

At the heart of every printer there is an imaging pipeline, which takes a print job and works out the pattern of ink drops to print. Since the invention of photomechanical color printing 125 years ago, this process has retained an analog mindset, centered around asking the question of how much of each of the available inks are used for printing a given color. Even past the advent of digital printing, this fundamentally analog approach has persisted and is the basis of all color printing today. As a result, printing involves deciding how much of each ink to use for each part of a print job, followed by a halftoning process that for each ink builds a drop pattern to be printed. Finally, the patterns for each ink are sandwiched together and a color print results (Figure 1).

Thinking about print in such analog, ink-by-ink terms has three major drawbacks: first, that the interactions between inks are not controlled directly second, that the choices for how a color

is to be obtained are limited (e.g., with CMYK inks the only choice is whether to use more or less black ink for a color) and, third, that detail and edges are dealt with independently for each ink, which can result in blurring.

HP Pixel Control introduces a paradigm shift, based on the realization that it is the contents of individual print-resolution pixels that are the basic building block of printing. Whether a pixel contains a drop of cyan and another near it a drop of magenta, or whether the two inks coincide at a pixel makes a world of difference. Yet, using the traditional, analog mindset it was impossible either to access these different choices directly or to control precisely what happens at a specific pixel. As a result, HP Pixel Control makes direct choices about which kind of pixel to assign to each area in a print. Instead of sandwiching together separate per-ink halftones, it builds the print-ready, multilink halftone directly (Figure 2).





Figure 1:
An image and its
per-ink halftones,
sandwiched to obtain
the final print.

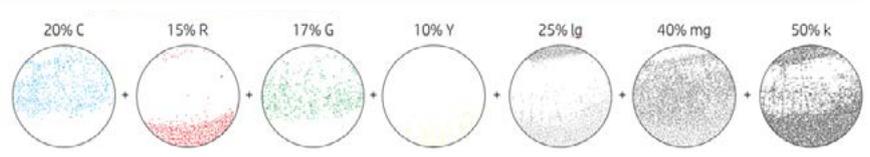


Figure 1

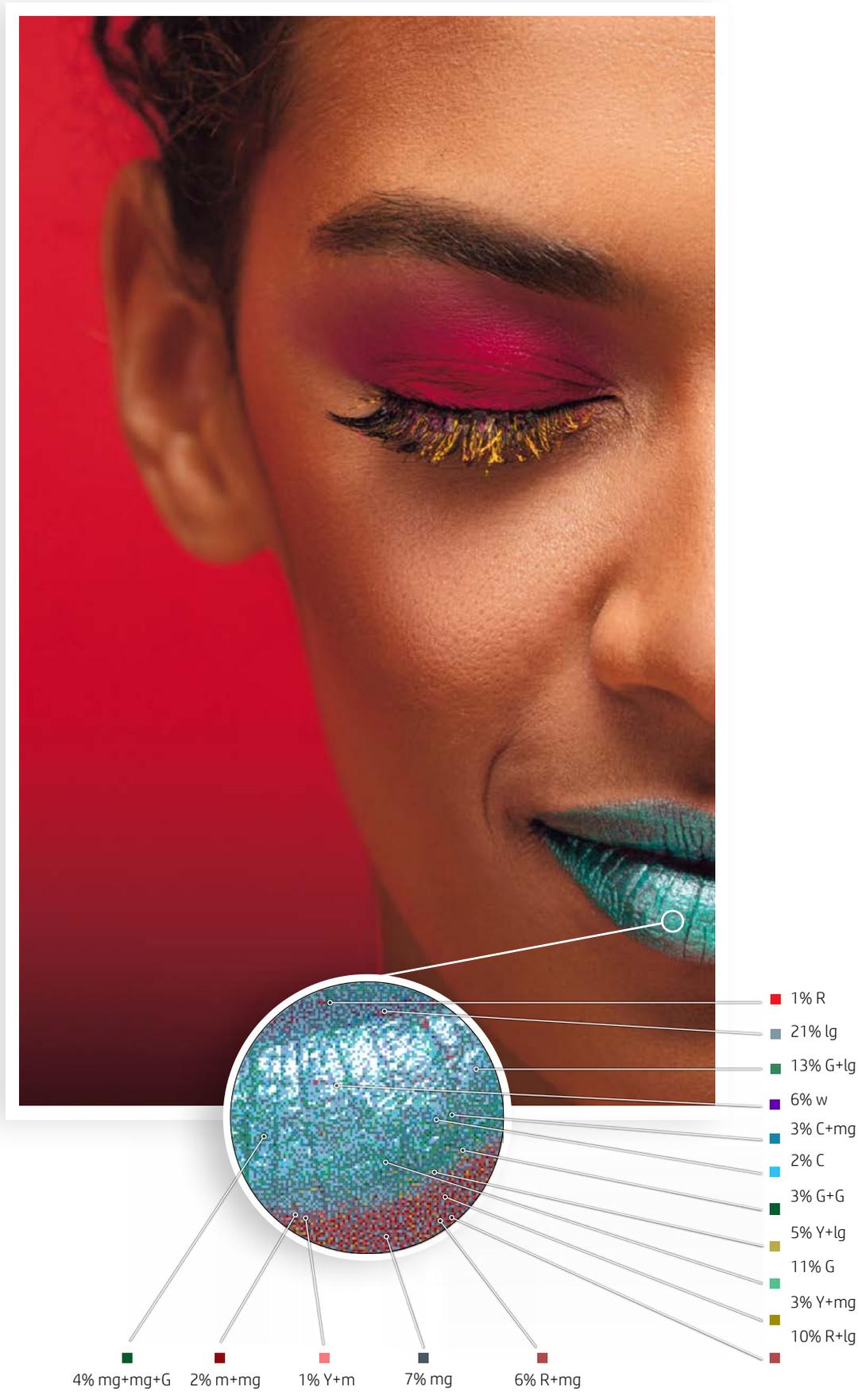


Figure 2

Figure 2:
An image and its
direct, HP Pixel
Control halftone.

With HP Pixel Control, printing becomes truly digital, which results in three fundamental transformations:

First, it leads to vastly more choice. Before, the question was how much of each ink to use for a given color and for a printer like the HP Designjet Z9+ or Z9+ Pro, it would have meant making choices for its 9 inks. With HP Pixel Control, the choice becomes about pixels instead of inks and since the HP DesignJet Z9+ and Z9+ Pro Printers includes 9 inks, five of which can be printed at two different drop sizes and each of which can have up to three drops printed at a pixel, this leads to 414 possible ink drop combinations at any one pixel. Instead of making choices about 9 inks, HP Pixel Control has access to selecting from among over 268 million different pixel types. Even in simple cases, like that of having cyan, magenta, yellow, and black (CMYK) inks and being able to print only up to one drop per ink per pixel there are 16 pixel types that HP Pixel

Control can use, instead of only the four inks that result in them.

Second, it allows for an entirely new degree of control. Before, the choice of certain ink amounts lead to a specific, indirect choice of halftone pixels after the individual inks were halftoned and sandwiched together (e.g., choosing 50% of cyan and 50% of magenta ink always lead to a certain proportion of the resulting print being left blank, another proportion covered using cyan ink only, another using magenta ink only and some proportion having pixels with both cyan and magenta drops). Once ink amounts were decided, no control was available over the specific pixels that got printed. With HP Pixel Control it is, instead, possible to combine pixels at will. For one color, HP Pixel Control can use cyan and magenta drops always on top of each other, while for another color it can keep them apart, since it exercises precise control over how to use each printable pixel type.

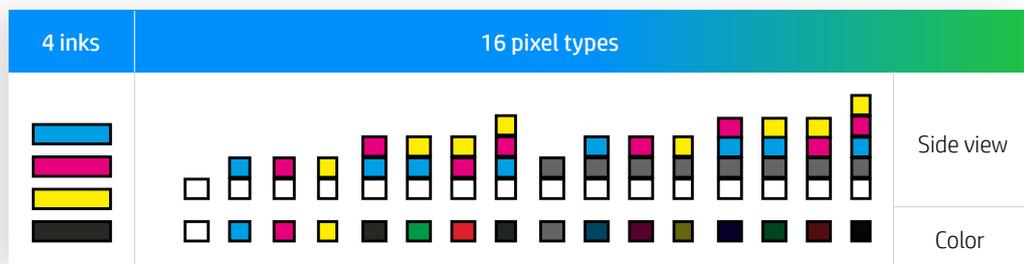


Figure 3

Figure 3:
Four inks versus
their 16 pixel types.

Third, HP Pixel Control combines pixels in exactly the same way in which the eye sees the world around us. Before, choices were made in ink amounts, where the relationship with the colors we see is indirect and complex. With HP Pixel Control, pixels are assigned to specific areas of a print at a scale that the eye cannot distinguish. The eye then averages these pixels' colors in proportion to the areas that HP Pixel Control has determined for them (e.g., if half of a microscopic area has one kind of pixel and the other half another kind of pixel then the eye will see a color that is half way between those pixels' colors). In summary, analog printing first decides how much of each ink—a fundamentally analog quantity—to use for matching a color. This decision is also at the heart of current, analog imitated color processing, which therefore inherits the analog mindset. HP Pixel Control in-stead makes

choices about what pixels—which are natively digital—to use for obtaining a color. HP Pixel Control decides whether to leave a pixel blank, use one ink at a pixel (e.g., a cyan), use multiple drops of an ink at a pixel (e.g., three drops of blue), use two inks at a pixel (e.g., a drop of green and two drops of yellow), or to combine even more ink drops at a pixel. The decision of what to do is taken at a pixel. Instead of asking how much of the available inks to use, HP Pixel Control asks what pixels to use. While analog imitated processing could in principle be done in an analog way, HP Pixel Control results in prints that could not, even in principle, be obtained using analog methods. The three core features of HP Pixel Control, for which over 25 patents have already been granted and a further 80 are pending, then lead to three key benefits for the HP DesignJet Z6/Z9+ and Z6 Pro/Z9+ Pro printers:

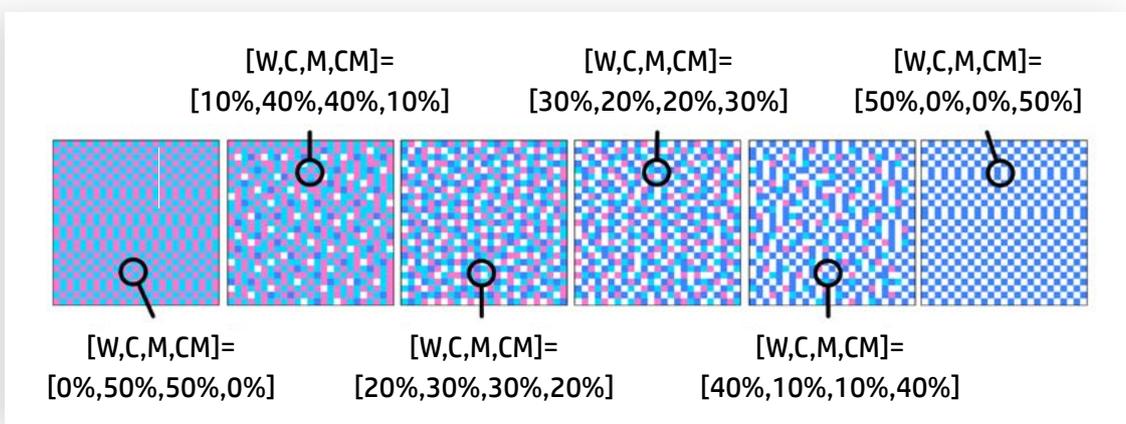


Figure 4

Figure 4: Examples of HP Pixel Control alternatives available instead of a single 50% cyan and 50% magenta ink amount choice.

First, prints made with the HP DesignJet Z6/Z9+ and Z6 Pro/Z9+ Pro series printers have smoother transitions. This is the case even for the most challenging content, where different colors blend smoothly into each other and where the previous imaging pipeline would have lacked the control to make those transitions look seamless and natural. Here, the fact that HP Pixel Control combines pixels in the same way as the eye then merges them plays a key role.

Second, prints made using HP Pixel Control result in more color gamut, with deeper, richer dark colors than before. This is because the new imaging pipeline can combine pixels in ways that were previously not possible. By having precise control over when to overprint inks at a pixel and when to keep them apart, HP Pixel Control can build halftone patterns that result in colors that were

previously beyond a printer's color gamut. Such control also means that it is possible to match, and on some media even exceed, the gamut of a 12-ink printer allowing the DesignJet Z9+ to deliver up to 20% more color gamut than the DesignJet Z3200 Photo printer on plain paper, and making the DesignJet Z9+ Pro the printer with widest gamut in its category.

Third, prints made with HP Pixel Control show more detail, as can be seen above, because it makes choices only once for each printed pixel. Instead of deciding where to place drops for each ink separately, and therefore risking both that edges end up in one place for one ink and in another place for a different ink and that textures get disturbed, HP Pixel Control decides the content of all the inks for a given printed pixel in a single operation.

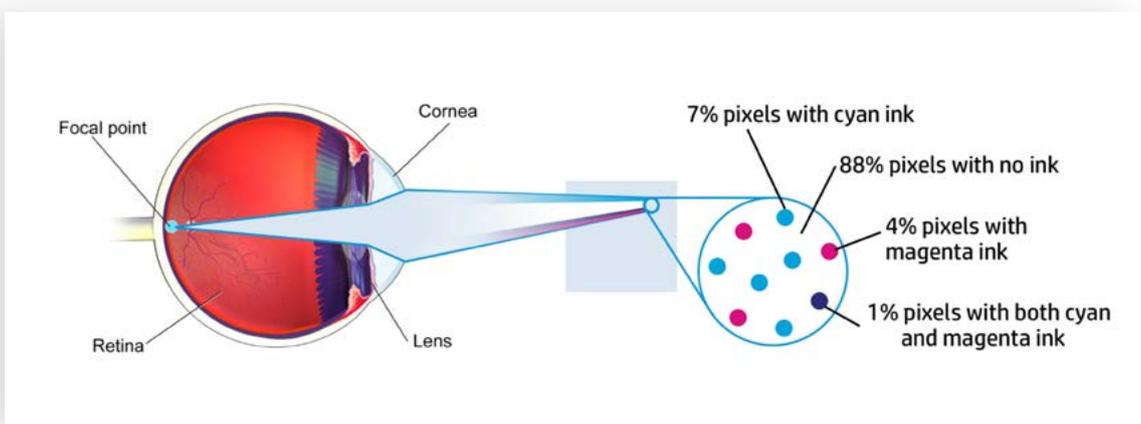


Figure 5

Figure 5:
HP Pixel Control combines pixels in the same way as the eye then sees them.

Finally, since HP Pixel Control is the imaging pipeline of the HP DesignJet Z6/ Z9+ and Z6 Pro/Z9+ Pro Printer series, it is used for printing every single print made with these printers. HP Pixel Control therefore requires no setup or configuration and is applied regardless

of the application, operating system, or printing workflow used. As a result, the additional gamut, smoother and more predictable transitions, and greater detail are always on and show in every single print.



Figure 6

Figure 6:
A complex transition printed using the previous imaging pipeline (left) and HP Pixel Control (right).



Figure 7

Figure 7:
An image with rich, dark colors and detail (center), printed with the same inks, using the previous imaging pipeline (left) and HP Pixel Control (right).

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