What's a Megapixel Lens and Why Would You Need One?

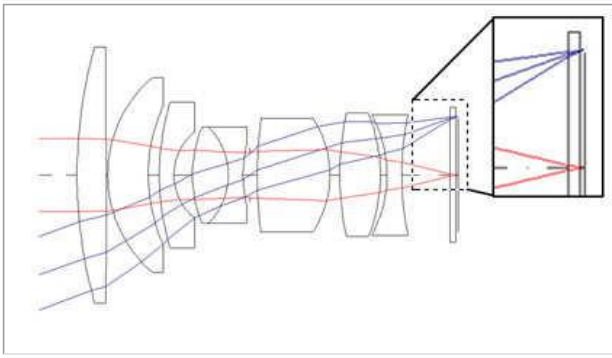
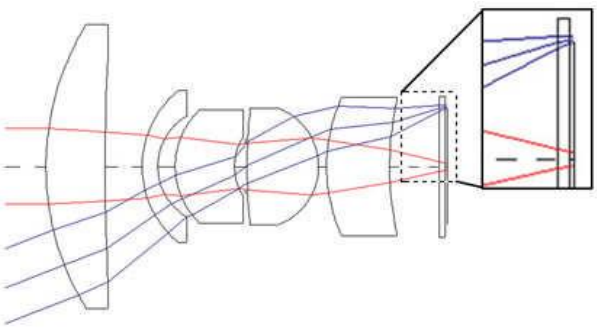
It's an exciting time in the security department. You've finally received approval to migrate from your installed analog cameras to new megapixel models and expectations are high. As you get together with your integrator, you start selecting the cameras you plan to install, looking forward to getting higher quality, higher resolution images and, in many cases, covering the same amount of ground with one camera that, otherwise, would have taken several analog models. You're covering the basics of those megapixel cameras, including the housing and mounting hardware. What about the lens?

Also translated in Russian: Что такое мегапиксельный объектив и для чего он нужен

You've just opened up Pandora's Box.

A Lens Is Not a Lens Is Not a Lens

The lens needed for an IP/megapixel camera is much different than the lens needed for a traditional analog camera. These higher resolution cameras demand higher quality lenses. For instance, in a megapixel camera, the focal plane spot size of the lens must be comparable or smaller than the pixel size on the sensor (Figures 1 and 2). To do this, more elements, and higher precision elements, are required for megapixel camera lenses which can make them more costly than their analog counterparts.

Figure 1	Figure 2
	
Spot size of a megapixel lens is much smaller, required for good focus on megapixel sensors.	*Spot size of a standard lens won't allow sharp focus on a megapixel sensor.*

One would assume, then, that all somebody specifying a megapixel camera needs to do is specify a megapixel lens. However, it's not that simple and, in many cases it can be quite difficult to assure that the lens needed is the lens being offered. Traditionally, just about any decent lens would do the job for traditional analog cameras so specifying the lens hasn't been a problem. As a result, too many designers and integrators are still unaware that, for megapixel cameras, a "lens is not a lens."

With a megapixel camera, designers and integrators have entered a whole new world, one in which millions of pixels and 1500 pixel wide images are the norm, not the 320 TV lines used in most analog cameras. The old TV lines can now be thought of as rows of pixels. Resolution needs have skyrocketed.

It's true. Many manufacturers refer to their products as a "megapixel lens" but they seldom define what the adjective "megapixel" means. Is that "MP" lens to be used with a 1.3 megapixel camera or a 3 megapixel camera? Can it be used with all megapixel cameras?

By referring back to Figures 1 and 2, you can probably surmise that different levels of megapixel cameras would also need different lenses and higher megapixel cameras with their smaller pixels need lenses with more elements and higher precision elements than lower megapixel models to deliver the greater performance.

So what can help you determine the quality of lens you need? A Line Pair per Millimeter (LP/MM) specification provides the resolution properties of a lens and can be used to help select the correct lens for your camera. LP/MM determines the smallest width of a pair of adjacent pixels that can be resolved by the lens.

For instance, standard analog cameras need a lens with around 30 LP/MM while megapixel lenses start at 60 LP/MM and can go up to over 200 LP/MM. For example, a lens with resolution of 60 LP/MM on a 1/3-inch 1.3MP camera that has resolution of 133 LP/MM does not utilize the full resolution of the camera. That's because the lens resolves only 60 LP/MM while the camera requires 133 LP/MM for its full megapixel resolution. The lens cannot see enough detail for the camera's sensor.

In the example above, a feature such as a pole which would be 1 pixel wide will be washed out by the lower lens resolution and not be visible. The pole would have to cover almost 3 pixels before the lens can resolve it. In other words, no object less than 3 pixels wide will be visible with the lens and camera in the example. The consequence is that the extra pixels of the camera are wasted – you paid too much for the camera.

Beware, too, many lenses are labeled megapixel based on the LP/MM in the center of the lens, not at the edge. This difference can be major for you as the user. It's not uncommon for a megapixel lens to have a 60 LP/MM in the center but only a 30 LP/MM at the edge. This means that the resolution at the edge of the "so called" megapixel lens is no better than that of a standard analog camera lens at half the price.

Also, the size of pixels varies from megapixel camera to megapixel camera, influencing which lens is best for a specific camera. A LP/MM "required" resolution can also be calculated for the camera based on the camera pixel size.

Adding to the complexity, the physical width of pixels in cameras will vary due to their differing image sensor sizes and the number of pixels that must fit on the imager. In other words, you can have two different size sensors each with the same number of total pixels, yet the resolution required of the lens will be different. This means that the LP/MM is relative only to the size of the pixels on the sensor. A lens with a 120 LP/MM might be perfect for a 1.3 megapixel camera using a 1/2 inch imager but not very good for a 2 megapixel camera using a 1/3 inch imager because the pixel size of the latter is much smaller. Ideally the lens resolution should be greater than the camera resolution.

Applications Really Test Lens Selection

Without question, there is a great difference between the lens needed for a standard analog camera watching over a general store, the 1.3 megapixel lens covering the parking lot of a mall, and the 3.0 megapixel lens providing surveillance at a correctional institution check-in station. Applications such as license plate recognition, face recognition and/or identification are very common uses for megapixel cameras but are demanding in terms of image resolution and detail needed.

Covering large areas is also a prime use of megapixel cameras. Since a megapixel camera can cover the same amount of space as several analog cameras at the same resolution, many integrators select them for this reason. Multiple cameras can be eliminated, saving money on cameras, recording equipment, and installation and maintenance.

In such applications, the megapixel camera has to enable image magnification (digital zoom) at any part of the image, including the edges. Using an ultra wide angle lens without fisheye distortion such as a rectilinear lens will provide a super wide field of view with better resolution at the image edges than a lens that has barrel distortion.

Remember, too, the detail in an image is also determined by the field of view. The tradeoff must be made between how much object width and how much object detail you can see with one camera. A larger field of view spreads out the pixels of the camera over a larger angle so the pixels per foot at the object will be affected. For instance, a 1.3MP camera with a sensor 1280 pixels across spread over a 90 degree field of view will have about

13 pixels per foot at an object distance 50 feet away. But, at half the field of view, you will have twice the object resolution, about 26 pixels per foot.

What Can You Do?

To calculate the LP/MM needed for a given camera, divide the width or height of the sensor in pixels by the physical width or height of the sensor in millimeters, then divide this number by 2. Dividing by 2 is necessary because LP/MM is defined for 2 adjacent pixels (a line pair).

Pixels per chip width / width / 2 = LP/MM

While the LP/MM lens rating was not generally provided by lens manufacturers in the past, it is becoming more common with the adoption of megapixel technology and can be useful in specifying a lens today. However many manufacturers will use a simplified lens rating for the megapixel specification (e.g. 1.3 or 3 MP) and standard sensor size (e.g.1/2 or 1/3 inch).

However, due to the large number of interacting and dependent variables, the most helpful tool in selecting the right lens is provided by lens manufacturers who offer a "lens calculator" on their websites. By entering the resolution and sensor size plus application, the calculator indicates the right lens for the application.

Get the Maximum

When buying analog cameras, you were concerned about darkness, glare, rain and other factors but seldom gave the lens a second thought. With today's high-resolution, megapixel cameras the lens might be the most important accessory to specify with each megapixel camera. After all, if the lens doesn't provide the resolution that the camera is capable of producing, you've simply wasted your investment on a higher resolution camera.

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