TECHNICAL PAPER ON RESOLUTION.

WHO CARES ABOUT RESOLUTION?

At Poli we certainly do not care about resolution as a concept! However we do care deeply about resolution when used as a measure of quality.

Resolution is a very dry and technical subject – but, hang in there – I do think you will be surprised about the information contained in this short paper. You may even find it interesting because it relates closely to the prints you are holding in your hand and because it relates to most everything else in our daily lives from reading glasses, books, traffic signs, computer screens to TV monitors. As an example; The difference between regular TV screens and HD TV screens is resolution!

What is resolution?

Very shortly; Resolution is a measure of how many pairs of one black line and one white line, of exactly the same width, a medium can distinguish when these pairs, of one black and one white line, are placed right next to each other.


This is an example of a resolution of 10 dpi per inch.


This is an example of a resolution of 20 dpi per inch.

This is an example of a resolution of 300 dpi per inch; the white dots cause the line to appear gray instead of black. As you can see neither your monitor nor the printer, used to print this paper, has enough resolutions power to show each individual dot in this line.

Myths and facts about "Lp/mm" and "dpi":

Resolution is expressed either as the European Lp/mm ("line pairs per millimeter") or as dpi ("dots per inch").
It is important to notice that when the term "dpi" is used it is not meant as "dot pairs" per inch but simply as dots per inch.

One inch is the same length as 25,4 millimeter (mm) in the metric system.

If a medium can resolve 100 Lp/mm then that is equal to 100 pairs = 200 lines per millimeter. 200 pairs consisting of 1 black and one white line. Translated to DPI this will be 200 x 25.4= 5,080 dpi.

Or visa versa; If a medium can resolve 300 dpi then that would be equal to a resolution of approx 6 Lpm. ((300/25.4=11.81)/2 = 5,91 lpm)

In this paper I will work with DPI and will translate all Lp/mm to DPI to make it simpler to understand the comparisons that will follow.

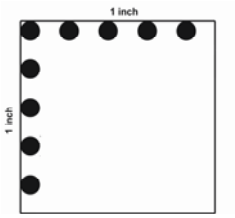
Film Cameras;

A good film from Kodak OR Fuji can resolve 160 lines per millimeter. This is equal to 8,128 DPI.

The lens on the camera reduce the actual resolution to some degree. Only very expensive lenses can resolve more than 80-100 lp/mm = 4,064-8,128 DPI.
When film is enlarged to a photograph another lens is used (enlarging lens), which once again reduce actual resolution a little bit.

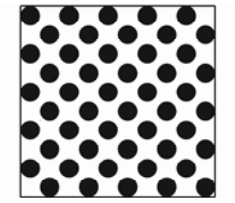
TECHNICAL PAPER ON RESOLUTION.

For the clarity of this paper, and the examples that will follow, we have accepted a high actual resolution of film at 100 Lpm, equal to 5,080 dpi . An actual resolution of 5,080 are not found in consumer cameras.



A 35mm **film** camera produce an image that is approx 24mm x 36mm on the film. The 24mm, on the short side, can then contain 24 x 100 line pairs per millimeter which adds up to 4,800 dots (DPI) total, on the short side of a 35mm film negative.

The long side of the frame on a 35mm film is approx. 36mm long, which adds up to 36 x 100 pairs = (36x100)x2) 7,200 dots total on the long side of the negative frame.



Therefore the entire area of the 35mm film can resolve a total of 4,800 x 7,200 = approx **34,5 million dots.**

On the two samples to the right we are working with a resolution of 10 DPI to make it easy to check and follow the example.
The 1" square, to the right, with 10 dpi resolution, can hold 100 dots total. (10x10=100)

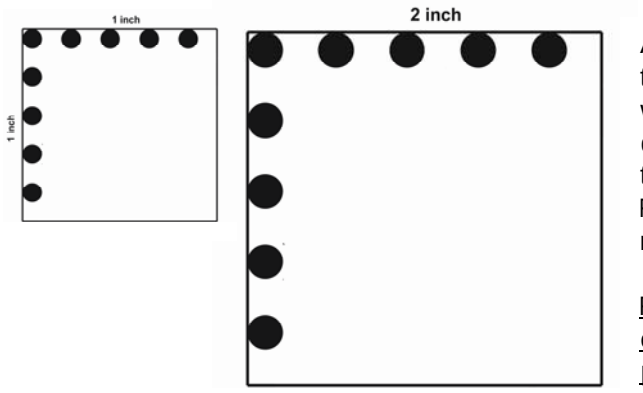
The short side of a 35mm negative is approx 24mm which is approximately equal to 1 inch (1" = 25,4 mm.) The long side of 36mm is equal to approx 1.5" (1.42")

34.5 million dots in a 35mm negative has no real meaning unless we start enlarging the negatives to make prints for viewing. Our eyes simply cannot resolve 4,800 dots on a 1" long line let alone 34 million dots on a 1x1.5 inch area.

If we enlarge a typical 35mm negative to a 4x6" print we enlarge the film approx 4 times (4.23 times, to be exact). The short side is being enlarger 4.23 times, and the long side is being enlarged 4.23 times to 6" (1,42 x 4.23 = 6.01")

Film is a static medium in the sense that films ability to resolve is embedded in the emulsion as silver grain for B&W film or color coupler for color film.

Film being static in relation to resolutions power means that we have the exact same amount of dots available whether we enlarge 4 times or not at all.



As you will see here from our example the 10dpi from the film remains 10 dpi when we enlarge 2 times. The only difference is that the dots are now twice as big.
From this follows that the resolution is now 5 dpi (5 dots per inch)

Regardless of how many times we enlarge film the total amount of dots per inch (dpi) remain the same, only the size of the dots increase.

TECHNICAL PAPER ON RESOLUTION.

Digital Cameras;

Digital cameras operate in much the same way as Film cameras. Instead of a film, which use silver halides to record light, digital cameras have a light sensitive sensor (CMOS Sensor) that senses light and colors.

A CMOS sensor in a high end digital camera can resolve less dots per inch than film can resolve.

A typical high end digital camera use a CMOS sensor that is approx 24x36mm. Which is approx 1x1.42 inch.

The typical CMOS sensor work with 3456 light sensors on the short side and with 5,184 light sensors on the long side of the imaging area. Therefore enabling the digital camera to record a total of almost 18mp (Megapixels).
On the short side 3,456 light sensitive dots x 5,185 light sensitive dots on the long side equals 17,915,940 dots = approx **18 million dots** = **18 Mega Pixels**.
(This is approx half of the dots that a 35mm film frame can hold, if we talk 100 lp/mm resolution. Or approx 1/5 of the resolution of film if we talk film with 160 lp/mm resolution.)

(The Belgium-based CMOSIS company has developed a high-resolution CMOS image sensor capable of capturing 10,000 by 7,096 pixels = 70 mp. However since this CMOS is not yet on the market this paper works only with the 18mp Cmos sensors currently available)

Film can record **34,5 million** dots on the same area as a digital camera can record **18 million** dots.

Film can then hold almost twice as much information as a digital camera. (34.5/18=1.92)

Are prints from film then twice as detailed as prints from Digital cameras?

They used to be, but not any longer.....bear with me and read on just a little longer....remember that film is static when it comes to enlarging.

"Static" is the key word in this context.

Polielettronica SpA Italy has invented a new type photographic printer that can produce 1216 DPI in print sizes up to 50" wide.
This is a world sensation!

The fact Polielettronica printers can maintain the 1216 dpi resolution up to 50" wide prints means that, despite film having much more native resolution than digitally recorded images, digital image files now out performs film negatives, by far, as soon as the print is larger than 4x6"

More over the new 1216 dpi resolution in prints actually enhance the quality of all digital files.

NOW your existing digital cameras are capable of producing prints with a stunning clarity that far exceeds anything you have previously seen from your digital camera.

This is how it looks when an engineer expresses it:

TECHNICAL PAPER ON RESOLUTION.

Producing Photographic Prints:

	Native resolution	4x enlargement 4x6" print	5x enlargement 5x7" print	8x enlargement 8x12" print	11x enlargement 11x16" print	20x enlargement 20X28" print	30x enlargement 30X42" print (30x50")	50x enlargement 50X71" print (50x100")
35mm film	**34.5-88 million dots**	**1,200dpi**	**960dpi**	**600dpi**	**436dpi**	**240dpi**	**133dpi**	**96dpi**
18mp CMOS sensor	**18 mill. dots 3,456 dpi (5184x3456)**	**864dpi**	**691dpi**	**432dpi**	**314dpi**	**172dpi**	**115dpi**	**69dpi**
18mp CMOS sensor **+ POLI PRINTER**	**1216 dpi (stepless in 1 dpi increments)**	**1216dpi**	**1216dpi**	**1216dpi**	**1216dpi**	**1216dpi**	**1216dpi**	**615 dpi**
Comparison data.								
70mp CMOS sensor	70 million 7,096 dpi (10,000x7096)	1670 dpi	1340 dpi	840dpi	609 dpi	335dpi	223dpi	134dpi
70mp CMOS sensor **+ POLI PRINTER**	1216 dpi (stepless in 1 dpi increments)	1216dpi	1216dpi	1216dpi	1216dpi	1216dpi	1216dpi	615 dpi
4X5 FINE ART FILM	1,274 million dots	1:1 19,300dpi	1.25x= 15,440dpi	2x= 9,650dpi	2.75x= 7,018dpi	5x= 3,860dpi	7.5x= 2,570dpi	12x= 1,544 dpi
8X10" Fuji Velvia or Provia Fine Art transparency film.	4,954 million dots. (4,954 MB or approx 5TB)	na	na	1:1, 63,200 dpi	1.4x= 45,150 dpi	2.5x= 25,280 dpi	3.75x= 16,850 dpi	6.25x= 10,100 dpi

The fact of the matter is that a 30x50" print from a 35mm negative is not a very pleasing result. Enlargements larger than 20x from film is rarely technically acceptable.

30x42" enlargements from an 18mp CMOS sensor are now as sharp, pleasing and vivid as 4x6" prints from negatives, when printed with the new Polielettronica HD printers.

High Definitation:

Polielettronica has introduced 1216 dpi resolution for production of photographs in professional photo labs, large consumer labs and retail photo labs (minilabs)
The Poli engineers have developed such sophisticated technology and so finely focused lasers that it is now possible put 1216 individually separated exposures on a 1" long line on photopaper or film.

Imagine the beam from a flashlight. Then imagine a beam that is so thin and delicate that it can expose 1216 individual black marks on 1" long line on light sensitive photopaper or film. It is a pretty amazing technical leap.

Still these technical advancements may in them selves not appear to be very revolutionary. The revolution occurs when these technical properties are being combined with new software also developed by Polielettronica.

TECHNICAL PAPER ON RESOLUTION.

When the hardware is combined with the newly developed software it becomes a totally new photographic printer designed for professional photolab's, large consumer labs and photo stores.

The new printer can produce a photograph from a customer's digital file, recorded in 72 dpi (or any other dpi) with print resolution of 1216 dpi, which results in unbelievable sharpness and crisp details. It almost seems like the new print have depth, almost a 3D effect.

The new Poli software use Bicubic Interpolation to look at the digital file before it is printed. It looks at the image, it looks at the shapes, faces, lines, forms, flowers, boxes etc. and then based on the shapes in the image it calculates a new high resolution image. In short you can say that the new software takes a high resolution picture of the existing image file.

A digital image (file) from a high end consumer camera holds approx. 18.000,000 pixels. (18mp) These 18,000,000 bytes the Poli software turns this into 6,653,952,000 bytes/pixels or almost 7GB (6653MP) when producing a 30x50" print. Yes, that is the correct, 7GB, because we use TRUE 1216 dpi.

When an inkjet printer produce an image in 300 dpi, say an even gray, it will use 100 dots of Magenta, and 100 dots Yellow and 100 dots cyan to produce an even gray. When the poli printer produce a similar photograph it will use 1216 dpi of each of the tree colors, not 400 of each. (red, Green and blue because we are working with light and not paint or dye as the inkjet printer.)
Compared to inkjet printers the Poli printer also excels because it "Paints" with light. In the Poli printer the laser light is sent to the photopaper with a speed of 20mhz which for the naked eye will look like a continuous stream of light in varying colors. This result in images printed without any artefacts, dots or marks like is the case with inkjet prints that create images by of spraying "overlapping dots of water soluble ink" on paper.

OK, so far so good, now hold on;

Resolution in film is static. This means that there is a specific resolution available in a film negative. Because it is silver halide or color couplers that is embedded in the film it cannot be changed after the film is developed.

Let us say for this example that a 35mm film has a resolution of 5,000 dpi. Then, because it is static dpi; when you enlarge the 35mm negative (which is 24mm x 36mm = approx 1x1.4") to a 4x6" print you have already diluted the dpi 4 times.
When you enlarge the original 1" to a 2" print you cut resolution in half.
When you enlarge the original 1" to the new 4" you reduce the resolution by a factor of 4. Therefore; if you start with a 35mm negative, and a resolution of 5,000 dpi, then when you enlarge to 4x6" print you have already "diluted" (Reduced) the resolution to 1,250 dpi. When you enlarge a 35mm negative to an 8x10" print you have reduced the resolution to 625 dpi. When you enlarge a 35 mm negative to 20x28 the resolution in the print will be as low as 240 dpi.

It is largely the same with a digital camera. The CMOS sensor is approx 24mmx 36mm and behaves more or less like a piece of film, except that because it is digital the DPI is not static. It can be altered by software like the Poli software.
An average high end 18 megapixel digital camera has a resolution of 3456 dpi, which is lower than that of film. Therefore when you enlarger a file from an 18mp digital camera

to 20x28" you end up with a resolution of 172 dpi in the print. And that is not really acceptable to anyone. The print will look jagged and very unsharp.
This has hurt the photo industry because sales have dropped considerably for print sizes larger than 5x7".

Till today the issue of sharpness and resolution has never been an issue that has been openly discussed because the printers from Fuji, Durst, Noritsu, Poli and others were capable ONLY of printing with 305dpi and in some situations 405dpi resolution, regardless of the print size.

Whether we are talking 4x6" or 50x100" print; till today it has not been possible to print with more than 405 dpi.

Therefore the lack of sharpness and resolution has been treated with silence and swept under the carpet.

The new Polielettronica printer will change all that.

After testing for 6 years in Government facilities the Poli HD printer is now ready to be released to private industries. The Poli Printer will maintain 1216 dpi dpi all the way from 4x6" prints to 50" wide prints. The poli printer can produce a print 30"x50" that is as sharp, crisp and detailed as a 4x6" print from film, both can be printed in 1216 dpi.

This is revolutionary news for owners of digital cameras. Now they cannot only make photographs that are as good as prints used to be from film, they can make enlargements that are better than film was ever capable of producing.

In fact the poli printer have improved the quality of every single digital camera in the world.

This is not just good news for the consumer, it is also good news for the photo industry. The photo industry has been under siege by companies producing inkjet printers. Huge amounts of the market has moved out into homes and photo studios because "home made" in many cases was better than the quality made by photolabs.

Producing inkjet prints are vastly more expensive, for both consumers and photolabs, than producing prints on photo paper.

Poli has not stopped at improving the quality of real photographs, they have also this year introduced a printer capable of printing on both side of the photopaper.

Again both the consumer and the photo industry are benefiting. Now calendars, baseball cards, low cost photo books etc can be made by photolab's at prices that leave the arch enemy "inkjet" in the prehistoric realm.

Notes,

Resolutions advancements:

The Belgian company; CMOSIS have developed a high-resolution CMOS image sensor capable of capturing 10,000 by 7,096 pixels. This resolution is not only twice what any existing 35mm consumer camera have ever been able to resolve, it is also more resolution = details and sharpness than film!!!!

When this new CMOS becomes available for the consumer and the files combined with a POLI Printer, the photo industry will be able to take a gigantic leap forward and leave inkjet as a relic of the past.

http://www.zdnet.com/70-megapixel-sensor-paves-the-way-for-ultra-high-resolution-digital-cameras-7000013805/

HUMAN EYE Resolution:

The human eye can resolve 3200dpi/picture height at most, because it resolves a maximum of 16dpi at this distance, which is called the 'least distance of distinct vision'. For the 35mm film format with 24mm picture height this corresponds to 122dpi. The spatial frequencies important for the human eye are therefore also in the range up to 80 dpi. If one considerably enlarges the image viewed, however, and nevertheless views it from a relatively short distance, the eye can use the highest spatial frequencies of the system and it suddenly sees weaknesses which would not be noticed during normal viewing of the image. This is, incidentally, what happens when one views digital pictures on a large monitor in 100% representation. In this case, the image of a 12MP camera is more than one meter wide.

http://cameras.about.com/od/reviews/tp/best-large-resolution-cameras.htm

http://www.zdnet.com/70-megapixel-sensor-paves-the-way-for-ultra-high-resolution-digital-cameras-7000013805/