cartographic techniques

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Small Type, Screens and Color in a PostScript Offset Printing Environment

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As with any map design project, a conventionally printed map (i.e. halftone-tinted, offset-printed), is easier to create if a wide variety of colors are available for all aspects of the map. One place where this becomes challenging is in small type and symbols (for this paper symbols and type are considered the 'same'). In order for type to be legible, sense dictates it be printed in a solid color, as half-tone screens will render most small shapes illegible.

Logically then, a cartographer will fall back on solids of the inks he/she will be printing in, to determine what colors are available for small type. If one is printing in the standard CMYK process universe, this means three solid colors: black, which is fine; cyan, which is not the best possible blue but is certainly acceptable, and magenta, which is an unpleasant, acid color. No green, no brown, no gray….etc.

Historically, if a cartographer wants a good range of colors, it is useful to think in terms of printing outside the standard process palette of cyan, magenta, yellow, and black. Many national survey series are based on such alternate palettes, like the USGS 7.5' series' familiar black, green, red, blue, brown, and purple.

Another alternative is to adopt an alternate four-ink process palette. In the mid-twentieth century, many U.S. oil company maps adopted a palette consisting of a light blue similar to cyan, a warm red instead of magenta, a yellow somewhat redder than modern process yellow, and a dark blue instead of black (Figure 1 is an example, a section from a Gousha-published Gulf Oil map of New Jersey form 1942). Though a desirable palette, Hedberg Maps adopted a different palette early in its publishing history that allowed for a somewhat larger range of colors, and was closer to CMYK for proofing purposes. This palette was also observed in the late Falk-Suurland's line: process cyan and black, combined with a warm red and reddish yellow.

The disadvantages of using such a non-CMYK process palette are more modest than a totally spot-color-dominated palette, but do include (1) incompatibility with off-the-shelf proofing and color-calibration systems, (2) problems integrating photography or client-supplied artwork, and (3) a modest additional expense from printers (especially for short print runs) involving press wash-up and ink costs.

In theory, of course, mapmakers can approximate most colors by using combinations of the modern process palette. The problem is that virtually all colors involve screen tints and these, as mentioned above, do not generally support the shapes of letterforms at small sizes—or that, at least, is the theory.

In the last few years, Hedberg Maps has switched to standard CMYK, and has maintained a relatively broad range of small type colors, by adhering to the principles and techniques outlined in this paper. These principles

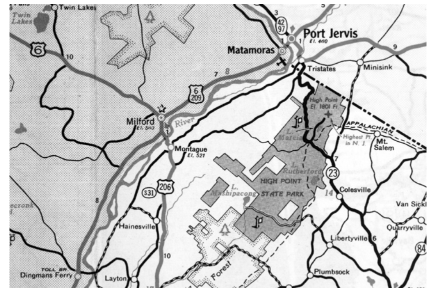

Figure 1. (see page 81 for color version)

Figure 1a. (see page 82 for color version)

and techniques depend on good registration, so lower-end map printing applications need to adjust these rules judiciously. It has been noted that several other map companies are engaging in similar techniques, therefore this paper should spark further creative thinking about color and type.

1. Use The PostScript Edge

PostScript defines all letterforms by their outline. This hard edge is maintained all the way through processing a vector-based PostScript file, to the point where it is rasterized for the output device. Among other things, this means that halftone screen dots that cross the hard line will be cut cleanly along the line, maintaining the shape rather than distorting the edge fluidly towards the dot. If output is direct to plate, this hard edge will be first-generation when it hits paper.

This is dramatically different from older manual techniques, where—especially over the life of multiple revisions—you could count on small but cumulatively significant optical distortions related to the overall set of shapes and their interactions, not to the specific shape objects. Figure 1 shows how the photo-film process caused water type in the same ink as the green tint behind it to meld with the blue screen portion of that tint.

2. Solid Ink Plus Screened Ink

A solid of one color is sufficient to hold a shape if open tints of a second color are added. Open tints are those formed by solid dots in an open space, i.e. screens under about 55% using most algorithms. The theoretical screen percentage where dots in a square grid would touch is 78.5%, but the convention is to switch positive and negative somewhere between 50% and 60%, so that in darker tints the pattern is not dark dots against paper, but paper dots reversed out of a solid ink If closed tints (those formed by open circles within a solid ink) are added to a solid of another color, there is a risk that in the event of off-registration, both inks trying to hold the letterform shape will compete and accentuate the registration problem. By placing a series of dots against a solid of another color, you allow the solid to hold the shape, while the "shapeless" mass of dots in another ink only adds color.

3. Dark Ink Plus Light Ink

Most cartographers already so this to create greens and warm reds. In the CMYK world, yellow can be added in any screen percentage (including 100%) with near-impunity to any solid dark ink. If you are using non-CMYK inks, any light ink will have the same effect. To judge an ink's lightness, consider its "L" value in the L*A*B color system. For example, in Photoshop (where one can determine L*a*b values in the color picker) black has an L*a*b lightness value of 0, cyan of 62, magenta of 48 and process yellow of 94 (Kennelly and Kimerling, 2003).

4. Solid Type Against Screened Line Work Not Including That Ink Color

Running any solid dark ink type against an open screen of another dark ink (or inks) works well, because the edge of the solid dark type remains intact. For many of our street maps, Hedberg Maps use a street line that's a combination of cyan, yellow and magenta. When street labels are printed in black ink, the line work and the type do not have to be kept totally separate (though of course it looks even better when they are kept separate).

This is not a carte blanche. One still can't print dark type over linework with too strong a contrast. As a principle, the contrast between your type and your overprinted linework should be greater than that between the linework and the background. Figure 2 illustrates two editions of Hedbergs Maps' Cambridge Street Map title. On the left is the first edition as printed in four spot colors. On the right, a modified process palette meant creating a street line color as a tint combination. This illustrates that the street line work was too dark.

5. Solid Type Against a Screen of the Same Ink Color: Text Line Weight should be at an appropriate ratio to the dot diameter.

Solid type can be placed in some situations against tints of the same ink color, but as the type gets smaller, the potential for legibility

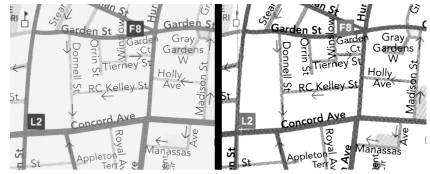

Figure 2. (see page 83 for color version)

problems gets greater. The letter shapes begin conflicting with the dots of the screen pattern. What appears to happen, in part, is that the reader's eye wants to average the dot pattern out as gray, but doesn't know what to do when a dot is also affecting the shape of a small piece of type. The end effect is often one where some pieces of letters seem to disappear as they move in line with rows of dots, and where other pieces of type become "filled in" as other dots close gaps and breaks in letter shapes.

An initial subjective look at samples, for example in Figure 3, seems to indicate that the determining factor is dot size versus the width of lines forming the letter

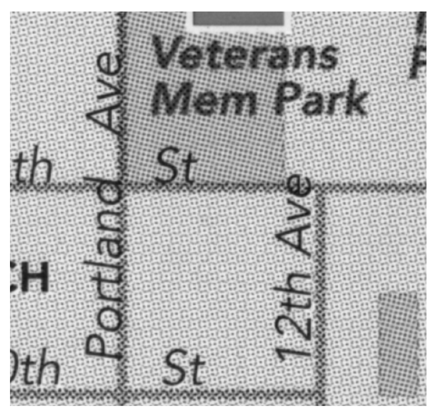

Figure 3a. (see page 83 for color version)

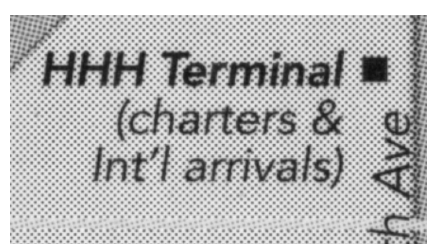

Figure 3b. (see page 84 for color version)

form. This makes sense intuitively: if a dot is dramatically smaller than a line it overlaps, it may not read as a related shape, whereas if a screen dot approaches the density of a shape within a letterform, it may become hard to tell them apart when reading or scanning at full speed. Of course, other factors creep in to affect legibility: small type in general can be hard for many to read, and fonts in themselves can be easier or harder to read depending on size, and at very small point size (under 6 point, and especially under 5 point) great care must be taken in choosing fonts for legibility.

To use this principle, it helps to have an idea of dot size and the width of lines within letters. To calculate dot diameter *d*, given a screen frequency *f* in dots per inch (dpi) and a tint percentage *p*, the relationship can be initially stated as:

$$\frac{p}{100} = \frac{\left(\frac{d^2\pi}{4}\right)}{\left(72\frac{1}{f}\right)^2}$$

This can be reduced to:

$$d = \frac{\sqrt{p}}{f} \times \frac{14.4}{\sqrt{\pi}} \approx 8.125\frac{\sqrt{p}}{f}$$

This formula will give *ideal, theoretical* dot size. RIPs and output devices distort this in order to make up for dot gain, and once on press dot gain can make a mockery of the numbers thus derived. Nevertheless, Figure 4 is a table giving ideal dot diameters in points for common tints and screen frequencies.

The easiest way to calculate the line weight of a font is to set a piece of type at 10 points, and on-screen to draw a line that matches a thin line within the test. The crossbar of the small letter "e" is a good example, or the crossbar of a capital "T". One can then multiply by one-tenth the actual text (i.e. line weight of 6 point type will be .6 times the 10 pt weight).

Screen percent	50 dpi	72 dpi	100 dpi	133 dpi	150 dpi	200 dpi
5%	0.36	0.25	0.18	0.14	0.12	0.09
10%	0.51	0.36	0.26	0.19	0.17	0.13
15%	0.63	0.44	0.31	0.24	0.21	0.16
20%	0.73	0.5	0.36	0.27	0.24	0.18
25%	0.81	0.56	0.41	0.31	0.27	0.2
30%	0.89	0.62	0.45	0.33	0.3	0.22
40%	1.03	0.71	0.51	0.39	0.34	0.26
50%	1.15	0.8	0.57	0.43	0.38	0.29

Figure 4

A few basic examples: Adobe's Helvetica Regular has a minimum line weight at 10pt of .69 pt and Helvetica Bold is .91 pt. In Hedberg Maps' "house font", Avenir, the weights are: Book, .54 pt; Roman, .66 pt; Medium, .72 pt; Heavy, .89 pt; and Black, 1.02 pt.

The acceptable ratio of letter line weight to dot diameter is really an individual decision. In different situations, a reasonable lower limit is somewhere between 1:1 and 1.5:1. For Helvetica then, if 1.5:1 is chosen as the threshold, then using the chart above, at a 133dpi screen, 6 point type (with a line weight of about .6 x .69 pt = .41) could offer nothing lighter than about a 22% tint (with a dot diameter somewhere around .28 pt), and a 10% tint (dot diameter of .19pt) would work with type no smaller than 4 pt (line weight of .28pt).

Serifs make the calculations almost impossible at a numeric level. Instead, a variant on the test performed in Figure 4 is suggested. Here a 50dpi screen series is laid against 10pt type for various fonts. Working at this large scale will allow a few things: first, what will be discerned is what the acceptable dot-font size ratio is, without regard to whether the type works well in general at a small size. Second, the test can be performed without utilizing expensive high-end output; 50 dpi screens have pretty accurate dots on most modern laser printers, though some laser printers (e.g., Xerox) tend to make dots form into diamonds as they approach 50%.

As an example, if on such a test you decide that a 50dpi screen of 20% is as dark a screen as can be tolerated for 10pt FontX, that means a dot diameter of .73 is your minimum at 10 pt. Size changes are proportional, so at 5 pt FontX, the maximum dot diameter is .5 x .73 or .37 pt. If printing at 133 dpi, this means the threshold for screen darkness is a little lighter than 40%.

This technique is in need of more rigorous testing with a larger sample of fonts and font styles. In particular, while this series of measurements works fairly well for fonts with nearly even line widths throughout, the numbers fall apart for serif fonts, where line weights vary dramatically. Times Roman, for example, varies at 10 pt from about 1 pt down to about .35 pt. Italic versions (which are conventionally used as hydrologic labels, often over a tint of the same blue ink the type is printed in) are even more variable. A font-by-font analysis would be necessary, and perhaps the technique outlined above will allow us to make better judgements for specific fonts.

6. Light Lines

The same basic principles work for light lines. On Hedberg Maps' campus and community map series, very light lines are used to outline buildings. Over the years, Hedberg Maps has used lines both in a CMY color combination and in a black tint. In both cases, lines of hairline (.25 pt) and .5 pt weight have also been tried. As Figure 5 shows, which color model is used makes little difference. In both cases, .5 pt is necessary.

In this case, it is the space between dots that is important. In a 133 dpi screen, the dots are a little over .5 points from center to center. A similar effect could have been achieved with a proportionally narrower line if the screen frequency were higher.

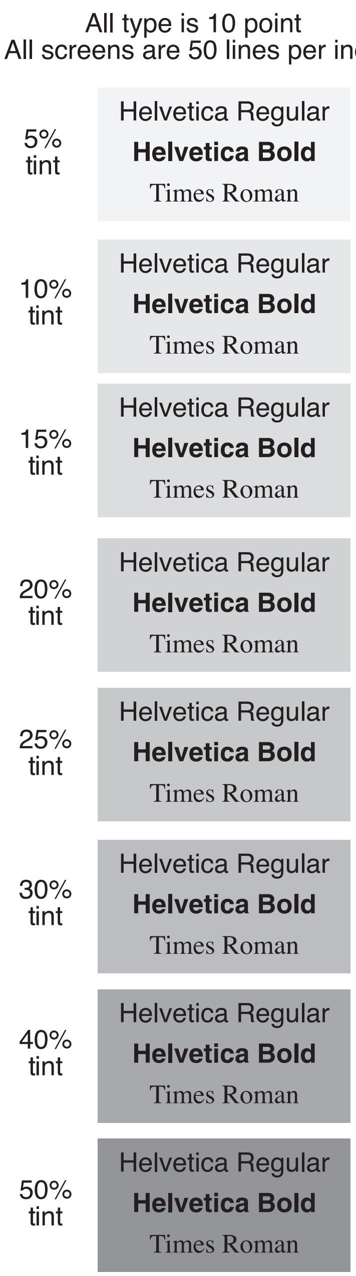

Figure 5

7. Screened Type

Figure 6 illustrates an example of screening type. While it was noted earlier that screened type does not hold up well, at some point the shapes become large enough to hold up even when viewed through a screen. As in the above section on lines, the key seems to be the ratio of the line weight to the distance between dot rows. Extensive testing has not been conducted on this, but the type appears legible when the letter type weight is about 2 to 2.5 times the distance between rows (i.e. the inverse of the screen frequency).

The above applies to open screens. For closed screens, the ratio can get much closer, down to 1 to 1.5 times the dot-to-dot distance. In these cases, the goal is that nowhere will a "hole" or inverse dot cut across a piece of type so as to distort the type. As in screening behind type, both open and closed screen tints of type itself are much easier in simple sans serif fonts than in serif fonts.

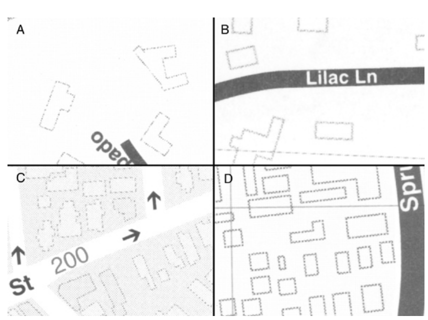

Figure 6. (see page 84 for color version)

Conclusion: Think In Inks

In the digital age, comparatively little time is spent thinking about separations and how they will work together when compared to the era in which each separation was assembled manually from a variety of elements. The automatic nature of separation makes life easier, but it also takes away some awareness of how using the four (or more) separate ink colors can expand our design options. Thinking in terms of inks is still important.

For better or for worse, though, this technique may be moot in a few years time. Stochastic printing has its own design challenges (screens of light graduated tints, for example, look quite different), but it does make type composed of almost any ink combination a viable option. As it appears stochastic is finally working its way into the mainstream, color printing will in the near future have resolved most of what is discussed in this article, opening up yet further design options to cartographers.

Acknowledgements:

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References

Kennelly, P. and Kimerling, J.A., 2003. *Analytical Hillshading with Luminosity from Aspect*. Paper presented at the Annual Meeting of the North American Cartographic Information Society, Jacksonville, Florida.