

Resolution

Resolution is the ability of a system to produce and output image in which features in the object that are separate from each other appear as separate in the image. The most common example has to do with astronomy. Looking up to the heavens, we can see many “stars”. In fact most of those “stars” are in fact galaxies. With a telescope we can begin to see the stars, and with a really giant one, we can clearly make out the stars. The naked eye could not resolve the objects that are in reality 1,000’s of miles across and light years apart. Add the telescopes and the ability to resolve these objects becomes possible.

Classically the basic feature is a pair of adjacent lines, or a *line pair*. Usually one is black and the other is white. They are of equal width and parallel. It is common to put several of these line pairs in combination to create a test target. The object lines can be made in a series of descending widths, and the number of line pairs per millimeter of the finest resolvable target is taken as the *resolving power* of the system under test. The US Air Force Resolution Test Target is one of the most common of these. There are other measures of resolution, however, most of those require special equipment and the use of the output is not very intuitive. Modulation Transfer Function and Actuance are two examples. In the majority of instances these all tend to correlate with each other.

For the photographer, the important question generally is the practical issue of will I be able to photograph the fine detail that I need to study? If the resolving power is greater than that fine detail, then the answer is yes. Otherwise, special steps will be needed, and these may not be practical. If this is the case, and if a digital camera is being used, then you will need a camera with more pixels. If you are using film, you need a higher resolution film or a different (larger format) camera.

So the issue boils down to: how can the photographer translate the number of pixels in the camera to the resolving power? It turns out that it is not very difficult at all. To start the process, there are four things you need to know. The first is the number of pixels across the width of the camera’s sensor chip. You can either get this from the manual or take a photo using the highest resolution setting and open it in a software package such as Adobe Photoshop. It will give you the number of pixels in each row and column. Let’s say the camera has 3,000 pixels across each row.

Next you need to know the size of the finest detail that you want to resolve. Let’s say you want to photograph fingerprints and you estimate that the width of each line-trough pair is 200ths of an inch. So you want to record detail of 200 line pairs per inch (LPI).

At the same time, you want to photograph an entire hand print. The long dimension of the image then has to be about 9 inches.

So far we know that we want to be able to see 200 LPI across a 9-inch frame. That is a total of 9×200 or 1,800 line pairs. Remember that the camera has 3,000 pixels across each row which can be used to record the image.

Now, here comes the magic. In many tests of cameras, both film and digital and flatbed scanners, it has been found that it takes a minimum of 3 pixels to resolve a line pair. So the number of line pairs that a 3,000 pixel row can capture is 1,000. In this case we want to capture 1,800! Not enough.

The basic formula is very simple:

$$LPI = \frac{(Pixels - per - Row)}{3 \times (Frame - Width)} \quad eq\#1$$

Or if you want to know how many pixels you need:

$$(Pixels - Per - Row) = LPI \times 3 \times (Frame - Width) \quad eq\#2$$

Note that equations one and two are the same, just written differently. Using equation 2, it is clear that we would need a camera with 5,400 pixels per row to do the job described above. We might also look at the frame width. For this we can rewrite the equation again and get:

$$(Frame - Width) = \frac{(Pixels - Per - Row)}{LPI \times 3} \quad eq\#3$$

Now we can see that with a camera with only 3,000 pixels per row, and detail of 200 LPI, we cannot work with an image that is any greater than 5 inches across. A possible solution would be to carefully take two photos, one covering the fingers part of the object and the other the palm, and if both are taken correctly, we can stitch the two images together to get the image we wanted in the first place.

Photographic film does not have pixels per se, but we can imagine that it has equivalent pixels. In tests done at IFI, it was found that the magic number, 3 pixels per line pair, applies in this case as well. Testing with top-of-the-line cameras, films and lenses, it was found that this combination behaves as if it were a 14 megapixel camera. To come to this conclusion, the actual line pairs that the system produced was evaluated using equation #2 to get a number of equivalent pixels. Then several photos were taken of test targets and compared to the same photos taken with various digital cameras. The film combination behaved as if it were a 14 megapixel camera.

The IFI calculator on this website uses this formula. For more detail on this topic, see [Understanding Forensic Digital Imaging](#), by Blitzer, Stein Ferguson, and Huang, published by Academic Press, chapters 6 and 17.