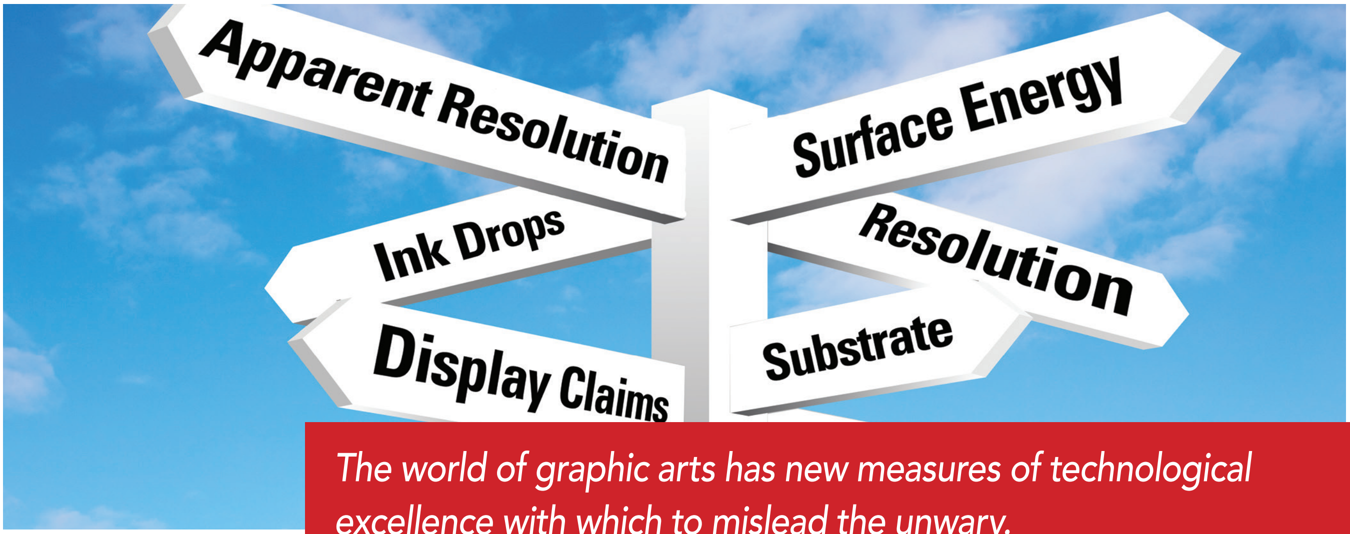
Print Direction and Mis-Direction: How Specs Can Mislead



The world of graphic arts has new measures of technological excellence with which to mislead the unwary.

Back when computer processor speeds were measured in millions of instructions per second (MIPS), cynics said the acronym stood for 'Meaningless Index of Processor Speed', or 'Misleading Index of Performance for Systems'. The complaint was that the performance of a computer depends on a lot of factors, not just the speed of the processor — so marketing claims based on having more MIPS than the other guy were mostly hot air. The complaint was a fair one: The size of the cache memory, the bandwidth of the input and output data-paths, the speed of the RAM and hard disk, all play a role in determining how fast a computer system can complete a task. This was particularly true when manipulating large image files in the days when RAM was too expensive for a retouching or page composition workstation to keep a whole page of full-color images in memory while editing. Forty megabytes of RAM, at $1,000/megabyte? Unthinkable!

Now that we can compose pages and perform image operations on a Mac or an iPad with an ease that previous generations of Scitex retouchers could only dream of, the focus on MIPS to compare computers has gone away. But the world of graphic arts has new measures of technological excellence to mislead the unwary. One example is the number of megapixels quoted for digital cameras and smartphones. Until quite recently, reviewers of consumer cameras would routinely rank cameras with more megapixels as 'better' on the grounds that more pixels automatically means better image quality. Marketers of smartphones certainly jumped on the megapixel bandwagon, leaving some consumers confused as to why the pictures from their new smartphone did not look as good as the pictures from their older digital camera with a smaller megapixel count. Fortunately, the advent of cameras with different sensor sizes, and the growing awareness of the limitations of "lossy" JPEG compression have brought the realization that sensor size is critical to quality, and megapixels are another Misleading Index of Performance — henceforth called a MIP.

Those who market to the print professionals in wide-format imaging are not above mixing in a few MIPs with their RIPs. If you look at the press releases accompanying many recent wide-format printer launches, you will see 'maximum resolution' specified, but rarely alongside the productivity that results from the selection of this resolution — and usually with no discussion of whether the resolution is appropriate for a typical viewing distance. Billboards used to be screen printed with a 30-line screen, and nobody could tell from the street or through their car windshield. But now, manufacturers vie with each other to claim that 720, 900, 1,440 or even 2,880 dpi is essential to remain competitive. But to focus on the dpi spec is to ignore the fact that resolution cannot be separated from the number of shades of grey to be reproduced. A photographic image must be 'half-toned' to be rendered smoothly, and the more grey levels, the less chance of 'contouring'.

So, a printer capable of laying down 1,440 dpi might use this resolution to create five grey levels for each pixel by placing dots in a two-by-two box. This halves the effective resolution. Conversely, and to compound the confusion, is the fact that some manufacturers use greyscale (variable drop-size) printheads, and so do not need to create these half-tone boxes — the printhead inherently supplies the half-

Chris Lynn, CEO, Hillam Technology Partners, LLC

To focus on the dpi spec is to ignore the fact that resolution cannot be separated from the number of shades of grey to be reproduced.

A better guide to gauging the ultimate quality of the printed image is the **minimum drop-size**, rather than the quoted '**resolution**'.

toning by dynamically changing the size of the spot on each pixel. But the printhead resolution spec seems inferior, so the manufacturers feel the need to talk about the 'apparent resolution' produced by their machines in order not to be outshone by the higher resolutions claimed by others who use a fixed drop size. Thus, a 360 dpi print made with eight grey levels may be said to have an 'apparent resolution' of about 950 dpi — it looks roughly as good as a print of this resolution made with a fixed drop size. This is actually not necessarily misleading unless you get up really close on the four-point text, when the human eye's ability to detect staircasing on linework and text will become apparent. Fifty shades of grey might be fun, but it does not help much when you are not talking about flesh-tones.

So the dpi number in the hands of an unscrupulous marketer is another MIP. Compounding this MIP is the fact that many of the people talking about 'resolution' really do not mean resolution at all. They mean 'addressability'. This is what wide-format printer specs usually refer to, although few say it. The claim of a print resolution of 720 by 1,440 dpi, for example, really means that the encoders on the machine allow ink drops to be placed on a rectangular grid of pixels which are 1/720th by 1/1440th of an inch in dimensions. (In metric units, this is about 35 by 17.6 microns.) This does nothing to help the perceived print quality if the ink droplets are the same size as the droplets used for, say, 360 by 360 dpi. Calculating the size of the spot that an ink drop makes is not straightforward: The amount that ink spreads out when it hits a substrate depends on the surface tension of the ink, the surface energy of the substrate, absorption and other factors. As a rough guide, a 42-picoliter drop of UV-curable ink will generally give full ink coverage on a 360 dpi grid. In other words, the drop will spread out to a diameter of about 90 to 100 microns — much too big to give the kind of photographic image quality implied by 1,440 dpi. A better drop size for the print quality implied by that resolution would be around four picoliters. So, in summary, a better guide to gauging the ultimate quality of the printed image is the **minimum drop-size**, rather than the quoted '**resolution**', a figure that is either not quoted, or buried deep in the spec of a printer.

Some people go even further, claiming that a print resolution of up to 4,000 dpi is necessary for the best possible image quality. This is based on arguments like, "This matches the grain size on silver halide film." But consider this, the normal human eye can resolve objects that subtend an angle of about one arc-minute (one 60th of a degree) at the eye. This means that, at a viewing distance of one foot (30 centimeters), someone with 20/20 vision can distinguish between two lines about 1/300th of an inch apart. If we allow for a four-by-hour half-tone grid (to give 17 grey levels), we need to place 300 by four, or 1,200dpi to achieve the best photographic quality that the human eye can resolve. This is nowhere near the resolution of most film, and, given the eye's extra sensitivity to black-to-white transitions, is also about as high as we need to go when viewing text at normal reading distance without 'jaggies'. As an aside, Apple's 'retina' display claims to mimic the resolving capability of the human retina — in this case, what they mean is that, with a screen resolution of 264 pixels per inch on the latest iPad, you cannot see the individual pixels at normal viewing distance. This is generally accepted to be a reasonable claim, though you must not lose sight of the fact that each pixel can have up to 256 grey levels.

So drop volume is a better measure of how good a printer is than dpi? Yes, but…

Now that the wide-format world is getting wiser to the resolution MIP, people are starting to claim that the drop size is the only performance measure that counts. Buyers think that a machine with 14-picoliter printheads is better than one with 42-picoliter printheads, and one with four-picoliter drops is even better still. True, up to a point — as we have seen, smaller drops potentially enable better resolution. But to focus only on drop size is to ignore the productivity trade-off. If each spot contains less ink, you need more spots to achieve the same print density — duh! This means that spots must be laid down more closely together. The only ways to achieve this are by driving the printheads at a higher frequency (more drops are ejected every second), running at a slower print speed or by using more passes, which is to say lower productivity. Resolution specs cannot be separated from productivity, and trade-offs are inevitable.

We are unpeeling the onion, and there is another layer of MIP in printing. As we just noted, the way printer designers try to overcome the resolution/productivity trade-off is to drive the printheads at a higher frequency. A printhead operating at 30 kilohertz, laying down drops at 600 dpi, can cover 30,000/600, which equals 50 inches/second. Obviously, a printhead operating at 15 kilohertz will go only half

Printhead	Drop size (pl)	Frequency (khz)	Nozzles	Liters/hour
Dimatix Polaris PQ-512/15AAA	15	30	512	0.83
Konica-Minolta 512m	14	12.8	512	0.33
Ricoh Gen-4L	15	30	384	0.62
Seiko SPT 508GS/12	12	36	508	0.79
Xaar Proton 15	15	15	382	0.31

*Note: 14–15pl drops are unnecessarily small for outdoor signage, and these vendors all have larger-drop printheads, but I have used these because the current trend is toward smaller drops.

as fast. But does this mean that the first machine will be twice as productive as the second? And will the print quality be equivalent? The answer to both questions could well be 'no'. The maximum speed of the carriage — which has to accelerate and decelerate on each pass — might be the limiting factor on maximum print speed. In other words, the higher firing frequency in the first machine could be wasted.

And, more subtly, the speed of the ink drops can change at different firing frequencies: It is typically constant up to a certain threshold frequency, and then ink drops will travel faster or slower at different firing frequencies above that point. This means that the drops do not all land where they are supposed to when the carriage is accelerating or decelerating, in turn affecting print quality, and potentially causing visible image artifacts. Perhaps the 15-kilohertz printhead is operating in the linear region, with no change in drop velocity as the carriage speeds up or slows down, but the 30-kilohertz printhead could well experience some changes in drop velocity (and hence in drop landing accuracy) between 15 and 30 kilohertz. Again, we have a potential MIP in the printhead firing frequency.

So far, so confusing. The moral: A healthy skepticism is appropriate when specs are being bandied about. Neither dpi, nor numbers of picoliters, nor carriage speed nor firing frequency tell the whole story on their own. And the optimal value for each of these parameters will depend on the intended use of the printer: Printing POP materials clearly has different quality demands from printing billboards.

What then are the printer performance indices that are less likely to be misleading? As always, seeing is believing. The time taken to produce specifically sized sample prints whose quality can be verified will confirm the productivity and print quality of a machine better than any written spec.

For printhead specs, the 'pumping power' is a good measure of potential productivity although it tells you nothing about image quality. Pumping power is the number of liters of ink the printhead can eject per hour, and is calculated simply:

(maximum drop size in picoliters) x (firing frequency in kHz) x (number of nozzles) x 3.6/1,000,000 = L/hr

The table below shows the pumping power for several leading printheads with similar drop sizes*:

An often-used figure of merit to compare the different printheads is 'cost per nozzle', but this is oversimplistic; not all nozzles are created equal, and 'pumping power per dollar cost' is arguably a better measure. But even this cannot be used as a performance measure in isolation: The caveats about small drops and frequency also apply, of course, and the relative cost and complexity of the electronics and ink supply to the head need to be considered. For a complete machine, you might look at the number of square feet produced per shift for every thousand dollars of cost, at a given quality level.

In summary, no single performance measure is adequate to make a purchase decision between competing imaging and printing technologies, and all parameters involve trade-offs. Marketing people, like politicians, try to make complex decisions seem as simple as possible by highlighting only one or two factors, which are, inevitably, those factors that happen to favor their product or point of view. Real products, like real life, are more complicated — so do not be misled by a MIP.

Chris Lynn is a consultant dealing with digital technologies for printing and packaging. A 27-year veteran of the digital pre-press and inkjet printing market, he is a principal of Hillam Technology Partners, LLC, based in Atlanta, Georgia. He can be contacted at chris@hillamtech.com.