A Synectics Guide To

Camera Resolution and Performance

Security and Surveillance

SYNECTICS

Contents

This guide makes sense of camera descriptors and outlines what a camera's name tells you about its performance in order to help you make the best selection for your specific application.

Introduction

New security video cameras are constantly introduced to the market with ever improving technical specs.

Resolutions keep on climbing, from 1080p to 8K and beyond. But there's still a lot of confusion about what security cameras are called and how that description relates to the picture quality they can produce.

Resolution conventions can be puzzling. Is a 4K camera higher or lower resolution than an 8 Megapixel (MP) camera? No, they are (roughly) the same. And yet a 12MP camera can also be 4K. **Confused? You're not alone.**

Read on to find out how to interpret camera descriptions to make the right security choices – and why there's much more to image quality than megapixels.

How Cameras Get Their Names

It's all to do with sensors. A camera's sensor is covered in lightsensitive detectors known as pixels. When hit by light coming through the lens, each pixel generates an electrical charge.

That charge is then amplified, converted to a digital value and combined with the signals from all the other pixels to create the image.

The number and configuration of pixels on a sensor grid is where consumer camera descriptors like 4K, 1080p and Full HD originate. This same language was then adopted by the video security industry.

In other words, different camera names are simply alternative ways to describe the pixel count – and therefore the resolution – of their sensors.

Full HD	1080
HD	720
Quad HD	1440
2K	1440
Ultra HD	2160
4K	2160

Resolution and Pixel Counts

Taking the 'p'

When the first HD cameras appeared, they were called 720p. The name relates to the number of vertical pixels (1280 horizontal x 720 vertical) captured in the image.

HD cameras also sparked the shift to a different aspect ratio – 16:9 as opposed to the 4:3 that had become commonplace with analog.

Aspect ratio is the ratio of the horizontal to the vertical pixel counts of the sensor – and an important metric for security cameras as we'll see later in this guide.

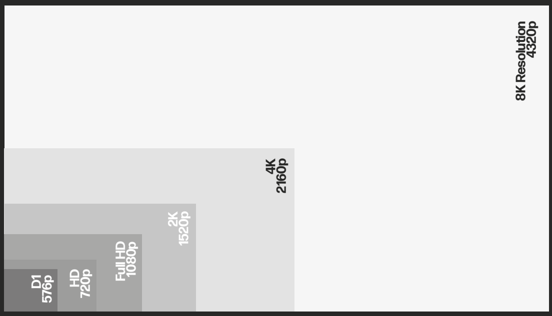
Later generation Full HD sensors had 1920 horizontal and 1080 vertical pixels (1920 x 1080). Their aspect ratio continued to be 16:9 and they were referred to as "1080p" cameras, again referring to the number of vertical pixels.

Moving on to 'mega'

Quoting the total number of sensor megapixels is the other popular way of naming cameras, one perhaps familiar from your phone camera: 5MP, 6MP, 16MP, and so on. One megapixel simply equates to one million pixels.

To calculate that total, the number of horizontal pixels is multiplied by the number of vertical pixels. Expressed this way, a sensor in a 1080p camera will have over two million pixels – or 2MP.

Comparison of Resolutions



So when is 'K' ok?

Using "Ks" (2K, 4K, 6K, 8K and so on) is an increasingly common way to express resolution, where K is an abbreviation of kilo or 1000. However, unlike 720p and 1080p, K resolutions refer to the number of horizontal rather than vertical sensor pixels.

For instance, 4K means there are roughly 4,000 horizontal pixels and around 8MP in total. The word 'roughly' applies as the count isn't necessarily exact.

One common 4K sensor offers 3840 x 2160 pixels (4K UHD or, more commonly, UHD-1), however there are many others on the market with different pixel counts that are still referred to as "4K", like 4096 x 2160 (DCI 4K – a movie industry standard).

With such variation, the key is to always check camera pixel counts and aspect ratio carefully.

Aspect Ratio

Names like 4K or 1080p tell you a lot about total pixel count, but not about a sensor's aspect ratio i.e. the ratio of horizontal to vertical pixels. This is a problem.

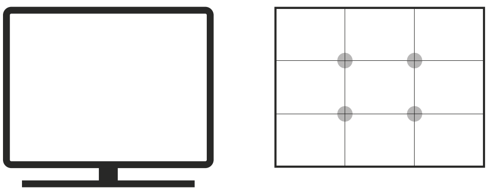
With the advent of HD TV, consumers moved from 4:3 aspect ratios to the 16:9 widescreen format. HD aspect ratio is the modern standard and most of today's security monitors are 16:9 – as are most 2MP and 8MP security cameras.

The trouble is many security camera sensors are 4:3 including 3MP and even the latest 12MP cameras.

This mismatch means a 4:3 image has to be altered to fit the display.

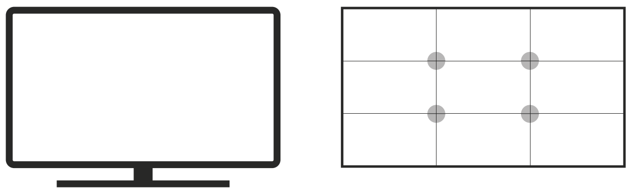
You either end up viewing a distorted image or the top and bottom of the image is cropped to fit the screen and appears with black borders.

Changing resolution to match the format is one workaround but not a good one. For example, setting a 3MP sensor to stream at 2MP (to match the 16:9 format) may cause a drop in image quality.



4:3

Aspect Ratio with Rule of Thirds



16:9

Aspect Ratio with Rule of Thirds

Common camera names (and their AKAs)

Known as	Also known as	Pixel count	Aspect ratio
720p	HD, 1MP	1280 x 720	16:9
2MP	Full HD, 1080p	1980 x 1080	16:9
3MP	2K, Quad XGA	2048 x 1536	4:3
4MP	2K, Super HD	2688 x 1520	16:9
5MP	2K, Super HD	2592 x 1944	4:3
4K	8MP, Ultra HD, Ultra HD-1, 4K UHD	Varies e.g. 3840 x 2160, 4096 x 2160	16:9
12MP		4000 x 3072	4:3
8K	Ultra HD-2, 8K UHD	Varies e.g. 7680 x 4320, 8192 x 4608	16:9
12K	Ultra HD-2,	12000 x 256	16:9

Image Quality

We can already see that sensor pixel count (resolution) alone is the wrong way to assess image quality or a camera's suitability for a specific surveillance application, aspect ratio is crucial too.

There are also many other factors which all contribute to image quality and application suitability. Five important ones to consider are:

- Sensor size and quality
- Camera lenses
- Depth of field
- Iris size and type
- Compression and processing

Sensor size and quality

Think of each pixel on a sensor like a little bucket that needs to be filled with light. The larger the sensor, the larger the pixels, and the larger the pixels, the more light you can collect. More light gives less 'noise', and therefore clearer, images.

However, the majority of camera sensors for commercial or industrial use are still relatively small in size. This is one of the reasons why 2MP cameras will often outperform 3MP cameras, particularly in low-light conditions.

The term 'generally' is used here because there are exceptions. For example, newer "micro pixel' technology (pixels less than 3um), used in conjunction with a quality, correctly sized lens, offers the ability to blend higher resolution image capture with strong low light performance.

Shedding a light on lenses

The lens format size must match or exceed the proportions of the camera sensor. If they don't, the corners of the scene will appear out of focus, darker or be cut off altogether.

It is important to consider lens focal length. The smaller the focal length – let's say 3.6mm compared to 9mm – the wider the field of view; great for overview shots such as monitoring parking areas or expansive industrial zones but not ideal for greater detail.

Upping the pixel count supports 'digital' zooming to combat this but then that is at the expense of the wider field of vision sought in the first instance.

Conversely, longer focal length lenses minimize field of view but do deliver greater detail. However, the greater length also limits the total amount of light passing though which means low-light performance is reduced. On a more practical/ aesthetic note, lenses with long focal length are physically bigger which necessitates an increase in camera housing size.

The detail on depth of field

There must be sufficient depth of field to ensure the zone of interest image is sharp and detailed.

Looking from the front to the back of the camera image, we refer to the area that's in focus as the depth of field. Shallow depth of field means there's only a small focused zone, for example, a person's face is sharp but the background is blurred. With greater depth the zone in focus increases.

Depth of field is influenced by the aperture size of the iris, focal length, and the camera's distance from the area of interest. The smaller the iris, the greater the depth of field, but a small iris cuts down how much light enters the camera which can be problematic in low-light conditions.

More on irises

There are four different iris types – each having benefits and drawbacks.

1. A fixed iris is exactly that, a hole whose size cannot be adjusted.

2. Manual irises can be adjusted during installation but not thereafter.

Both are perfect for indoor locations where light levels are reasonably constant. It's worth noting that using manual irises in conjunction with auto shutters will allow for some variation in light conditions but will not function adequately if faced with significant changes.

3. An auto iris adjusts automatically to cope with changing external light levels so that the amount of light hitting the sensor stays roughly constant.

4. A Precise Iris or "P-Iris" camera auto adjusts but also employs software that sets the iris size so that the central, best performing part of the lens is used as often as possible to give minimal optical distortion and deliver a greater depth of field – ideal for low and changeable light conditions.

Compression and processing power

Bitrate directly affects the amount of storage required and the playback picture quality, along with the live picture quality for IP cameras.

The higher the bitrate, the more storage needed, but also the better the quality of the picture captured. Picking a bitrate that balances the desired image quality with storage and transmission capabilities will deliver the best and most practical picture for that location.

Likewise, the camera's processor speed is also important. The faster the processor, the harder it can work to enhance a given image, the more frames-per-second (FPS) it can handle and the higher the resolution of the images it can deal with too.

What is H.265 compression?

H.265, or High Efficiency Video Coding (HEVC) as it is sometimes referred to, is the latest standard in video coding and is an advancement of H.264, also known as Advanced Video Coding (AVC). The ultimate aim of this standard is to offer the same, or improved, picture quality but with increased compression efficiencies to make large data files more manageable and reduce storage burden.

Estimates vary regarding the potential savings, as multiple factors will impact real-world results, but as a guideline field tests commonly show that H.265 can decrease bit rate requirements and associated storage needs by approximately 30% with no perceived loss to video quality. Similarly, retaining the same bit rate enables much-improved image quality.

Why has it been introduced?

The arrival and adoption of 4K technology has been a key driver in the development of H.265. In simple terms, 4K cameras could result in files four times bigger than normal 1080p (Full HD), which has huge implications for how that data is handled.

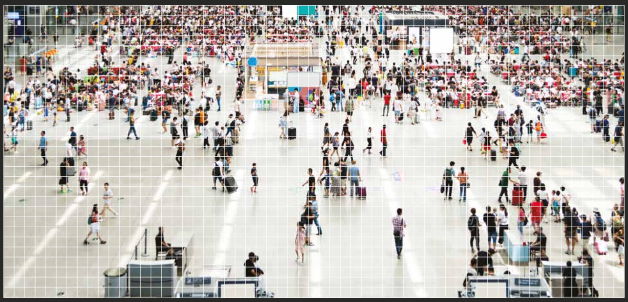
Until now, compressing 4K camera footage in order to reduce bit rate for faster streaming and reduced storage requirements has often resulted in poorer picture quality than less heavily compressed HD footage. With H.265, that problem can, in theory, be eliminated. However, the caveat 'in theory' is important here as there are drawbacks associated with adopting H.265, most notably the higher processing power required for footage playback.

How does H.265 compression work?

H.265 compression is based on the same principles as H.264 i.e. rather than encoding every pixel from every frame, bandwidth usage is minimized by identifying static areas (that do not alter from frame to frame) so that detailed encoding can be applied to areas that are actually changing.

The difference is that with H.265 this process is more aggressive. As well as expanding the areas examined for changes or pattern comparison from 16 x 16 pixel to sizes up to 64 x 64, capabilities such as motion compensation, spatial prediction, and sample adaptive offset (SAO) image filtering have all been enhanced as part of the compression algorithm.

H.264 (AVC)



Macroblocks Up to 16 x 16 pixels

Regular image quality.
Lower processing power required for playback.

H.265 (HEVC)

Macroblocks Up to 64 x 64 pixels

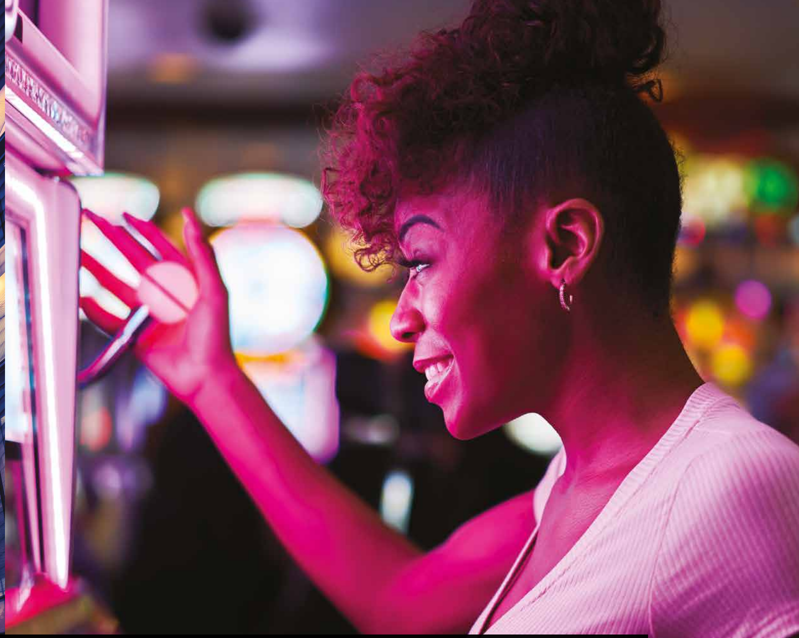
Best image quality.
Higher processing power required for playback.

A Focus On The Future

The state of the art in surveillance cameras is currently Ultra HD with 4K/8MP and now 12MP cameras. With leading edge camera resolutions still soaring – the 8K Ultra HD sensors now available to filmmakers offer a huge 33MP – this will undoubtedly change.

But even as sensor development rolls onwards, picking the optimum surveillance image quality is about far more than impressive pixel figures. It is also important to remember that progress isn't restricted to pixels. In particular, advancements in terms of H.265 compression technology and cloud-based surveillance will also factor heavily in camera selection moving forwards.

The best solution is to put serious effort into researching, specifying, and configuring the most suitable cameras for each surveillance application – or find a trusted partner to do it for you. It will be time well spent.



Protecting what matters, where it matters most

Synectics is a leader in advanced security and surveillance systems that help protect people, property, communities, and assets around the world.

We have a deep and unique understanding of our customers' issues and challenges, and we draw on this to create solutions they can rely on completely – giving them peace of mind by securing the assets, people, and livelihoods they are responsible for protecting.

We have built an enduring reputation for our problem-solving expertise, technical excellence, and total commitment to delivering for our customers.

Specifications subject to change. E & OE.

Literature Reference: MON-EX/1123 Iss2

SYNECTICS

synecticsglobal.com