Final Report

Comparative Study: *Hewlett-Packard Business Inkjet 1100d* *vs.* Epson Stylus C84

The *SpencerLab* Digital Color Laboratory, a division of Spencer & Associates Publishing, Ltd., has conducted independent testing and evaluation of ***Throughput Speed Performance, Ink Yield/Cost-per-Print,*** and ***Print Quality*** of the **Hewlett-Packard Business Inkjet 1100d** (BIJ 1100) and **Epson Stylus C84** (Stylus C84) color inkjet printers.

Testing was performed utilizing a variety of real-world representative documents, including professional office word processing and desktop publishing applications from the *SpencerLab* Printer Test Suite[1] and HP-supplied documents.

Test results showed the BIJ 1100 provided *faster Throughput Speed Performance* than the Stylus C84 for desktop publishing documents – containing mixed text, color graphics and images; on a monochrome report the BIJ 1100 was 12 seconds slower.

Test results also showed the BIJ 1100 had *lower Cost-per-Print* than the Stylus C84 on all test documents – including a typical monochrome office letter and desktop publishing documents – and had on average *more Prints-between-Interventions* due to cartridge changes – in all document tests.

The BIJ 1100 produces exceptional Black and Color Text with sharp, smooth character presentation. Black Line art is excellent and Tints are vibrant and well saturated. Images are rendered with superior quality. Areas for improvement include smoothing of screening patterns, where those from the Stylus C84 were less noticeable, and increased compatibility between the BIJ 1100 and HP Premium Inkjet Paper – in some cases, print quality on plain paper exceeded that on the premium media.

The *SpencerLab* Digital Color Laboratory is an independent test laboratory with a broad base of industry clients. Although this comparative study was commissioned by Hewlett-Packard Company, *SpencerLab* believes these results maintain its reputation for the integrity of its procedures and analyses. Results stated herein are based upon direct testing by *SpencerLab* personnel of actual products believed to be representative.

[1] The *SpencerLab* Printer Test Suite, now in ßeta, is an extension of Spencer & Associates' *Color Hardcopy Quality Factors* test suite, a de facto industry standard since 1990.

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Throughput Speed Performance

Methodology

Two test document files were selected from the *SpencerLab* Printer Test Suite and one document was supplied by HP (and *spencerized*[2]) to represent an appropriate range of office user applications for this class of color inkjet printers:

- *Monochrome Report* (Microsoft Word 2002) – black text with grayscale logo and headings, and a table with gridlines; *SpencerLab* document, 5-pages
- *SpencerLab Greenland* (Microsoft Word 2002) – compound color text, color graphics and images in report format; *spencerized* HP document, 5-pages
- *Newsletter* (Adobe Acrobat 5.0) – mixed text, color graphics and photograph; *SpencerLab* document, 1-page

All time measurements begin with the request-to-print. The TOTAL PRINT TIME measurement or LAST PAGE OUT time (when the last page drops into the output tray, also known as "Click-to-Clunk") is augmented by measurements of APPLICATION RELEASE and WORKSTATION RELEASE, ENGINE START (a perceptible sound or mechanical action), and FIRST PAGE OUT time.

THROUGHPUT MODES	HP BIJ 1100d	Epson Stylus C84
Monochrome Report	PRINT QUALITY: FAST NORMAL COLOR OPTIONS: PRINT IN GRAYSCALE, BLACK PRINT CARTRIDGE ONLY	QUALITY OPTION: TEXT ADVANCED: BLACK INK ONLY
SpencerLab Greenland	PRINT QUALITY: NORMAL	QUALITY OPTION: TEXT & IMAGE
Newsletter	PRINT QUALITY: NORMAL	QUALITY OPTION: TEXT & IMAGE

Directly impacting user workflow, APPLICATION and WORKSTATION RELEASE times allow the user to resume working, and their workstation to return to full processing power, respectively. ENGINE START time provides important feedback to the user – that the print request has progressed to physical printing. All timings are recorded for each test document over several iterations to assure accurate results within a prescribed tolerance (1% ±1 second).

Since the print modes available on each printer are different, a focused print quality evaluation was performed to establish comparable output quality levels for each file. Accordingly, samples from applications often used to produce graphics output were tested at higher quality levels than those applications used primarily for text with incidental graphics. Throughput was performed in the modes noted on the preceding Table. Based on the results of this comparison, throughput tests were then performed.

Testing was performed on a 2.0 GHz Dell Dimension 4500 Pentium 4 workstation with an 18.5 GB hard drive and 256 MB RAM running Windows XP and USB communication with each printer, one-at-a-time, to the BIJ 1100 and Stylus C84. Clean system software was reinstalled before testing each printer, including only that printer's current driver.

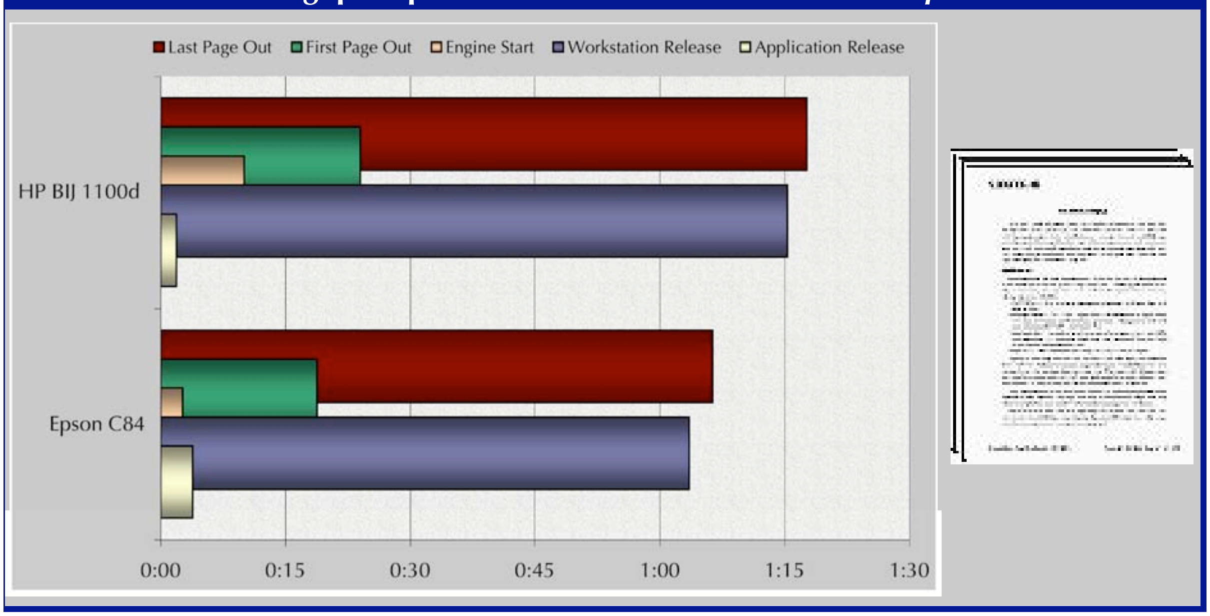
[2] *Spencerizing*, our proprietary document optimization process, is used by more than a half-dozen major industry clients.

Test Results and Analysis

“Monochrome Report”

On this 5-page, monochrome document the Total Print Time (Last Page Out) of the BIJ 1100 was 1:18[3], 12 seconds slower than the Stylus C84 at 1:06. Application Release was 2 seconds quicker on the BIJ 1100 (1.9 seconds) than on the Stylus C84 (3.9 seconds), but all subsequent timings were faster on the Stylus C84. Workstation Release of the BIJ was at 1:15, whereas the Stylus C84 was 1:04; Engine Start was at 10 seconds on the BIJ 1100 and just 2.6 seconds on the Stylus C84, and First Page Out, available on the Stylus C84 at 18.8 seconds, was 5.2 seconds faster than the BIJ 1100 at 24.0 seconds. The BIJ 1100 achieved an average print speed of 4.5 pages-per-minute (ppm), and the Stylus C84 at 5 ppm.

Throughput Speed Performance – *Monochrome Report*

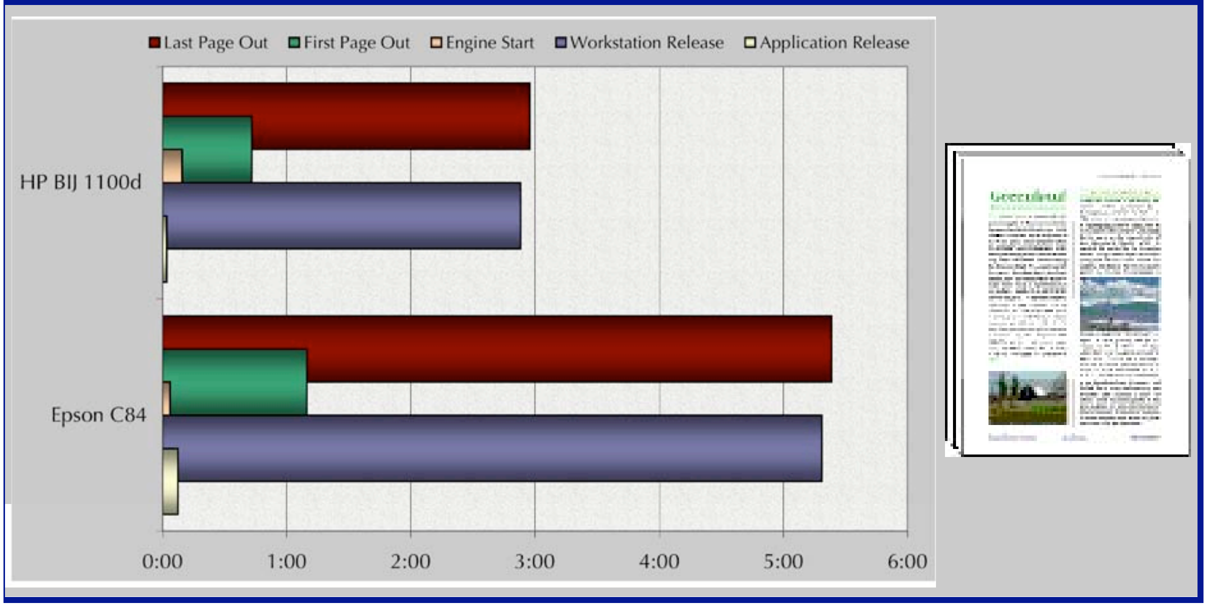


“SpencerLab Greenland”

The BIJ 1100 Total Print Time on this 5-page color test document was faster at 2:57, with the Stylus C84 taking over two minutes longer (82% longer) at 5:23. Application Release occurred quickly on the BIJ 1100 at 2 seconds, and at 7.5 seconds on the Stylus C84. While Engine Start on the BIJ 1100 (9.5 seconds) was 6 seconds after the Stylus C84 (3.6 seconds), the BIJ 1100 was able to produce First Page Out in 43.3 seconds, 26.7 seconds faster than the Stylus C84 (1:10). Workstation Release on both the BIJ 1100 (2:53) and Stylus C84 (5:19) was just short of the respective Total Print Times. The BIJ 1100 achieved an average print speed of 1.8 ppm, while the Stylus C84 averaged just less than one ppm.

[3] Times are denoted as min:sec.tenths, min:sec, or sec.tenths.

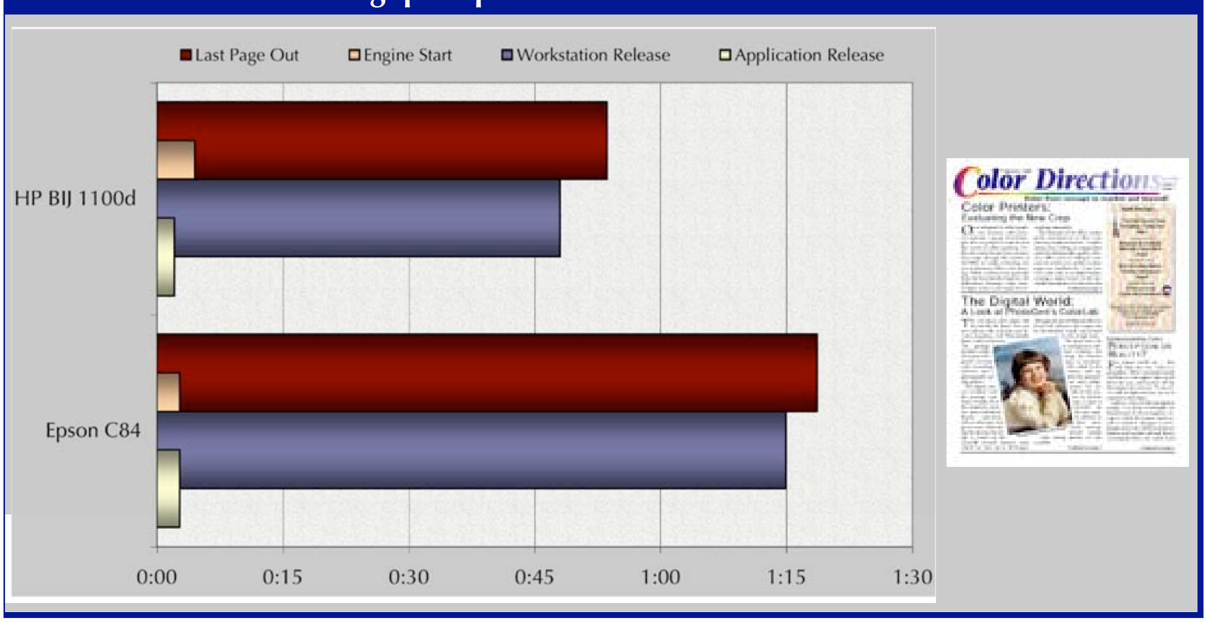
Throughput Speed Performance – *SpencerLab Greenland*



"Newsletter"

On the *Newsletter* file, the BIJ 1100 had the faster TOTAL PRINT TIME of 53.6 seconds, with the Stylus C84 taking almost 50% longer to print, at 1:19. Again, while the BIJ 1100 (4.5 seconds) had a slower ENGINE START than the Stylus C84 (2.7 seconds), the WORKSTATION RELEASE of the BIJ 1100, at 48 seconds, was substantially quicker than the Stylus C84 time of 1:15. Both the BIJ 1100 and Stylus C84 had quick APPLICATION RELEASE TIMEs at 2.1 and 2.7 seconds, respectively.

Throughput Speed Performance – *Newsletter*



Cost-per-Print/Ink Yield

Methodology

Three single page test documents were selected to represent an appropriate range of office user applications for this class of color inkjet printers; one test document file selected from the *SpencerLab* Printer Test Suite and two test documents supplied by HP:

- ♦ *Monochrome Dignissimas2* (Microsoft Word 2002) – black text with grayscale chart, HP-supplied document
- ♦ *SpencerLab Greenland* (Microsoft Word 2002) – compound color text, color graphics and images in report format; *spencerized* HP document
- ♦ *Newsletter* (QuarkXPress 4.1) – mixed text, color graphics and photograph; *SpencerLab* document

The primary method of determining Cost-per-Print is based upon a determination of the number of copies of a test document that can be printed by the black and color ink cartridges. Testing for this determination is repeated over multiple cartridges to assure consistency. Once an average number of Prints-per-Cartridge is established for black and for each color, the cost of each cartridge is divided by this result to calculate the black and each color component costs. For this analysis, Manufacturer Suggest Retail Prices (MSRPs) for cartridges were obtained from manufacturer websites. These component costs for each ink color are then summed to obtain the total ink Cost-per-Print for each of the test documents. Additionally, as in the case of the BIJ 1100, if a printer is equipped with user-replaceable printheads, this cost is also calculated to determine its contribution to the total Cost-per-Print.

In order to determine when it is appropriate to replace a cartridge (end-of-life), the print quality is continuously monitored. A cartridge is judged to be at end-of-life at the earlier of an INK OUT signal on the control panel or when test prints show visible defects attributable to ink supply. Both printers in this test contain individual color component ink tanks. Cartridges are replaced at their end-of-life and tests are re-run until sufficient, consistent data is acquired.

This testing utilized a 2.0 GHz Dell Dimension 4500 Pentium 4 workstation with an 18.5 GB hard drive and 256 MB RAM running Windows XP; printers were connected via USB. All test files were in PDF format using Adobe Acrobat 5.0.

COST-PER-PRINT MODES	HP BIJ 1100d	Epson Stylus C84
Monochrome Dignissimas2	PRINT QUALITY: FAST NORMAL COLOR OPTIONS: PRINT IN GRAYSCALE, BLACK PRINT CARTRIDGE ONLY	QUALITY OPTIONS: TEXT ADVANCED: BLACK INK ONLY
SpencerLab Greenland	PRINT QUALITY: NORMAL	QUALITY OPTIONS: TEXT & IMAGE
Newsletter	PRINT QUALITY: NORMAL	QUALITY OPTIONS: TEXT & IMAGE

Since the print modes available on each printer are different, a limited print quality evaluation was performed to determine comparable output quality levels for each file. Accordingly, samples from applications often used to produce graphics output were tested at higher quality levels than those applications used primarily for text with incidental graphics. Based on the results of this comparison, cost-per-print tests were then performed. Modes were as noted on the chart below; if not otherwise noted, printers' defaults were used.

Cartridge and Printhead Cost

The following table lists manufacturer list prices of cartridges and printheads in US$ as of January 2004:

Component Costs	HP BIJ 1100d	Epson Stylus C84
Cyan/Magenta/Yellow Cartridges	$33.99	$12.34
Black Cartridge	$33.99	$23.74
Cyan/Magenta/Yellow/Black Printheads	$33.99	-----

Test Results and Analysis

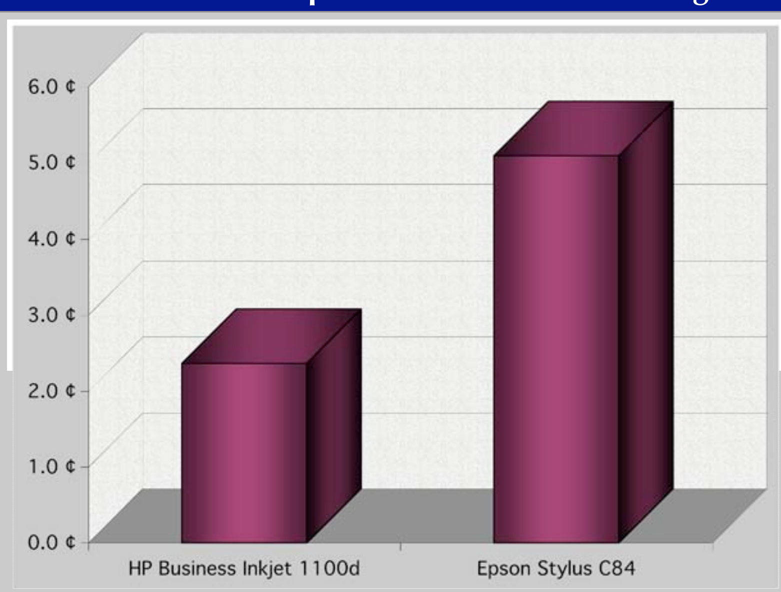
The Cost-per-Print of the BIJ 1100 is significantly lower than that of the Stylus C84 on all test documents, with the Stylus C84 ranging from 115% to 129% more expensive. The overall results of *SpencerLab's* Cost-per-Print analysis are summarized in the following table. Results include the costs for black and component color inks, plus the cost of the printheads for the BIJ 1100; media is not included.

Cost-per-Print	HP BIJ 1100d	Epson Stylus C84
Monochrome Dignissimas2	2.37¢	5.09¢
SpencerLab Greenland	7.96¢	18.15¢
Newsletter	7.05¢	16.15¢

The results of the ink Cost-per-Print analysis for the three individual test files follow.

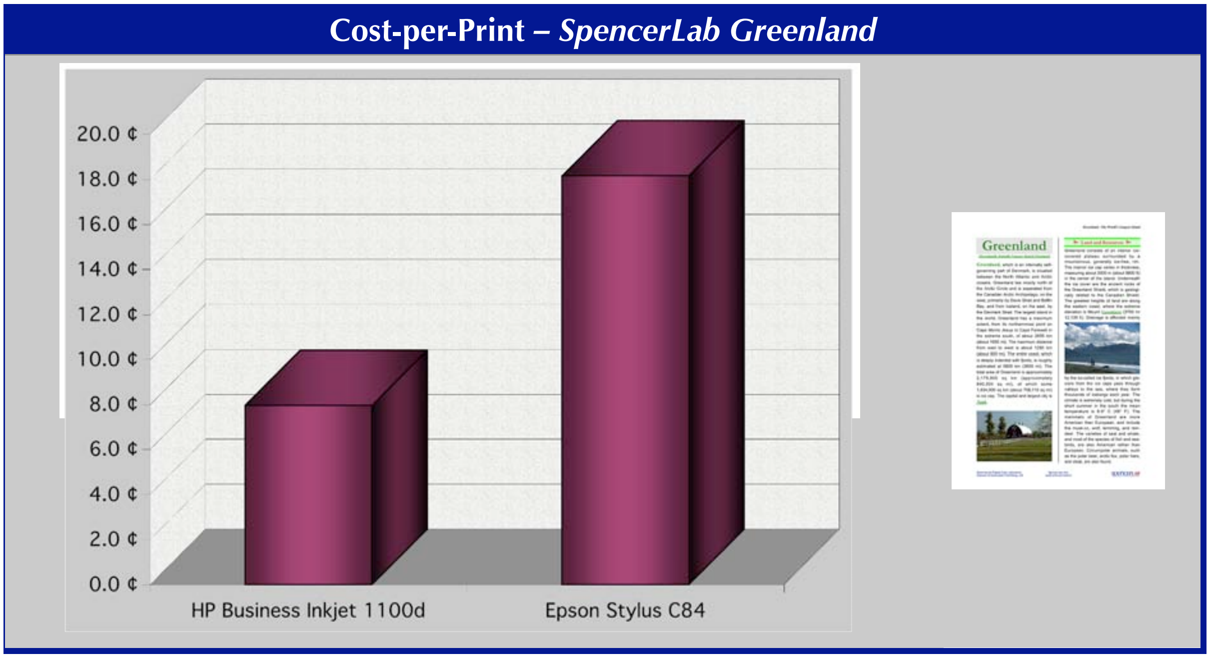
"Monochrome Dignissimas2"

Cost-per-Print – *Monochrome Dignissimas2*



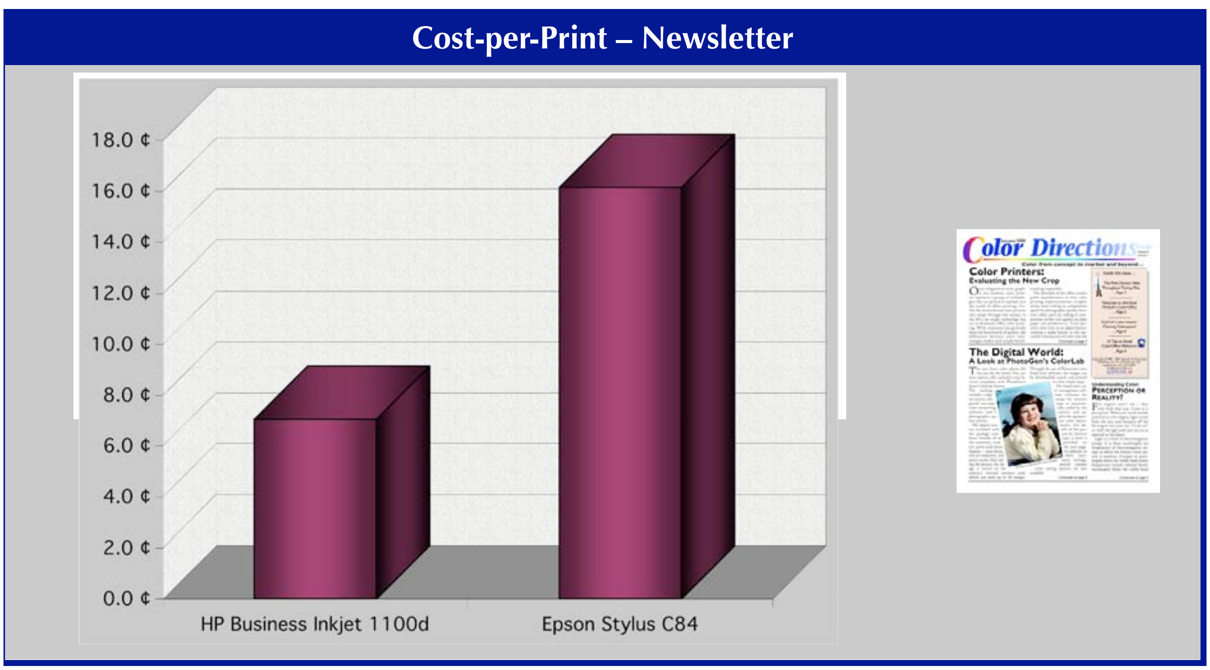
The BIJ 1100 prints this monochrome letter document at less than 2½¢ (2.37¢) per print; the Stylus C84 is over twice the cost, over 5¢ (5.07¢) per print.

"SpencerLab Greenland"



On the *SpencerLab Greenland* text and color graphics test document, the BIJ 1100 cost-per-print is less than 8¢ (7.96¢); the Stylus C84 is more than twice as expensive (+128%) at over 18¢ (18.15¢) per page.

"Newsletter"



The BIJ 1100 costs about 7¢ (7.05¢) per print of the *Newsletter* test document, while the Stylus C84 at over 16¢ (16.15¢) per print was again more than twice (+129%) as expensive.

Prints-between-Interventions

Methodology

The greater the number of Prints-between-Interventions, the less a user must interact with the printer. As noted in the above discussion of Cost-per-Print test and analysis, that methodology is based upon determining the number of prints of a test document that can be imaged by the black and color ink cartridges, or Prints-per-Cartridge. Since an operator Intervention is required to change a cartridge every time it reaches end-of-life, the Prints-per-Cartridge data may be used to estimate a upper bound on the number of Prints-between-Interventions. That is, additional Interventions for other reasons (such as printhead replacement or paper jam) may lower the average number of prints between them, but at the minimum Interventions are required for ink cartridge replacements.

The Prints-per-Cartridge data for the black and color may be combined to calculate the minimum bound on Interventions as follows:

$$\text{Prints-between-Interventions}_{Average} = (\text{Prints-per-Cartridge}_{Black}^{-1} + \text{Prints-per-Cartridge}_{Color}^{-1})^{-1}$$

Test Results and Analysis

The HP BIJ 1100 registered the higher average number of Prints-between-Interventions due to cartridge changes in all document tests – both monochrome and color.

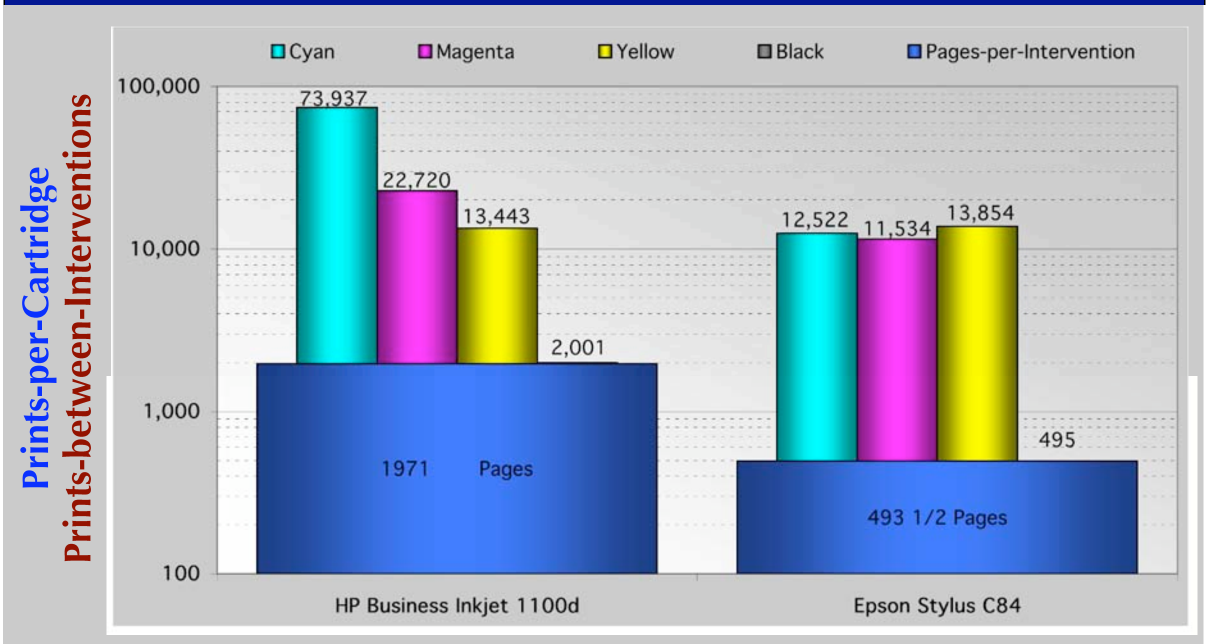
The results of Prints-per-Cartridge tests and the average Prints-between-Intervention calculations are summarized in the table on the right. This data for Prints-per-Cartridge and the upper resultant bound on the number of Prints-between-Interventions are shown graphically for each test document below.

	Average Prints -between-Interventions	Prints-per-Cartridge		Black
		Color		
Monochrome Dignissmas2				
HP BIJ 1100d	1971	Cyan	73937	2001
		Magenta	22720	
		Yellow	13443	
Epson Stylus C84	494	Cyan	12522	495
		Magenta	11534	
		Yellow	13854	
SpencerLab Greenland				
HP BIJ 1100d	893	Cyan	1751	1296
		Magenta	2628	
		Yellow	2311	
Epson Stylus C84	174	Cyan	422	239
		Magenta	625	
		Yellow	371	
Newsletter				
HP BIJ 1100d	1026	Cyan	1694	1953
		Magenta	2117	
		Yellow	2929	
Epson Stylus C84	180	Cyan	305	411
		Magenta	304	
		Yellow	546	

"Monochrome Dignissmas2"

At an estimated average bound of 1,971 Prints-between-Interventions when printing documents such as the *Monochrome Dignissmas2* file, the BIJ 1100 required interventions to change a print cartridge about four times less often than the Stylus C84. Correspondingly, the BIJ 1100 required only 0.51 Interventions per 1000 prints, while the Stylus C84 required 2.02. The lower Black page yield per cartridge of the Stylus C84 contributed significantly to its need for more user Interventions when printing monochrome documents such as this.

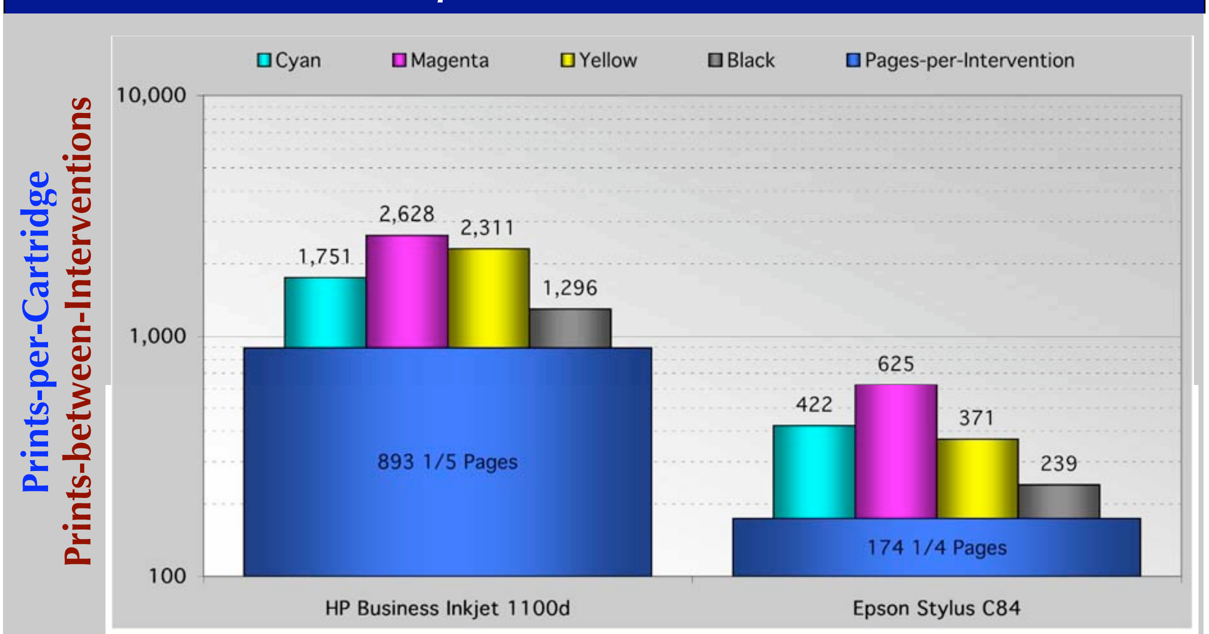
Monochrome Digissmas2



"SpencerLab Greenland"

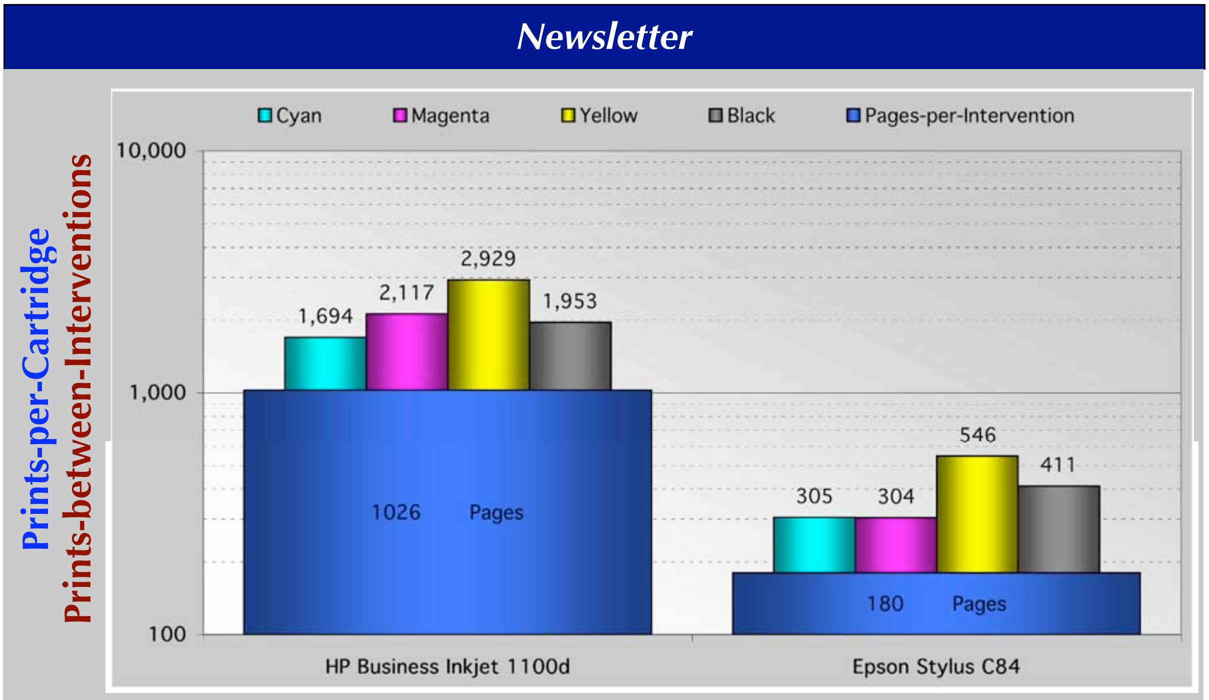
At an estimated bound of 893 Prints-between-Interventions when printing the *SpencerLab Greenland* file test document, the BIJ 1100 requires an Intervention to change a print cartridge over fives times less often as the Stylus C84, which requires Intervention at an estimated bound of only 174 pages. Correspondingly, the BIJ 1100 required only 1.12 Interventions per 1000 prints, while the Stylus C84 required 5.75.

SpencerLab Greenland



"Newsletter"

At an estimated bound of 1,026 Prints-between-Interventions when printing the *Newsletter* test document, the BIJ 1100 requires an Intervention to change a print cartridge almost six times less often than the Stylus C84. The Stylus C84 requires Intervention at an estimated bound of 180 pages. Correspondingly, the BIJ 1100 required only 0.97 Interventions per 1000 prints, while the Stylus C84 required 5.55.



Print Quality Analysis

Methodology

A range of test documents from the *SpencerLab* Printer Test Suite was printed on each of the printers in a range of print modes, after printer setup and alignment. These test documents included current versions of the *Color Spectrum, Graphic,* and *Graphic RGB* programs (originally developed as part of the *Color Hardcopy Quality Factors* study series). Also included was the *Enhanced Graphic* PostScript program (originally developed as part of the *Hardcopy Quality Enhancement* study) and a range of images and application test documents from the suite, covering a variety of printing requirements. Print Quality was analyzed by element type (*e.g.*, Black, Color and Reverse Text, Lines, Tints and Blends, and Images) across these test documents. A single printer of each manufacturer was used in analysis and was assumed to be representative.

Test Results and Analysis

HP BIJ 1100 print quality surpasses that of the Epson Stylus C84 in Black and Color Text, Black Lines, and Image rendition. BIJ 1100 Tints have exceptional saturation, but screening patterns are more evident than on the Stylus C84. Images on the HP BIJ 1100 offer excellent richness, sharpness, detail and smoothness.

In some instances, plain paper output is of higher quality than that produced on HP Premium Inkjet Paper. For example, Text printed on plain paper renders sharp, smooth characters; however, on HP Premium Inkjet Paper, Text appears thick and rough, resulting in a slight loss of legibility.

Text

Reflecting their different print quality issues, Black, Color, and Reverse Text are discussed in the following sections.

Black Text

Black Text represents the most common use of an office printer, and is primarily comprised of thin, filled solid regions. As the principal vehicle for communicating ideas, text is designed to be very legible while being unobtrusive to the reader. Print quality limitations can cause distractions that subtract from the effectiveness of the communication; in the worst case, they can render text illegible.

Because of the limited number of addressable dots with which to render a font character, small text poses the greatest challenge to legibility. Two and 4-point text is often used in situations where legibility is crucial but precise artistic accuracy is not necessary; the sophistication of font design increases at 6 points and larger as the visibility of fine details improves with point size to even the most casual reader.

Uniform character stroke weights and spacing provide uniform “typographic color”, the perceived overall darkness of the text. This enhances effective communication when successful, but may detract significantly when distorted and uneven. Font details such as fine serifs, thin strokes, and uniform kerning can easily be lost due to poor reproduction.

Black Text on the BIJ 1100 is sharp, clear and crisply rendered. Text is legible down to 2-point, and only minor dropouts are visible at 4-point, under magnification, and no visible splatter is visible. Typographic color is even and consistent, with very smooth gradations. Black Text rendered on plain paper produces thinner characters, with sharper and smoother edges, than output produced on HP Premium Inkjet Paper. Overall, Black Text quality is of higher quality than the Stylus C84 on both plain and premium papers.

The Stylus C84 produces thick and jagged Black Text with noticeable wicking, especially when printing in TEXT mode. Black Text is legible down to 2-point, and dropouts are visible at 4-point without magnification. No visible splatter is present.

Color Text

Color can be used to highlight or emphasize particular words or phrases – improper rendering of such color can shift the emphasis from the key idea to the lack of adequate print quality. Because most colors (all but pure primaries and secondaries) require some halftoning even at full saturation, text quality is often decreased further due to the halftone cell structure.

Color Text on BIJ 1100 is ranked highly, and is comprised of smooth and legible characters. Screening is excellent and barely visible, even in tertiary colors such as orange or brown. Text is legible and sharp down to 2-point, though it appears thicker on Premium Paper. Color Text appears lighter than that of the Stylus C84, and upon comparison gives a somewhat washed-out effect. Grayscale Text offers excellent legibility, however midrange grays are a bit too dark, yielding less distinction across the darker shades.

Color Text output on the Stylus C84 is darker than BIJ 1100, which on higher point sizes is pleasing, but produces overly heavy character rendition and decreased legibility at the lower point sizes. Screening is slightly less smooth than that on the BIJ 1100.

Reverse Text

Although less significant than other print attributes for many applications, reverse text represents a specific use that some printers tend to reproduce poorly due to enlarged spot size, toner splatter, and other causes of poor modulation transfer function. Typically, thin lines and fine font fills are dimmed or dropped out completely.

In Reverse Text, both Color and Black on the BIJ 1100, text is legible down to 4-point on plain paper and 6-point type on Premium Paper. Minor fill-ins begin as high as 14-point on Premium Paper and at 12-point on plain paper. BIJ 1100 Color Reverse Text is of slightly higher quality than that on the Stylus C84, whereas Black Reverse Text is of somewhat lower quality, due to fill-ins and character width. As seen in Color and Black Text, plain paper printing delivers a slightly higher quality output than that on HP Premium Inkjet Paper.

On Stylus C84, Color Reverse Text displays edge jaggedness, resulting in a decrease in sharpness. Reverses are legible down to 4-point, with minor fill-ins visible on 14-point characters.

Line Graphics

As a graphical element, lines are critical in representing data, providing visual separation of document sections, and contributing to artistic graphics; in fact, the prevalence of lines in printed material is overwhelming and nearly as common as text. Of these, the most common are vertical and horizontal ruled lines – fortunately the simplest to render on a rectilinear grid. Because of the geometry of such a grid, diagonal lines are subject to an increase in minimum thickness; a printer's ability to maintain line thickness between the thinnest straight and diagonal lines is a tradeoff between offering thinner straight lines or greater uniformity.

While this uniformity issue is often of minor importance for discrete lines of different angles, curved lines require that they do not appear to vary in thickness unintentionally. In transitioning along curved lines from vertical or horizontal orientations to the angles between, many rendering algorithms will create noticeable artifacts that emphasize the jaggedness of the pixel grid.

In addition to width non-uniformity, lines often illustrate deficiencies such as drop out and ghosting, halftoning issues (some halftone algorithms are designed for use over large areas, but also employed in thin line situations), and color registration problems perpendicular to the orientation of the line.

The BIJ 1100 produces high quality, sharp, and smooth Lines. Thin angled Black Lines are produced consistently at all angles and line thicknesses are fairly even and uniform. Some minor fill-ins are seen on the Reverse Radial pattern and 300DPI lines are rendered thicker than 1/4-point lines. Near-Horizontal Lines are produced excellently, while Near-Vertical Lines appeared slightly broken. Lines are best rendered on plain paper in NORMAL mode, as they as rendered as pure blacK -- rather than process Black, as is rendered on the Premium and Gloss paper driver settings. Thin gray lines are produced well, with even gradations. Color Lines are smooth and well rendered. As with Black Lines, Color Lines are produced more smoothly on plain paper.

The Stylus C84 produces Black Lines that appear jagged and exhibit minor stepping. Near-Vertical lines are produced better than Near-Horizontal lines, which appear broken and rough-edged. Reverse Radial lines are not visible to the center, and Lines appear broken at the 10° angle. Thin Color and Black lines (as in the Mazda car drawing) appear broken and jagged, resulting in a loss of detail. Very thin gray lines are sometimes not visible at all.

Tints and Blends

Reflecting their different print quality issues, Tints and Blends are discussed in the following sections.

Tints

Unlike solid printing, tints introduce an increased sensitivity to resolution and mechanical issues. A tint is a large area of a single unsaturated color, such as pink, sky-blue, or brown. Therefore, it is also sensitive to hue color errors.

Traditional screening creates a tradeoff between resolution and the number of available intermediate colors that may be unfavorable. To enhance the number of colors a printer can produce, vendors have often introduced super-pixel dithering over traditional screening – even though this runs some risk of introducing pattern artifacts and moiré effects that can be annoyingly visible. Stochastic screening modulates the placement between high-resolution dots (spatial frequency modulation), minimizing most artifacts; however, this technique requires good color registration and may yield grainy pastels.

The BIJ 1100 renders very well-saturated Tints. However, screening is noticeable in the lighter shades. At less than 80%, Black has a slight Cyan cast on most media and mode combinations, however, on Premium Plus Glossy Photo Paper in BEST mode, a slight Magenta cast is evident. On plain paper in NORMAL mode, Tints are rendered with less screening distractions than the Stylus C84 in TEXT AND GRAPHICS mode.

On the Stylus C84, Tints are substantially less saturated than those produced by the BIJ 1100. Screening was slightly visible, particularly in the yellow tints and light pastels; yet less so than the BIJ 1100.

Blends

Blends are smooth transitions between two or more colors. While incorporating all the issues of tint generation, Blends additionally require an abundance of color levels, smooth transitions between these colors, and perceptual linearity of hue, saturation, and lightness ramps.

Highlights and shadows often deteriorate blend quality. This is due to the difficulties involved in providing accurate differentiation of shades in heavily toned regions, and in providing a sufficient number of pastel shades to smooth the transition to paper white.

Since a majority of print jobs will require a conversion from RGB to CMY, and since user documents in this market segment are increasingly created in RGB, the ability to produce high-quality RGB blends is more important than CMY blends.

Blends on the BIJ 1100 are rendered smoother overall than those of the Stylus C84. Ramp Blends on the BIJ 1100 are smoother, displaying good highlight and shadow ranges. The Rainbow and Highlight-Shadow Blends exhibit some harsh non-linearities and transitions in the Green, Yellow, and Cyan areas. Except for a harsh transition in the Green-Yellow range, in NORMAL mode on plain paper, the BIJ 1100 produces overall smoother Rainbow Blends than the Stylus C84. RGB blends on BIJ 1100 are smoother and more vibrant than its CMYK Blends.

The Stylus C84 Highlight-Shadow Blends exhibit non-linearities in the Magenta and Blue areas. Rainbow Blends are mostly smooth, with only a minor harsh transition in the Green range. Color Ramps reach 100% saturation too quickly, with shadow ranges reaching well into the mid-tone ranges.

Images

Unlike computer-generated graphics, images are the result of sampled raster data and seamlessly combine the quality elements of graphics, tints, and blends. Because of the wide range of potential subject matter in an image, a printer's ability to produce realistic, high-quality images is extremely difficult, but critical to the user's quality perception; even if only at the time of product selection; therefore, a printer must produce high quality images.

The use of photographic data sources for images leads to a high demand for color fidelity. This includes accurate reproduction of memory colors – those with which users are heuristically familiar – without requiring an original for comparison. Natural greens, sky blues, wood browns, and skin tones represent common memory colors that can tax a printer's color rendering ability due to color gamut restrictions, imprecise color balance, or sub-optimal colorants. Another demand for image color fidelity is matching a color-corrected photograph such as a calibrated image file with an associated profile or in a standardized color space such as sRGB or SWOP. Although sometimes causing conflict, both objectives are important.

High-frequency, high-contrast detail within an image reflects a printer's ability to provide high quality text and graphics. The device resolution is used to carry the high level of fine detail. In areas of little variation (low spatial frequency), process noise and screen artifacts (in the case of non-continuous-tone printers) can be readily apparent. Finally, smoothly varying regions require blend linearity in order to accurately capture the realistic appearance and visual depth of the original.

Images produced by the BIJ 1100 are rich, smooth and sharp, with exceptional contrast. Images are notably pleasing with smooth highlight areas, as seen in the clouds of the *Castle* and *Isle* files. Both highlight and shadow detail is superior on all images. Skin tones, as in the *Babies* and the *Woman's Headshot* files have a slight Magenta cast, and blue skies are rendered a bit too blue. Images are vivid and highly saturated with no re sultant loss of preferred color depth and contrast. The BIJ 1100 produces images that are of excellent quality from a printer targeted for a typical office environment.

Images from the Stylus C84, while somewhat more realistic than the richer prints of the BIJ 1100, are produced with a yellow cast, making them appear somewhat dull. The yellow cast is most disturbing on skin tones, as in the *Babies* image, the bridge and grass of the *Bridge* image, and the mountain slopes of the *Castle* image. Lack of smoothness is seen, particularly in the clouds of the *Castle* image. With a lack of highlight and shadow detail, overall image sharpness and image depth is degraded. With the sole exception of realism, images on the Stylus C84 are of lower quality than those produced by the BIJ 1100.

About *spencerLAB*

The *SpencerLab* Digital Color Laboratory is an independent printer evaluation facility that provides services to vendors and corporations for whom color printing is mission-critical. The Laboratory follows strict guidelines in the integrity of both methodology and reporting; vendor-sponsored studies do not guarantee favorable results. SpencerLab has developed industry-standard test software, and performs print quality, throughput speed, ink and toner cartridge yield and cost-per-page/TCO, and ease-of-use analyses for color and monochrome printers in all technology classes, from inkjet and laser printers to digital color presses.

SpencerLab is operated by Spencer & Associates Publishing, Ltd., a premier IT consulting boutique specializing in the application of Digital Color Technology to all aspects of color imaging. For over a dozen years Spencer & Associates has been providing strategic support to manufacturers in product planning, development, and launch. Color printing workflow analysis, print system selection, and usage optimization services are provided to corporate users.

For more information, please contact *SpencerLab* by email at info@spencerlab.com, on the web at www.spencer.com and www.spencerlab.com, by telephone at 1-631-367-6655, or by fax at 1-631-367-2878.

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Appendix A: Test Document Coverage Estimates

Page Coverage may be defined as *the percent of the total page* covered by *any color* – which can be comprised of one or more primary inks, or a tint.

Ink Coverage may be defined as *the sum of the percents of the total page* covered by *each primary ink* – this is normally defined at 100% equivalence; that is, a 10% tint of one ink covering the entire page is equivalent to 10% of the page being covered completely by that ink. Since most colors consist of two or more primary inks, this sum may exceed 100% and could theoretically reach 300% or more (many printers have a 230-250% total ink limitation).

Since many user pages are defined in an RGB color space and ink-printing technologies must use CMYK, a conversion is required. Furthermore, various devices' CMYK inks do not have the same color characteristics, and printer designs balance the optimization between print quality and cost-per-print among pragmatic constraints. Some printers use all four CMYK colors when printing gray tints to reduce individual dot visibility and many printers even alter CMYK files before printing. Additionally, as drop volumes continue to get smaller, the absolute dot gain will tend to diminish, and resultant print coverage will reduce for the same file. Some inkjets have variable droplet sizes, depending upon data and mode; some reduce ink in solid fill areas. Therefore, no two printers will have the same Ink coverage – even when printing from exactly the same original – and the only consistent measure (as the ISO has acknowledged) is digital coverage of the file.

SpencerLab methodology utilizes such measurement of the digital coverage of the files (*before* aforementioned dot gain). Alternative methodologies may apply different methodologies for coverage calculation, such as measuring the printed page on a particular ink jet printer (or perhaps an average of printers) after dot gain. Individual methodologies may render disparate percentages of total coverage, for the same printed page.

Therefore, an idealized CMYK printer needs to be defined, along with an idealized algorithmic conversion to it. The most prevalent CMYK standard is SWOP, and many printers even optionally emulate it. In the following table we have augmented Page Coverage with an estimate of Ink coverage based upon SWOP-based printing with Photoshop algorithmic conversions from sRGB.

		Monochrome Letter	*SpencerLab Greenland*	*Newsletter*
Page Coverage		**4.2%**	**22.0%**	**29.8%**
Ink Coverage	*Cyan*	—	13.2%	4.7%
	Magenta	—	10.3%	5.0%
	Yellow	—	11.5%	4.3%
	Black	4.0%	8.6%	10.0%
	Sum	**4.0%**	**43.6%**	**24.0%**