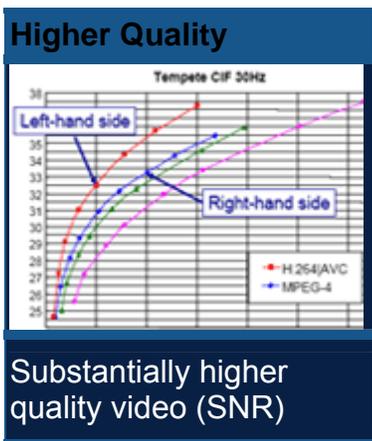
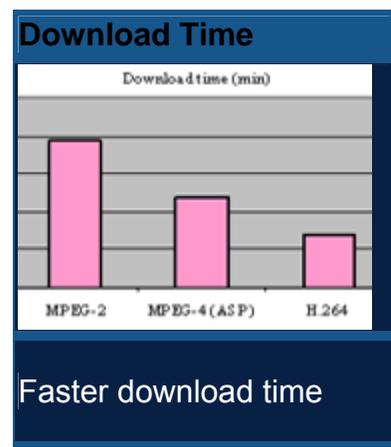
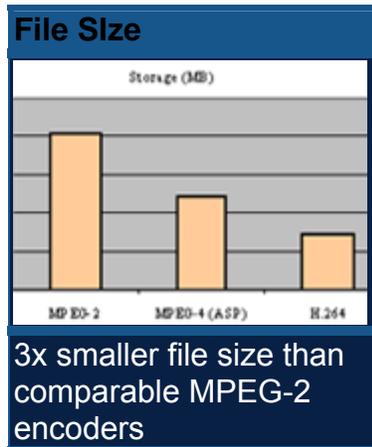
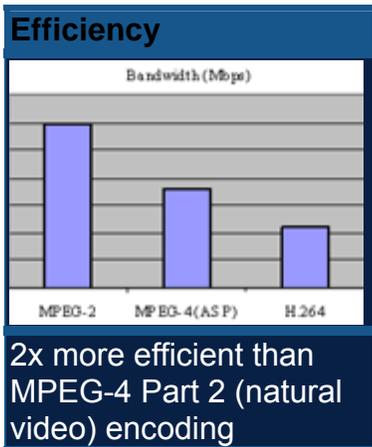
Where this is misleading is, each DVR manufacturer needs to modify the standard codec slightly in order to secure the data, so it may not be easily manipulated. This is important with respect to court admissibility. So technically speaking, each manufacturer's solution is in a way proprietary but based on the standard codec.



Chapter 17

Compression Technology

Compared to prior generations of MPEG4 and MPEG2 technologies, H.264AVC video quality and performance is significantly better. Even with its higher quality video the H.264AVC file packet size is at least 25% smaller than MPEG4 and 50% smaller than MPEG2, requires significantly less bandwidth and offers rapid download times. Unlike the earlier MPEG technologies, H.264AVC is capable of stabilizing images.



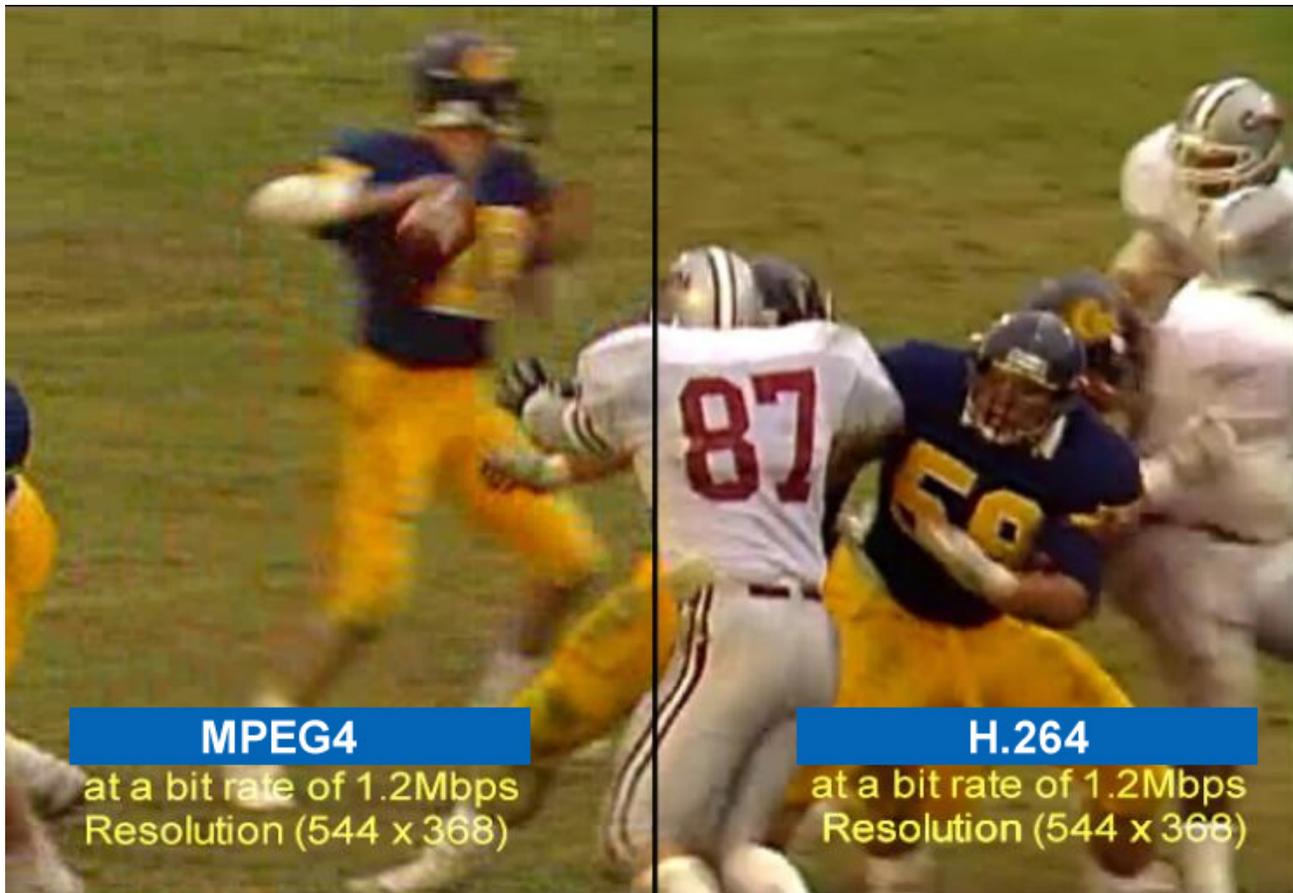
In contrast with 11-year-old MPEG2 and 7-year-old MPEG4 standards which were developed for TV and entertainment, the H.264 codec was designed with commercial security as one of its applications in mind.

H.264AVC is the standard for HDTV and runs everything from your mobile phone to Playstation, Quicktime and has been adopted by everyone from Microsoft and Apple to Intel and Motorola.

Chapter 18

Compression Technology Challenges

One of the problems of the older MPEG formats is their inability to properly record fast moving objects. When objects are moving quickly DVR's with older "simple" Codecs have a tendency to record blurred or distorted images, including mosaic patterns as you may observe sometimes on digital television broadcasts using similar technology.



While a scene or image is being processed, the next scene follows in sequence. As a result, there is latency, even if in milliseconds, due to time required to compress and decompress the images. Accordingly, when it can't keep up there are voids.

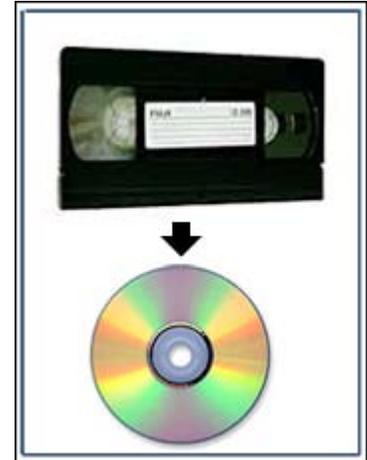
In order to efficiently negotiate a transition from one frame to the next; the codec needs a way to identify and predict what is happening in the coming scene. "Simple" codecs do not have the best of abilities to compensate or predict; resulting in potentially blurred or blocky images.

So beware. When evaluating a DVR solution for video quality, it's not the images with minimal motion that are of as much concern as the ones containing rapid motion. In older

compression technologies, to minimize the “*blockiness*”, the bitrate is boosted to a high level. This introduces the other concerns previously discussed of necessary resources to drive the escalated bitrate.



Can it still record 30 frames per second, without dropping frames and can it perform across multiple channels simultaneously? Is it going to overheat? Is it going to crash?



Also, by boosting the bitrate, which means larger file sizes, the storage requirements become massive. In the end, there is no fix for fast moving images using older codecs, the best that can be hoped for is a reduced amount of mosaic images with large storage requirements.

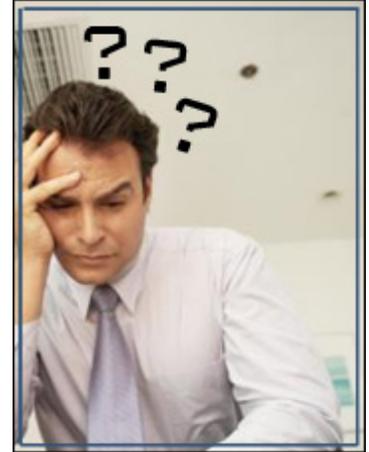
Part of the problem is older compression technologies were never designed for security or the new digital era. The first concern was simply how to compress video from a tape to a CD or DVD. So the variables and environment were somewhat controlled.

Chapter 19

Why is Everyone So Slow to Adapt

Why haven't the old well-known names in security moved over to the newer technology?

First, it's important to understand that only a few years ago the CCTV business was strictly analog. It was simply connect a camera to a monitor, VCR or switch. These companies were ill equipped to deal in the information technology age. A transformation had to occur. These old time companies were accustomed to bringing to market a product in two-plus years, and running with it forever. Between the old methods and the lack of understanding of the newest technologies they have been slow to adapt but are now rapidly coming up to speed.



Part of the problem was 9/11 created an impetus to have an immediate solution even though the technology of the time was just not ready. Therefore, the foundation and building blocks for a solution were flawed from the start. The troubles were compounded by further development on the deficient platform instead of waiting for proficient technology. Why didn't they change? How do you tell a customer that all the equipment you've been selling him for the past 5 years won't work, and it's not compatible with anything new that actually might work?



As previously discussed, many manufacturers rely on third parties, so they are at the mercy of their suppliers.

So when manufacturers eventually move to the new platform will they be on even par with everyone else?

Not necessarily. H.264AVC is not a magic pill. It is a core standard and platform on which applications have to be developed. As in all technologies there are processes and learning curves. In many cases, there are some MPEG4 solutions we are sure look just as good as H.264 solutions. Either because the underlying components are better or the solution is more stable than someone new working with H.264 for a relatively short period of time.

Understand that H.264AVC is just the "general" codec platform. Underneath this general platform many different "profiles" are being developed for different applications. HDTV will not have the same requirements as a video conferencing system. A Sony Playstation will not have the same requirements as a cell phone. So application specific profiles have been developed and advancements continue all the time.

Profiles

The H.264 standard includes many sets of capabilities, the following sets are an example of some popular profiles and how they differ. They are referred to as *profiles*, as they are targeting specific classes of applications:

- **Baseline Profile (BP):** Primarily for lower-cost applications demanding less computing resources, this profile is used widely in videoconferencing and mobile applications.
- **Main Profile (MP):** Originally intended as the mainstream consumer profile for broadcast and storage applications, the importance of this profile faded when the High profile was developed for those applications.
- **Extended Profile (XP):** Intended as the streaming video profile, this profile has relatively high compression capability and some extra tricks for robustness to data losses and server stream switching.

Similarly, other codecs also have a variety of profiles.

Some DVR manufacturers are onto third, fourth and fifth generations of the latest H.264 profiles, while others are first experimenting. With each generation come further enhancements, efficiencies and quality. Juxtaposed with the compression technology advances are digital processor advancements. Always remember it's a moving target and its never perfect, as new matches of components to hardware and software introduce new challenges.



Think about Microsoft, with billions of dollars – their operating systems are never perfect and are a constant evolution.

One thing to note, all the money in the world cannot buy the time necessary for product development, as DVR solution



development is "*linear*." Linear meaning, the next person in line must wait for the prior one to finish their programming or development, before they can continue. Therefore, many aspects of development cannot occur simultaneously.

More and more the newest entrants into the DVR business have been the IT companies such as IBM, Cisco and Motorola, who are well equipped from a technical perspective. They too though shall go through the same painful process as their predecessors but are more qualified to solve the problems in a more expeditious and efficient manner. These entities are also participants in the consortiums that develop the compression standards such as the Motion Picture Experts Group (MPEG) and the International Telecommunications Union (ITU).

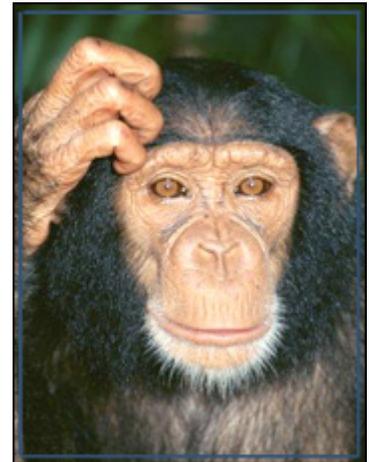
Chapter 20

Obsolescence

One of the more frustrating things about technology is how quickly it becomes obsolete. Buy something today and before it's up and running the next improved model is out. The VCR dating back to the 1980's never changed significantly.

This becomes more frustrating to a large enterprise who is spending significant dollars to find out that by the time the installation is complete, its' technology is old news and devalued. Some customers want to standardize across all their properties and lock into a single solution. The problem arises that logistically by the time the customer gets to outfitting the last property, it may be several generations old. So they are going to pay yesterday's prices today for old technology. Hardware costs universally go down in price not up. Whether it's HDTV's, digital cameras, etc. gravity always takes hold in electronics.

Would you want a purchasing program where you are locking in today's prices with today's technology, for installations which will be completed over the next few years? The philosophy doesn't work. From the technological side the issues are quite apparent. Financially, all you are doing is locking in higher prices. Technically, you are locking in older technology.



When manufacturers produce DVR's they often "flash" (install) their compression technology to the processors in the DVR card, which stores the compression technology data. These programs are either temporarily or permanently stored on the processors.



The permanent solution is Application Specific Integration Circuits (ASIC). It is specific to that particular application and cannot be changed.

The use of re-programmable DSP's (digital signal processors) has become all the rage. What is so special about re-programmable DSP's is you can upgrade the codec to the chip. Products no longer have to become obsolete in order to be upgraded with newer technology.

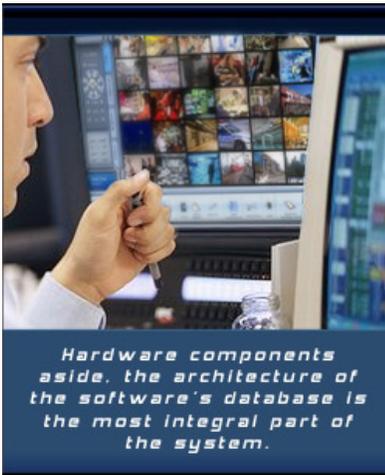
Don't confuse companies who say you may be able to "upgrade" software. It is still running on the same old platform and codec and what is being upgraded is a software interface or function, not the underlying quality produced by the codec.

Therefore, if a customer buys a DVR today which uses an ASIC with last generation codecs and new technology comes out, the system becomes even further obsolete than it already is. Even more frustrating, if they bought many systems and then want to expand the security initiative, they may find out the new equipment is no longer compatible with the old and the components are no longer available. Some manufacturers say they will sell you their present solution which can seamlessly transition to the newer codecs, which is impossible. Fact is, ASIC cannot be upgraded regardless of what a sales person tells you.

Chapter 21

The DVR Software

In order to efficiently control, monitor, search, view and replay video and audio recorded over multiple channels and comprising, perhaps, hundreds or thousands of events and containing millions of images, you're going to need one heck of a software program.



- How does the software facilitate storage of the images?
- What happens when multiple users simultaneously access the DVR?
- How does it prioritize tasks?
- What happens when you have to search through millions of images or conduct queries?
- How long do requests take?

To the novice, the software's graphical user interface (GUI – the main screens) may look like a million bucks, but tells you little about its core features or performance of the DVR.

We are often asked who made the first DVR software, because many seem to “look-alike.” Again, the graphics of some systems may look alike, but that is where similarities end. You can buy a Rolex watch or Prada handbag, which cost \$1,000's and last a lifetime or you can buy “knock-offs” on Canal Street in Manhattan for \$25 bucks. They both look identical but that is where it ends. Usually within a short period of time the buttons fall off, the strap breaks and it stops working; but it looked great the day you saw it.

Much of the software in the market place today is based upon adaptations of entry-level type basic video capture software from earlier generations. As technology progressed, many manufacturers continued to build on top of old programs that were outdated.

The key concern of the software is the quality of the underlying source code. While the database structure is very important to DVR stability, the quality of the written software is just as important. A simple incorrect string of data can cause memory leaks similar to problems encountered with Windows of years past and the system will gradually slow down and eventually freeze, reboot or crash completely. So understand that a simple successful product demonstration, speaks nothing of the product longevity. Software problems may not arise for days, weeks or months.



Chapter 22

The Hardware Components

We started out by saying some people consider a DVR, a PC with a video capture card and some special software.

There are PC's that cost a few hundred dollars, and there are enterprise grade computer servers that cost \$10's of thousands. This is the one place you need horsepower in the form of motherboard, controllers, processors, memory, etc. Like any other product there are inexpensive solutions with questionable reliability and there is best-of-breed where quality and stability are a given.

Being deficient in any one area brings us back to bottlenecking - once again, you are only as fast as your slowest component.

Another concern is not only having the best and the fastest components but ones that are well matched. Remember, the company that manufactures one component is not the same as the one who makes maybe the motherboard or the system memory. So while you may have the best of the best, it does not necessarily mean they are the best solution together. Many times when certain combinations are put together they are unstable or do not work at all.



Manufacturers can usually settle on a set of compatible hardware. The problem is its short lifespan. Next year, components are obsolete and you have to try to match new components and plan for backwards and forwards compatibility. The process is an ever moving target. Some manufacturers will just stockpile a set of components and 3 years from now you are buying 6 generation old technology.

Chapter 23

Peripheral Software

In addition to the main DVR server software and client workstations software, there are also a number of additional software programs that need to run in the background to give the system its reliability and stability.

The fact remains, DVR's are part of a very young technology where the bar is being pushed higher everyday. With constant demand for new features, a powerful foundation is required. But new features mean new unknown variables and accompanying problems.

Running diagnostic software, which constantly monitors several different functions of the hardware and software of both the DVR and server are essential. If the diagnostic detects any deviations from the established baseline criteria, it should automatically attempt to correct the problem and notify the system administrator it has detected a problem.

Diagnostic software is required onboard the DVR to monitor the operating system as well as the DVR program. From the hardware perspective, diagnostic software should monitor all devices, which are attached.



Chapter 24

The Heartbeat of your DVR

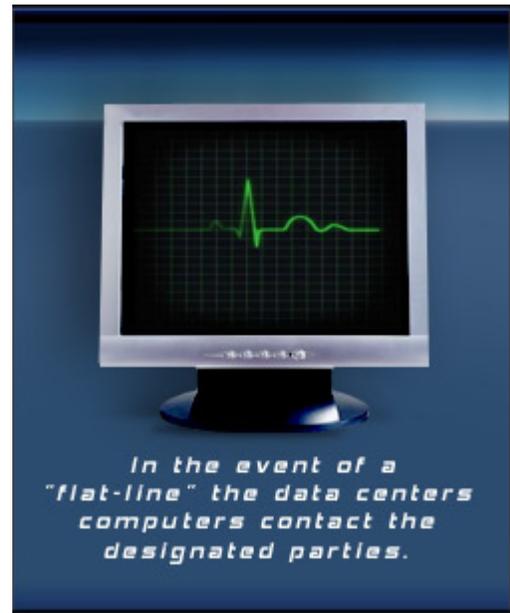
We like to think of a DVR as a living, breathing being which deserves the quality care and attention of any beloved.

As such, your DVR should have some sort of "heartbeat" or health monitor program that constantly transmits data to let you know that it's alive and well. In the event that your DVR became ill or could no longer perform its duties, you probably want to be immediately notified.

Often, DVR manufacturers will tout a "hardware watchdog" feature. This function detects problems in your machine and tries to reboot the DVR to correct itself. When the DVR fails, the system is supposed to notify you. However, that may not be possible in certain circumstances.

What if your DVR failed and was unable to restart itself? How could it possibly notify you?

The answer is, you need some sort of third-party notification program that transmits an emergency message when it stops communicating with your DVR. This software must be located on an external machine, as opposed to the disabled DVR which cannot help itself and transmit.



Chapter 25

References

Although Digital Video Recorders are relatively new there is already a well-defined customer base and it's growing daily. Like anything else-success stories travel quickly. Prudent business suggests that looking at who's using the product is usually a good indication of the level of quality.

Just because a company or an installer was capable with analog products does not translate to digital solutions. Just because a company is a household name doesn't mean they are a safe bet. Remember, many of the products in the marketplace are not manufactured by the companies that peddle them.



Most recently, a couple of the most popular companies in our business were sourcing product from a company in Asia. That overseas company got into financial trouble and there was a ripple effect. Unfortunately, for the people who bought solutions based on that architecture, good luck in the future getting support.

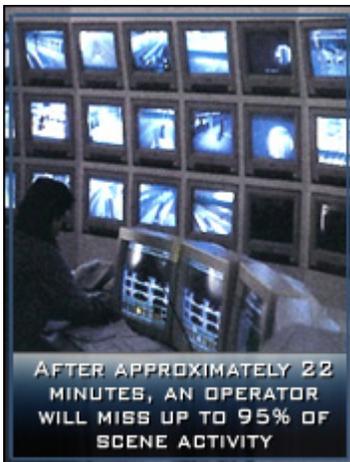
Similarly, another major industry participant was buying product from a third party, and that company was recently purchased by a competitor. So what is the likelihood that the product will receive continued support. So ask the right questions and know what you are buying and understand that buying a big name doesn't necessarily buy you job security.

Chapter 26

Welcome to the Future

Large enterprises have made significant investments in their video surveillance infrastructure consisting of hundreds of cameras, recorders, storage devices, and video monitors. Yet, with all this state of the art infrastructure, analysis of real-time or recorded video is bounded to the limitations of humans who are often required to monitor multiple monitors to detect security threats.

No matter how highly trained or how dedicated a human observer, it is impossible to provide full attention to more than one or two things at a time; and even then, only for a few minutes at a time. A **Harvard University** study concluded that humans are surprisingly unaware of the details of their environment, and often do not detect large changes to objects or scenes ('change blindness'). Furthermore, without attention, humans may not even perceive objects ('unintentional blindness'). The Harvard experiment results showed that 50% of people counting the passes made between two basketball teams will not notice a gorilla walk into the middle of the viewing area, beat its chest, and walk out. In another study, military experiments demonstrated that after 12 minutes of continuous viewing of 2 or more sequencing monitors, an operator will miss up to 45% of all scene activity. After approximately 22 minutes, an operator will miss up to 95% of scene activity. The conclusion is clear - humans do not reliably detect security threats, whether watching live video or reviewing archived data, resulting in false conclusions that nothing occurred when, in fact, something did (referred to as 'false negatives').



Prior to the technological advancements that have made computer vision based solutions commercially viable, many manufacturers of cameras and digital video recorders introduced Video Motion Detection (VMD). VMD technology essentially looks for pixels that are different than the current background model in the same region of the scene. Unfortunately, these systems end up causing high number of false alarms in environments where there is a lot of irrelevant motion – such as weather, clouds, shadows, changes in lighting, etc. In fact, this caused so many false alarms (referred to as 'false positives') that distracted the monitoring process, and the end user simply turned off the VMD feature.

Today incredible improvements have been made in the burgeoning field of “intelligent video.” It’s no longer a matter of detecting motion or a basic smart search to locate a missing item. Advanced analytical software offers some significant features:

- Unattended Baggage and Object Detection
- Exit Lane and Wrong Direction Monitoring
- Perimeter Intrusion Detection
- Loitering
- Vehicle Detection and Parking Violations
- Anti-Tailgating and Piggybacking
- People Counting and Crowd Detection
- Secure Area Monitoring
- License Plate Recognition
- Slip and Fall Protections
- Unusual Behavior Analysis
- Card Counting Identification
- Advantage Play Detection
- Facial Recognition

There is even the capability to identify objects, vehicles or humans by height, clothing worn, etc.

In addition to software analytics, intelligent cameras have arrived on the scene. These cameras can monitor and record in 360° and replace multiple area cameras. They also have the feature of being a “*time machine.*” After the fact, you can pan, tilt, and zoom, in all directions optically. Remember, a PTZ even at 26x zoom is only a 1x zoom after it has been recorded and only plays back where it was pointed.

So when the finance and management department say, it’s not a profit center, you can let them know, nothing could be further from the truth. Not only is intelligent video for surveillance, but it additionally has tools for marketing.

- How many people entered the premises at specified times
- Which direction people enter and exit
- How many people approached a specific area
- Identify VIP’s
- Demographic studies

The potential list of uses is extensive. Surveillance is entering a new era. Training on the newest technologies is going to be a daunting task. If anything it’s a transitional period that will require re-training and the appointment of personnel that have a cross section of skill sets encompassing IT, surveillance, etc.

While it’s a little intimidating and overwhelming I hope we have taken out a little of the mystery of digital video and provided an insight into what it can do for you.

Chapter 27

Buyer's Checklist

Demonstrations are just that and are usually "*prepared*" and "*controlled.*" For purposes of even the most basic evaluation you have to simulate real conditions. You need to control the environment, not the salesperson. Remember, they are not going to highlight their weaknesses.

One thing to consider, if you are going to compare manufacturers, test them on an equal footing. The best way to accomplish this is use the same feeds from your cameras to the test equipment. If possible, try to conduct the tests simultaneously, as then you can make a true apples-to-apples comparison. Otherwise, there may be other mitigating factors that may skew the evaluation.

Chapter 28

CAMERA TUTORIAL

This tutorial will address some of the facts and myths of security cameras. We will try to keep this as non-technical whenever possible and only provide you with what you need to know or may be relevant. For more detailed information about the technological aspects you can visit other portions of our website or some of our other tutorials.

Camera Styles

Cameras come in different shapes and sizes. Know that this in itself does not affect the picture quality. The shape rather should be looked at in terms of cosmetics, convenience of installation and camera placement. Two cameras with different housings and similar components should perform no different if constructed properly.

Dome Camera

Dome cameras typically are the best choice whenever possible

- When the camera is within someone's reach domes cannot be easily manipulated or vandalized
- Domes Install easy in drop ceilings – usually 2 screws
- Since a dome has a covered lens the direction the camera is pointing is hidden
- Domes can accommodate infra-red for Night Vision



NOTE: While dome cameras are the installation choice there are limitations. As the domes themselves are typically small you are limited in the size lens available. If you need to focus on long distances which requires a lens of 50mm focal length or greater it will not fit inside a standard dome camera. Dome cameras can be simple plastic ones or metal vandal-proof for public places.

Box Camera

- When mounting to a wall or any vertical area
- When viewing long distances where a long lens is required, which would not fit inside a dome or bullet camera
- When extreme low light conditions are not a consideration

NOTES: If the box camera is within someone's reach the camera is usually inserted in a protective enclosure. If the lighting is extremely low box cameras can be inserted inside enclosures that have built-in infra-red illuminators but the camera must be infra-red sensitive. Meaning it is able to utilize the infra-red illuminators from an external source.



Infra-red Cameras

- When there are extreme low light conditions
- When the camera is not within someone's reach

NOTES: The distances infra-red cameras can see are based upon its illumination capacity. Infra-red cameras have LED's, which cast out into the darkness. Realistically, a good rule of thumb (but not an absolute) is figure 1 foot for each LED. Therefore, if a camera has 30 LED's then it probably can see about 30 feet. There are some newer LED's called Cat's Eyes, which have more power, but they are not very common. You would notice a Cat's Eye by the extra large size of the LED's. With respect to infrared quality it has more to do with the intensity of the LED's and the distance they cover. One thing to note is that infrared LED's do have a limited life since they are illuminating so they do burn out over time. Just because one camera has more LED's than another does not mean it can cast a longer distance, there are different strengths in the LED's. Unfortunately, again for the consumer it is hard to properly compare.



Bullet Cameras

- When you want the camera to be inconspicuous but not covert
- When the camera is not within someone's reach
- When extreme low light conditions are not a consideration
- For shorter to middle distances

NOTES: As bullet cameras are small the type of internal boards and lens is limited. Accordingly, the picture quality of the bullet cameras cannot compare with other more traditional cameras, which can have double layer boards and camera function controls.



Covert Cameras

- Just as they say, these are meant not to be seen and come in all shapes and sizes from a wall clock to a sprinkler head or smoke detector

NOTES: It is important to check your local laws with respect to surreptitious recording. In some states certain types of covert cameras are illegal. For example, in New York State you are not allowed to install smoke detector cameras. With respect to recording audio, there are very specific laws, which vary from state to state. Some states require all parties consent to recording, while others only require a single individual.



Wireless Cameras

- When connection to the digital video recorder is not practical

NOTES: Remember though wireless is just for the video signal, you still need a method to power the camera. Wireless cameras can be found in most styles. For the most part wireless cameras require a line-of-sight to function properly. Distances will vary depending upon the strength of the transmitter and receiver, what other devices are in the same spectrum, etc. Realistically, you are looking at distances of 100' or less on affordable wireless equipment. There are external wireless transmitters and receivers that can attach to any standard camera and make them wireless, but the costs are incredibly prohibitive.



Pan Tilt Zoom (PTZ) Cameras

- When you want live control of the camera and adjusting the manual pan, tilt or zoom on a fixed cameras is not practical
- When you want to set up a camera to tour the premises
- When you want to view several angles from a single camera

NOTES: Pan, Tilt, Zoom cameras cost anywhere from 5x – 10x the cost of a fixed camera. The Pan, Tilt, Zoom camera cannot record or see where it is not looking. You cannot pan, tilt or zoom after it has been recorded (this can only be done with a 360 degree camera). Making a PTZ camera wireless adds thousands to the cost. PTZ cameras can though perform various functions not possible with a fixed camera. You can control a PTZ camera and zoom in optically up to 36x and beyond digitally up to 12x giving zoom capabilities in the 100's. The PTZ's have intelligence and can be programmed to perform pre-defined tours and upon the event of an alarm the camera can swing to a specified location before continuing its tour. An operator can override and take control of the camera at any time.



"I have old security cameras can I use them?"

The simple answer is yes, but the newest generation of CCD (Charge Coupled Device) cameras, are much better than their analog predecessors of as recently as 3-5 years ago. You may say, *"I spent a fortune on those cameras. They must be good!"* Well, is the VCR that cost \$2,000.00 two decades ago (not even taking into account its real cost in terms of inflation) better then the one you can pick up at WalMart today for \$49.00? The answer is a resounding no. Technology changes and advancements are made. In fact, to the contrary, it is a technologically inferior dinosaur. Much the same can be said for surveillance cameras.

Future generations of cameras will continue to improve upon this. Although cameras are called Digital CCTV cameras they are not "pure" digital. CCD is defined as follows:

So what is different between the analog cameras I bought a few years ago and now? It is most evident in the sharpness, definition and quality of the picture. If you're still unsure, we recommend replacing one or two first and compare the old with the new. Make sure when you compare cameras that you do it as apples-to-apples, meaning it is a similar shot, as lighting and various other conditions will affect picture quality radically.

Indoor vs. Outdoor Cameras

Ostensibly, indoor and outdoor cameras are the same in terms of styles, sizes and shapes. The principle difference is outdoor cameras are at a minimum weather-proof.

While rain is a primary issue other considerations such as moisture, dust, sand, snow, frost and humidity need to be addressed. Accordingly, some cameras are equipped with heaters and blowers to counteract the elements, while others can be housed in outdoor enclosures for the specified purpose.

Outdoor cameras most likely have to address low light conditions for evenings. Accordingly, they either have to have infra-red or some day/night technology, which today are quite affordable.

NIGHTVISION AND DAY/NIGHT CAMERAS

For low light situations there are two possible camera technology solutions. If there is total darkness then the only possibility is infra-red or otherwise known as night-vision.

Infrared (IR) radiation is electromagnetic radiation of a wavelength longer than that of visible light, but shorter than that of radio waves. The name means "*below red*" (from the Latin *infra*, "below"), red being the color of visible light of longest wavelength. The infrared portion of the spectrum has a number of technological uses, including target acquisition and tracking by the military; remote temperature sensing; short-ranged wireless communication; weather forecasting and for our purposes night-vision.

Infrared is used in night-vision cameras when there is insufficient visible light to see an object. The camera uses the infrared portion of the electromagnetic spectrum, sometimes referred to as thermal imaging. The radiation is detected and turned into an image, hotter objects showing up in different shades than cooler objects, enabling the camera to see warm targets, such as human beings and automobiles.

Day/Night technology is a sensitivity enhancement technology which improves light sensitivity of a camera by a factor of 2 for visible light and a factor of 4 for near-infrared wavelengths. It still cannot work in near zero light as will an infrared camera.

While both infrared and day/night technology sound expensive, both have become commercialized and are surprisingly affordable. The difference in camera pricing for one of these cameras versus a traditional camera is nominal.

The rule of thumb we like to use is if you walk the area where you intend for the camera to be and view it at its lowest possible lighting, if you can see with the naked eye, then the day/night camera should be fine. If you cannot see, then an infrared camera would be recommended.

CCTV cameras similar to your movie camera are rated in terms of "lux" for purposes of lighting. In addition to night vision and day/night cameras there are low light cameras, which are standard cameras with a low lux rating (0.1).

Video Quality

The manufacturers of the CCD's (which is the main guts of the camera) primarily make 2 or 3 basic grades of product in terms of camera lines of resolution. There is a standard resolution for color cameras (which people quote as anywhere from 330 TV Lines to 380 TV Lines) a high resolution for color cameras (which people quote as anywhere from 450 TV Lines to 480 TV Lines) and a new standard some refer to as "high definition" (which it is not true high definition – with quotes of anywhere from 520 TV lines to 550 TV lines). For black and white a 420 line and 600 lines are similarly standard and high resolution, respectively.

The more lines of resolution in the picture, the higher the quality of the picture should appear. You will find many companies will quote a higher number of lines to gain a marketing advantage, when in fact the information is incorrect. The CCTV camera business is dominated by 2 companies that control more than 95% of the CCD market; Sony and Sharp. It was very similar to the television tube market, which despite the name on the set; it was either a "Trinitron" tube from Sony or a Black Stripe tube. These companies make a limited number of CCD's for the surveillance market.

In our opinion, Sony offers a much higher quality picture and richer colors than Sharp. There is a significant price differential to go along with it. In fact, in our opinion a standard resolution Sony CCD appears better than a high resolution Sharp CCD.

This brings us to another issue. You will see some websites or companies publish specifications that are much higher than others. Be suspicious, as they should pretty much be the same; since the majority uses the same identical components and all they do is assemble. Some unscrupulous individuals will also try to sell you product represented as one component when in fact it's another. The 2 main components of the CCTV camera are the CCD and the Integrated Circuit (IC). So they may use a Sony CCD and a cheap IC. This is one of a handful of concerns.

This is a problem since the consumer has no way to easily identify whether it's a Sony or Sharp CCD or it's a standard or high resolution. It all comes down to credibility. Since the CCD's and IC's are commodities most pay similar component costs. Accordingly, suspicion should be placed on anyone selling dollar bills for 75 cents, meaning a similar product is being sold by one company well below the price point of the rest of the market. The only way to be able to truly identify the specifications of a product is if it is a well-known branded product and not a "blank box or "brand-x." The Internet creates part of the problem as just about anyone can hang up a shingle and promote themselves, as someone even if they are working out of a basement.

CCD quality is but one concern. We talked about earlier lux ratings. Even a high quality CCD has certain limitations. As such, you need the proper CCD for the job. Lower lux CCD's are more expensive and when you get into the area of day/night CCD's they can be significantly more than standard CCD's but not prohibitive.

CMOS cameras or digital cameras are referred to in terms of megapixels and are very uncommon as of this date due to the prohibitive costs associated with equivalent product to those of the CCD. There is a lot of confusion with respect to CMOS cameras. Probably the cheapest cameras in the market and the most expensive cameras in the market are CMOS cameras. There are CMOS cameras like your webcam that are made into CCTV cameras, which are inferior in quality in every respect and there are high megapixel digital cameras, which can cost in the \$1,000's, which are not necessarily much better. They are at opposite ends of the spectrum. CMOS cameras and the underlying IP camera technology have a long way to go.

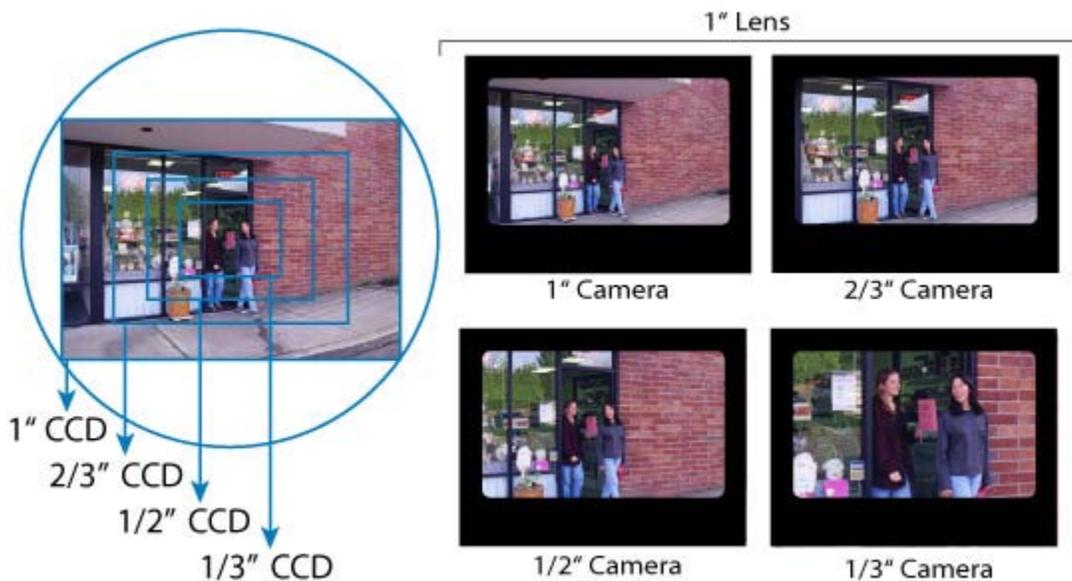
Lens Selection

Iris: *The iris on the lens determines how the camera will adjust to light. A camera lens iris come in a few varieties.*

- Auto-iris - has the ability to adjust automatically to lighting conditions.
- Manual iris - is one that you can adjust but as it states it is manual.
- Fixed iris - means just that, it is fixed and cannot be adjusted.

Focal length:

When selecting a lens, you are trying to determine the area you wish to cover; the width of the shot, and where the central focal point will be.



By clicking the following link you can find out what lens you will require in terms of the field of view. [Aventura Lens Calculator](#)

The unfortunate problem is; your needs for a shot in a particular camera view might fall into two categories. Let's take, for example, you have a retail shop, and the camera is set up to cover a large area, you may be able to see an incident occur, but not be able to distinguish the facial features because of where it occurred. So, you have one of a few choices – make sure you select a high resolution lens so you have better detail of the image, or select a higher millimeter lens to cover a smaller area, backed up with an additional camera to cover the balance of the target area.

There are also some other tricks you can use to minimize costs. You may not have to use a whole slew of cameras, if you know you are going to get a close-up view of a subject elsewhere. For example, if you had a camera at the front entrance to the store, that the subject has to pass through, then you have a good look at them and what they are wearing. So, even if they move about the location elsewhere, you can associate the face you saw at the front door, with the clothing they are wearing seen from a distance.

Although there are a myriad of lens sizes, there are a small group that comprise 95% of the market. Typically, they are 2.8mm (wide-angle), 3.6mm, 4mm, 6mm, 8mm fixed lens or a 4mm-9mm, 6~15mm or 6~60mm vari-

focal lens. The vari-focal lens gives you the ability to dial in manually anything within the focal range. So, when you install the camera, you would make adjustments until it covers that area you desire. Vari-focal lenses cost significantly more money than the fixed 4, 6, and 8mm lens but the quality is also better. There is a measurable difference. The following screen shots give you an idea of what each lens will look like at certain distances.



Selecting a lens, as well as the number of cameras, at times can be a difficult task because you have a balancing act of trying to keep cost down at the same time as accomplishing your goal. So, do you go with better quality cameras, but fewer of them, or lesser quality cameras but more of them? Although, when you start to add more cameras, the cost of the DVR increases because you require more available channels (channels are ports that cameras plug into on the digital video recorder).

So it is all dependent on your budget. We like to try to back into a solution predicated on the budget. This way you have a matching system of quality all the way through, and one that allows for change and growth plans.

When a lens is fixed, understand the image is as you see it. Forget what you see on the television show CSI. Even with a high-end digital video recorder will not get any larger than the original. Can the software increase the size of an image? Absolutely, but when it does so, it pixelates, meaning it gets grainier and less crisp. Don't believe claims that say they can read a license plate on a speeding car at 100 feet away with a standard lens or what you see in movies. It's not happening. The only quality you get when enhancing the original is lesser quality.

Lens Quality

What you also need to know about lenses is there are incredible differences in quality. There are plastic lens and glass lens. There is high quality glass and inexpensive glass. There are metal bodies and plastic bodies. There are precision mounts and some not so precise. No different than your still camera there are several thousand dollar Nikon and Leica lens and the ones you have on a disposable camera.

This again is a problem since the only specifications that a supplier provides you with is the iris function and the focal length. So you are relying on reputation. Even if you use a good quality CCD if the lens is not any good the pictures will suffer. There are CCD lens for less than \$2.00 from China.

Camera Assembly

The assembly of the components is critical as well as how the product is quality controlled. This speaks to the durability of the product. The last thing anyone wants is hanging a camera in an unreachable place and then find out you have to go back a couple of days, weeks or months later when it malfunctions. So how much does a lift truck cost for a day to get to the camera? How much is a half day of your time worth? A few extra dollars spent on a better camera may actually save you a lot of money, time and headache.

Mounting Locations

Security cameras are just that for security. Mounting locations are important for several reasons, some more obvious than others. If at all possible mount a camera that is out of physical reach. The concern is not always just physical reach but vandals at times will throw things at the camera, which will either break the camera or change the viewing direction. This is one of the reasons for using vandal-proof dome cameras. Not only is the camera location of concern but so is the wiring. If vandals can unplug a camera or cut a cable it's the same result. The trade off on making a camera inaccessible is when you want to periodically clean the lens or protective cover.

The location is also important so that you may be able to have a proper viewing angle without obstructions.

One common mistake is not a vandalism issue but rather a lighting concern. Cameras that are exposed to the sun need to be properly positioned and "shielded" so that the camera is not pointed directly into the sun.

Security

There are a variety of ways to deal with the security of the cameras in various environments. The problems you need to concern yourself with are – is the camera within physical reach of someone where they can easily either block the view of the camera (whether it be with spray paint, bubble gum or anything else), break it by hitting it with something, repositioning it so it is no longer viewing what it should or simply disabling it by unplugging it or cutting the line.

The use of dome cameras in indoor environments is a good remedy for most of these issues. If the dome camera is mounted into either a tile or a ceiling with the connections above, it is difficult for someone to easily tamper with it. Depending on which dome you buy, many are vandal proof lexan material so will withstand a good shot to it (not a gun shot!) and others even have tamperproof screws.

In the outdoor environment the cameras being mounted high enough alleviate many of the problems. The reason you put the cameras in an outdoor housing is for a few reasons. First, we already discussed the issue of weather. Next is the fact that if something gets on the lens it will easily obstruct the view. If something gets on the glass of the housing unit being that the housing unit is set a small distance away from the lens while it might still be obstructed you will still have a better view. Also if someone throws something at an exposed camera, the camera itself is susceptible. If a camera is mounted in a housing, it is just the housing that is susceptible, not an expensive camera.

Wiring a camera in outdoors environments requires the wires either inside the wall or inside conduit so that they are secure.

Some of these suggestions may not be required for simple installations, but are suggestions if you are concerned about these issues. There is no shortage of methods of vandalism, where un-secure cameras can

be altered to negate what you are attempting to monitor. A standard camera mounted in a store that is supposed to be watching employees is minimally moved with a broom each day without any notice. After a week or two the camera may be pointing completely elsewhere, there are innumerable stories.

Lightning Conditions

The human eye adjusts to changing light conditions by the iris dilating and constricting. Without it, think of what it would be like – it would be either too bright or too dark depending upon how your iris was fixed.

Similarly, the camera needs to adapt to changing light conditions. One of these adaptations is performed by a function known as “auto-iris”. Auto-iris is a lens component for controlling light intake electronically. The auto-iris function is built into the CCD imaging circuit of the camera and works in conjunction with the auto-iris lens. It works similar to the human eye allowing more light in when it gets dark, and reducing the intake of light when it's bright out. A manual iris serves no purpose in changing light conditions, as you are not going to climb up on a ladder and make changes to the lens throughout the day. A manual iris becomes applicable where you have fixed lighting conditions, such as in an interior office or hallway, which is not subject to ambient light from outside windows or skylights.

One mistake many people make is pointing a camera right towards the sunlight. Avoid this at all costs; if not completely possible, angle it so it is not direct or try to get a camera that has a sunshade on it. Pointing the camera right at the sun will virtually blind it regardless of the camera iris.

There are other lighting conditions to consider. The auto-iris reacts to what it sees and in some conditions may be misleading; requiring some other corrections. Back lighting can be an issue, and as a result washed out images may appear. To correct this, the CCD has a backlight compensation (BLC) function that may be automatic or may be turned on and off via a dipswitch located on the camera. Back Light Control dims intense back light automatically for a brighter picture of an object.

Another issue is when the light gets too low, the iris can no longer compensate. As the iris is an open and close function it needs other parameters to be addressed. CCD's have a function known as Automatic-Gain-Control (AGC), which compensates by brightening images under low light conditions.

Different CCD's have different abilities to adapt to low light conditions. This is known as a lux rating; the lower the number the better the adaptation to low lighting. Black-and-white cameras actually adapt better to low light than color cameras. In fact, in lighting conditions such as nightclub environment most likely a color camera will give unsatisfactory results where a black-and-white camera would excel.

Below is some sample lux ratings:

Direct Sunlight	107,000 – 140,000
Full Sunlight	11,000 – 22,000
Overcast Day	1,000
Retail Shop	500
Office Setting	300
Twilight	10
Deep Twilight	1
Full Moon	0.1
Moonless Night	0.0001
Overcast Night	0.00001

LOW LIGHT CAMERA VIEWING

For extreme darkness, the human eye as well as the camera iris has their limitations. There are two solutions to this, each having their advantages and disadvantages. The first is the Day/Night technology, which features a structure that is highly sensitive in the "near" infrared light regions, a range that is invisible to the human eye. This makes it possible to see and record in the dark by irradiating near infrared light on the recorded media.

Light in the near infrared light region which has long wavelengths is converted into photoelectricity deep in the semiconductor's (CCD) silicon. Conventional CCD structure, sensors were incapable of efficiently gathering the charge which has undergone photoelectric conversion. Day/Night technology allows a charge due to near infrared light, which was ineffective in conventional CCD devices, to be used as video information.



While Day/Night technology can adapt to low light or "near" infrared light regions it cannot adapt to total darkness or the infrared region, in this case the use of infrared cameras are in order. Total darkness means total blackness, so if there is moonlight or street lights then Day/Night is more than capable. If you have an interior room with no windows and no lights this would fall in the infrared range.

Infrared (IR) radiation is electromagnetic radiation of a wavelength longer than visible light, but shorter than microwave radiation. The name means "below red" (from the Latin *infra* , "below"), red being the color of visible light of longest wavelength. Infrared radiation spans three orders of magnitude and has wavelengths between 700 nm and 1 mm.

The Earth's surface absorbs visible radiation from the sun and re-emits much of the energy as infrared back to the atmosphere. Certain gases in the atmosphere, chiefly water vapor, absorb this infrared, and re-radiate it in all directions including back to Earth. Infrared is used in night-vision equipment, when there is insufficient visible light to see an object. The radiation is detected and turned into an image.

You will notice that most infrared cameras have a series of LED's. These LED's are what cast out into the darkness. Think of it as a flashlight you can only see out to the distance of the illumination capacity. You will see infrared cameras rated at distances. Remember these distances may be exaggerated and under optimal conditions. One need's to understand also the field of view is limited to the illumination area cast onto by the LED's which may be small. You are not going to read license plates 100 yards away in the darkness with standard reasonably priced commercial infrared cameras. This is not Rambo.

Power

Many cameras today are 12-volt. The reason we mention this is cameras of the last generation were primarily 24-volt. So if you plug a 12-volt camera into an existing line that is 24-volt, you may very well destroy the camera. Many of the better cameras today are dual voltage and can support both.

For the most part CCTV cameras can be purchased in 3 voltages: 120VAC, 24VAC and 12 VDC.

120VAC is not very common as it has some drawbacks the main being the requirement of having an outlet within 6 feet of where the camera is to be installed.

24VAC historically has been the professional's choice although more and more we see 12 VDC being used extensively. In fact, the majority of cameras available in the market today are 12 VDC. Longer distances though can be run for powering 24VAC wires. 12 VDC can also be used but distances are somewhat shorter than 24VAC due to voltage drop. You can view a voltage drop calculator in our *"How it Works" section* or by clicking on the following link. Distance only becomes an issue when running longer than several hundred feet. The convenience of 24VAC and 12 VDC is you can run the cables from the respective camera positions to a central point into a single power panel.

The camera power supply is most commonly connected using low voltage 18 or 20 gauge wire. The popular method for running video from the camera to the monitor or recording device is across an RG-59 or RG-6 coaxial cable. For convenience, "Siamese" cable can be purchased which houses the video and power under a single jacketed cable. Alternatively, a new method of cabling is running the video across Cat-5 computer network cable. Cabling is discussed further in our ["How it Works"](#) section of the website and elsewhere in this tutorial.

Each and every camera requires power. There are a few ways to power a camera.

1. A small power pack can be connected to the camera and plugged into a local wall outlet, typically within a 6' range. This in many cases is not possible as the cameras are located where there is no wall outlet.



2. Electrical wire can be run from each camera back to a central location and all the electrical wires are terminated in a power panel.



3. Electrical wire can be run from each camera back to a central location and all the electrical wires can each be attached to individual transformers, which can be plugged into a power strip and then into the wall. This method is not recommended as it usually is not very neat.



4. There is a type of cable known as "Siamese" cable, which houses a cable for video and an electrical wire for power, all in one single jacket. This way you only have to run a single cable from the camera back to the central location where the DVR and power are to be terminated.

Camera Connections

When connecting your cameras to the DVR in terms of video, either coaxial cable or category 5 twisted pair cable should be used.

The most traditional coaxial cables for video installation are RG-59 and RG-6 (RG = **R**adio-**G**uide).



BNC connectors (**B**ayonet **N**eill **C**oncelman connector-sometimes called a **B**ritish **N**aval **C**onconnector or **B**ayonet **N**ut **C**onconnector) are molded or crimped onto the RG-59 or RG-6 coaxial cable ends for connection to the camera and DVR.



Standard pre-made RG-59 coaxial cable lengths with BNC ends attached are 3', 6', 10', 25', 50', 75', 100' and 150'.



RG-59 and RG-6 coaxial cable also come in bulk rolls of 500' or 1,000' without BNC ends attached.

Although RG-59 and RG-6 cables are great stuff, they are relatively heavy and may be awkward at times, depending upon where you have to pull the cable. While cable manufacturers say you can run RG-59 out to about 750-1,000 feet, we recommend not to run RG-59 more than 600' from a camera to the DVR, otherwise you may experience signal loss and subsequent picture interference. RG-6 can usually be run at least 300 – 400 feet further than RG-59, but it does cost more.



With the advent of a new product called "video baluns" (**B**ALANCED **U**Nbalanced), you can now run video over a Category 5 cable. A balun is a device that connects a balanced line to an unbalanced line, such as a twisted pair to a coaxial cable. A balanced line is one in which both wires are electrically equal. In an unbalanced line, such as coaxial, one line has different properties than the other.

The Category 5 cable also known as Cat-5 carries four twisted pairs of copper wires in a single jacket, allowing for more camera runs on a single cable. Some even run power over the Cat-5 but you run the risk of interference, even if the cable is shielded. If you are going to run power over Cat-5 cable, we recommend running video on one cable and power on a completely separate cable. Cat-5 is also much lighter and easier to work with than RG-59. Cat-5 cable sometimes called network cable is the same cable you plug into your PC from the network. While distances beyond 1,000' may become a video signal problem for RG-59 and RG-6, Cat-5 can comfortably extend out



beyond 1,000' and with "active" video baluns that distance can be increased to 10,000'. Active video baluns are baluns with transmitters and receivers. Much debate is made as to whether RG-59, RG-6 or Cat-5 produces a better signal. In our opinion they are both fine and have their place.

Cameras Summary

Hopefully we have provided you with enough of an education to make an informed decision. In review:

1. Calculate budget
2. Identify the proposed number of cameras
3. Decide on the camera style based on the space available and environment
4. Calculate how many high resolution and standard resolution cameras you need
5. Select the lens and iris type
6. Figure out how you are mounting the camera so it is safe and secure
7. Verify lighting conditions
8. Decide on what cable type and length you will use
9. Decide on location to centrally locate the monitoring station and power termination