Comparison of Various RIP Software in Regards to Their Resolution Capabilities

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Keywords: Inkjet, RIP, Resometer, contrast-resolution, print contrast, output quality, dot circularity, wicking, inter-colour bleed, thresholding, image analysis

Abstract

The purpose of this study is to determine differences in the capabilities of software RIP solutions. Although one would think that there are no significant differences between these software solutions the authors of this paper have evidence that the same file processed by different RIP solutions and printed using the same device, as well as onto the same paper, resulted in slightly different output results, particularly in the processing of halftone dots.

The test file that will be used for this evaluation is Henry Freedman's *Resometer Watch* test file. The Resometer will be the primary tool in determining final image quality produced by the various RIPs. A key element is the contrast resolution indicator in the Resometer file.

The two initial approaches of evaluation were altered. Instead of both approaches, one approach was focused on. The Resometer test file, as well as a test form including G7 evaluation elements, was processed through different RIP systems, and onto similar substrate using various proofing and/or inkjet devices. The RIP solution and not the printer driver will address the proofing device. Software RIP solutions available at the School of Graphic Communications Management, as well as solutions from Fuji Canada were used to output print samples for this study.

Although it is known that the quality of the paper has an influence on the print quality, the addressability of the RIP and its true resolution will most likely not be influenced as proofing papers similar to one another were used. The focus will be put on the results of Resometer test file, as it contains several key elements that test the paramaters of device output quality.

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The Resometer file offers test fields in regards to resolution, fine type reproduction, addressability, contrast resolution, etc. (see below). The Resometer data will help assess the quality of the RIPs in combination with the output devices, as well as reveal the behaviour of the output device using different types of papers.

The variations between the printed halftone images reveal that different RIP software, as well as setting parameters within the RIP software itself can directly change the final output characteristics. Overall quality, ink density, trap, and gamut reproduction are dependent on the RIP and can vary between software and devices.

In addition to using the Resometer for the assessment of the printed quality, an additional quality assessment will be carried out through the use of an image analysis software that was used in the previous study carried out by the above listed authors. The unique test target that was used for this study will be used again for this project. The results of that study were presented at the 65th annual technical conference of TAGA in Portland, OR.

The main purpose of this study is to get a better understanding of all the parameters that influence print quality on a digital output device.

Introduction

A previous study conducted by the authors of this paper investigated a method for the evaluation of inkjet print quality using image analysis techniques. Using a threshold method, the standard deviation of the pixel luminance value was determined to be a successful measure for the uniformity of a printed test dot. The test dots were printed by themselves, and also with black dots adjacent to a yellow solid. This black and yellow area is used to determine the intercolour bleed using the previously mentioned threshold method.

The purpose of this study is to determine differences in the capabilities of software RIP solutions. Although one would think that there are no significant differences between these software solutions the authors of this paper have evidence that the same file processed by different RIP solutions and printed using the same device and onto the same paper resulted in slightly different output results, particularly in the processing of halftone dots.

The test file that will be used is the Resometer test file from Henry Freedman. The Resometer will be the primary tool in determining final image quality produced by the various RIP solutions. During this research project the Resometer test file and a custom test file were processed by various RIP and workflow solutions and printed using inkjet proofing devices. Paper with similar qualities were used to ensure consistency.

The custom test file included images and test areas for inkjet wicking and intercolour bleed. While, the Resometer file offers test fields in regards to resolution, addressability, contrast resolution etc. The Resometer data will help assess the quality of the RIPs in combination with the output devices, as well as reveal the behavior of the output device using different types of papers.

The variations between the printed halftone images reveal that different RIP software, as well as setting parameters within the RIP software itself can directly change the final output characteristics. Overall quality, ink density, trap, and gamut reproduction are dependent on the RIP and can vary between software and devices.

Besides using the Resometer for the assessment of the printed quality an additional quality assessment will be carried out through the use of image-analysis software that was used in the previous study carried out by the above listed authors. The unique test target that was used for this study will be used again for this project. The results of that study were presented at the 65th annual technical conference of TAGA in Portland, OR.

The main purpose of this study is to get a better understanding of all the parameters that influence print quality on digital output devices, so informed decisions can be made about RIP solutions.

Theory

Raster Image Processors or RIPs are necessary to translate the information contained in the document file into solids and halftones. "A raster image processor interprets an incoming PostScript language program, creates a display list that indicates how this program will be displayed on a page, and then creates rasters (or pixels) of the display list in the designated colors at the selected resolution for the ultimate imaging process" (Zwang, 1998). One would think that RIPs work basically very similar and that the results will not differ significantly. A perceived difference might be the achievable resolution. A higher output resolution will most likely result in a more expensive RIP solution.

The RIP takes vector graphics, defines them mathematically, and places them in a bit-mapped raster arrangement. While price usually indicates the performance of a device, there are many additional aspects to examine. Not all RIPs process information the same way. "The digital input commands that describe the rasterized image can be for example PostScript commands (PostScript is a trade mark of Adobe Systems Inc.) or AgfaScript commands), or any other digital commands coded in a PDL (Page Description Language)" (Deschuytere, 1998). There are individual commands for specifying graphics, characters and images for output, that allow reproduction onto a sheet of paper.

There are typically two types of instructions sent from the RIP. "The first instructions generate a binary bitmap indicating a high or low density of the solid regions and a binary bitmask indicating whether recorder elements belong to a solid or screened region" (Deschuytere, 1998). This is typically done with lossless compression. The second set of instructions The second type of instructions generate a contone map, which indicated contone levels and graphics that have intermediate levels (Deschuytere, 1998). These instructions typically use lossy compression.

Many RIP software today includes extra features such as linearization. "Linearization helps keep printer output consistent over time, and improves transitions from highlight to shadow in all colors, and is especially useful for making black-and-white prints even-toned" (Darlow, 2009). This can make an overall improvement to the quality of the image. Additionally, The RIP software may include preflight functions such as checking for missing fonts or graphics prior to RIPping (Bear, 2006).

Experimental & Results

The results of the experiment reveal that various RIP solutions result in different levels of output print quality. Each RIP software translates the postscript data differently, resulting in various resolution output and overall reproduction quality. No two RIP solutions yield the same results. The rasterization operation can be characterized by several rasterization parameters, including bit depth, resolution, output size, colour space, colour channel, colour space, etc. (Chang, 2002).

In order to compare the quality of each sample, the authors chose to complete a series of quality tests. Two different test images were printed for each RIP solution and substrate. The first was a PDF test form that includes G7 test images, the second being the Resometer .eps file. With the PDF test file tonal value increase, print contrast, ink trapping, dot circularity, mean pixel luminance, and topography values were measured. Figure 1 below shows the Verity IA test image that was incorporated into the test form.

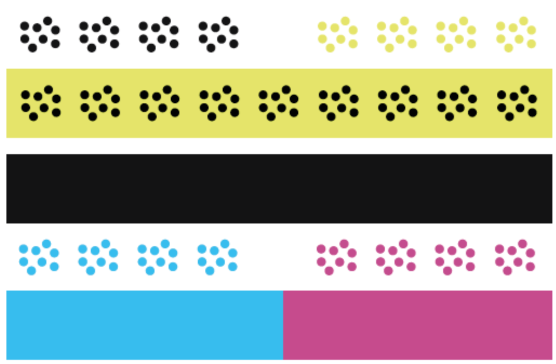

Figure 1: *Test pattern used for the determination of the inkjet wicking and pixel luminance*

The Verity IA program extracts or identifies the object of interest based upon the threshold value; those pixels having a value less than or equal to the threshold value are identified as being of interest. The program measurement algorithm then associates the identified pixels to form the objects that are then measured and reported. The associated pixels forming the object of interest, in our case a dot image, are further analyzed to compute the mean luminance value of all the pixels within its perimeter, i.e. its brightness.

The Resometer file indicates the x-y addressability of the device, and is also used to measure contrast resolution, ink/toner levels, vector line reproduction, and minimum type size reproduction. Figure 2 below shows the Resometer test image.

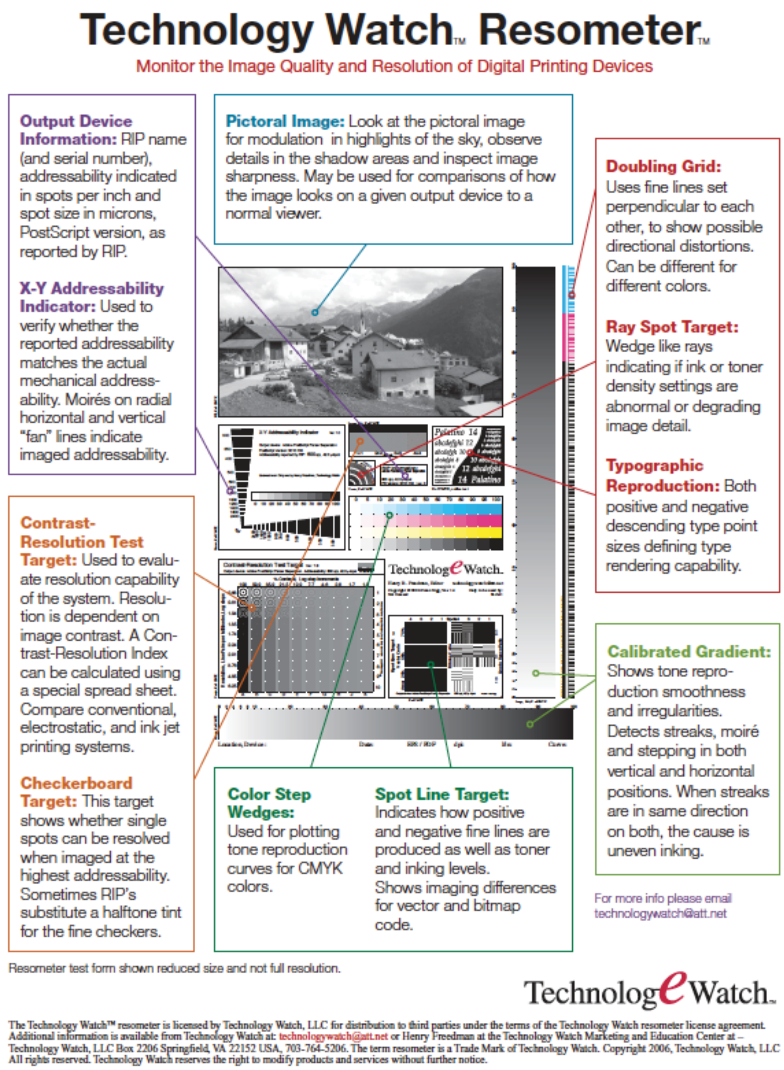

Figure 2: *Resometer image showing key addressability components*

Henry Freedman's Technology Watch Resometer "is designed to test performance of digital output devices in terms of contrast-resolution, addressability, quality of small type and fine lines, smoothness of gradients, directional tone value changes, possible different ripping of vector and bitmap images" (Technology Watch LLC, 2006, p2). Since the file is an EPS file it contains only instructions on what the RIP should do. How the RIP executes this file shows how different RIP systems interpret the given instructions.

For this research the following hardware and software was used to evaluate the printed samples:

- Kodak Prinergy V5, Agfa Apogee, Colorburst RIP, ColorGate
- Resometer test file
- VerityIA MicroDot V 1.3
- Epson Scanner, Model 2800
- Windows 7 PC with 2GB RAM
- ImageJ V 1.45s
  - Interactive 3D surface plot plug-in for ImageJ
- X-Rite 530 Spectrodensitometer

Prints made with Epson 3880. 4800, 7880, 9880, 9900, Epson Sure Color S70670, Acuity LED 1600, and Acuity Select at School of Graphic Communications Management and Fujifilm Canada

Conventional methods of analysis can provide one assessment of RIP solution quality. TVI, Ink Trap, and Print Contrast and Delta E were measured for each sample as a general quality comparison. GRACoL sheet-fed offset recommended values were the basis of comparison. The recommended target values provides an effective visual indication of the quality achievable, even though inkjet differs from offset printing. The results of the PDF test form are as follows:

Print Contrast

Table 1 below shows Idealliance's recommended print contrast values as measured at 75% tint. The results of print contrast, as measured from the printed PDF test form, reveal each combination of RIP and device solution produced different print contrast values. The print contrast is compared to recommended values for coated #1 offset paper. The print contrast should be 33 for yellow, 38 for cyan and magenta and 43 for black. The majority of the test samples meets or exceeds these values.

BLACK	CYAN	MAGENTA	YELLOW
43	38	38	33

Table 1: *Recommended Sheetfed Offset Print Contrast Values for 75% Tint (X-rite, 2003, p.8)*

A summary of print contrast is depicted in Figure 3. As shown by the black horizontal line, many samples achieved print contrast below and also above the recommended value of 43% for black.

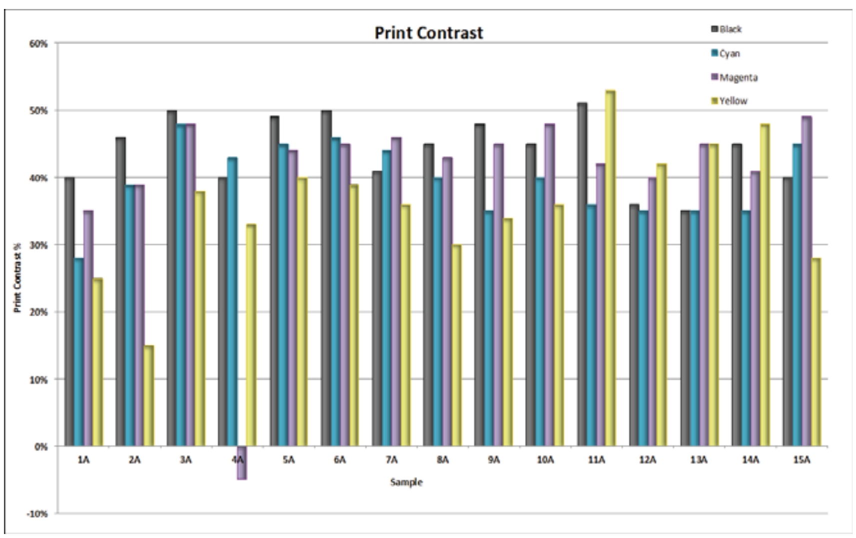

Figure 3: *Print Contrast for process colours*

Samples 1A, 4A, 7A, 12A, 13A, and 15A are below the ideal print contrast for black. The other samples have print contrast above the recommendation. Of all samples, sample 8A and 10A were most on target. It is important to note that sample 4A showed some significant smudging, which resulted in low and erratic measurements.

Ink Trap:

The recommended GRACoL ink trap values from Idealliance are listed below in Table 2. For the ink trap values, the guidelines for a #1 coated offset paper have been applied. The values are 70 for red, 80 for green and 75 for blue. Red and green trap reach or exceed these values, while the simulated ink trap for blue is low for the majority of the tested samples.

RED	GREEN	BLUE
70	80	75

Table 2: *Recommended Sheet-fed Offset Ink Trap Values for RGB (X-rite, 2003, p.7)*

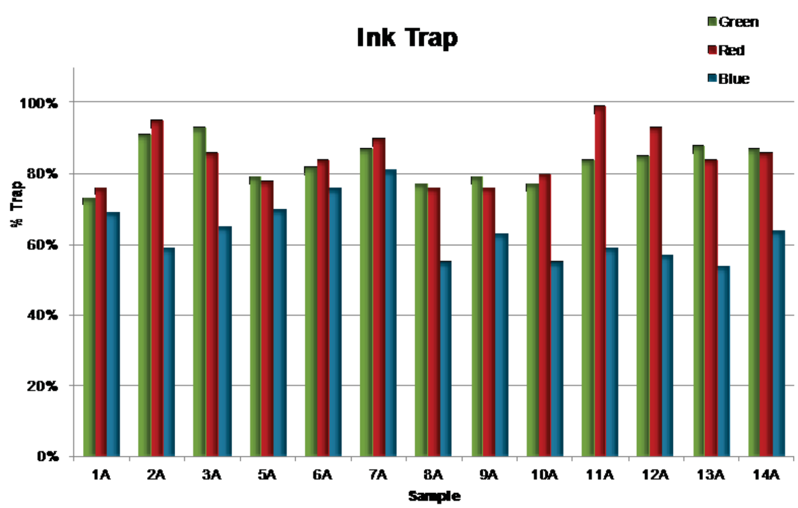

Figure 4: *Summary of ink trapping*

Tonal Value Increase (Dot Gain)

BLACK	CYAN	MAGENTA	YELLOW
22%	20%	20%	18%

Table 3: *Recommended Sheet-fed Offset Dot Gain for 50% Tint (Idealliance, 2007, p.30)*

According to Idealliance Printing Guidelines as shown in Table 2 above TVI should be about 22% for a 50% black dot. As depicted in Chart 3 below by the red bars, most samples are below the recommendation, while only 4 are above. Sample 4A, and 11A are right on target, while samples 7A, 12A, 13A, and 15A are much too high. In contrast, samples 2A and 3A are much too low indicating not enough ink was applied to the substrate by the output devices.

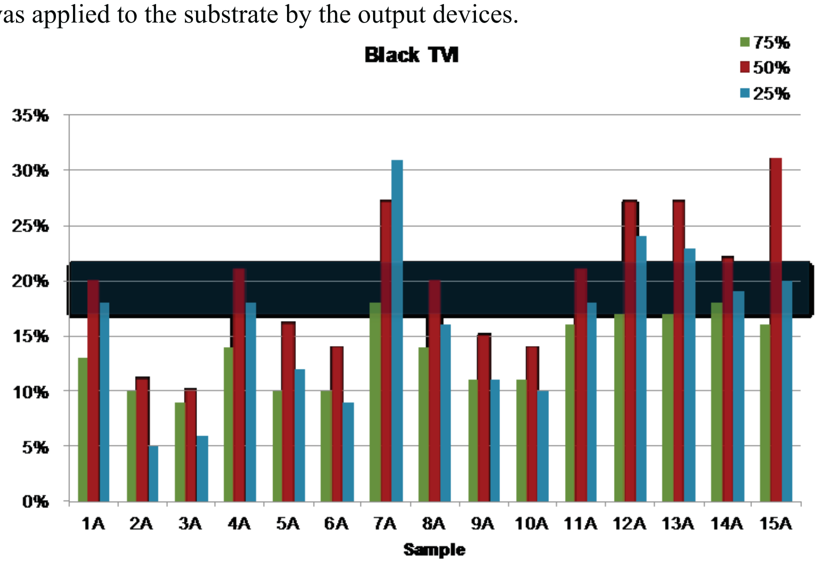

Figure 5: *Tonal value increase for black ink*

The majority of the samples showed the highest TVI in the 50% tint patch. The band going across the slide show the optimum TVI of 18 – 22% for a #1 coated paper. The red bar shows the results for the 50% tint patch. This is where most of the TVI should happen.

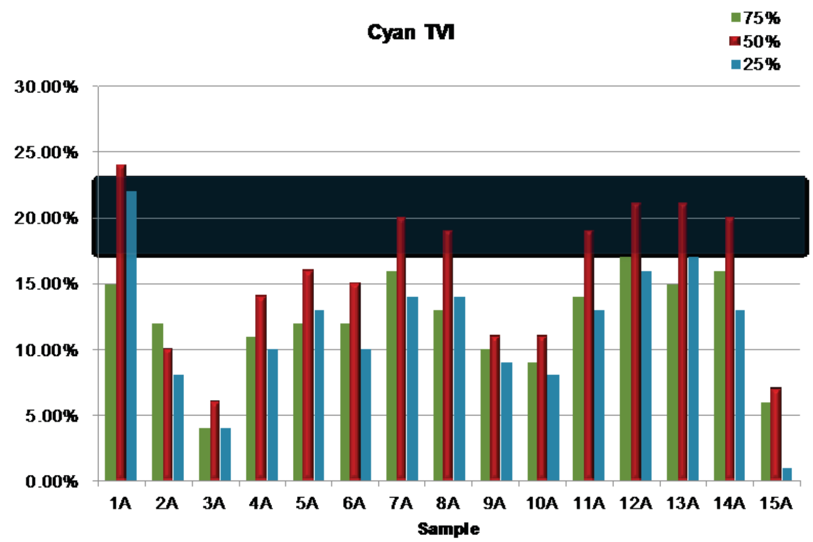

Figure 6: *Tonal value increase for cyan ink*

TVI for Cyan should be 20% as indicated by Table 3. Sample 1A shows too much dot gain, while samples 2A, 3A, 9A, 10A, and 15A are significantly below the recommended value, while samples 7A, and 15A are right on target. Most samples show quite low TVI for cyan, even for sample 4, considering the fact that it showed streaking.

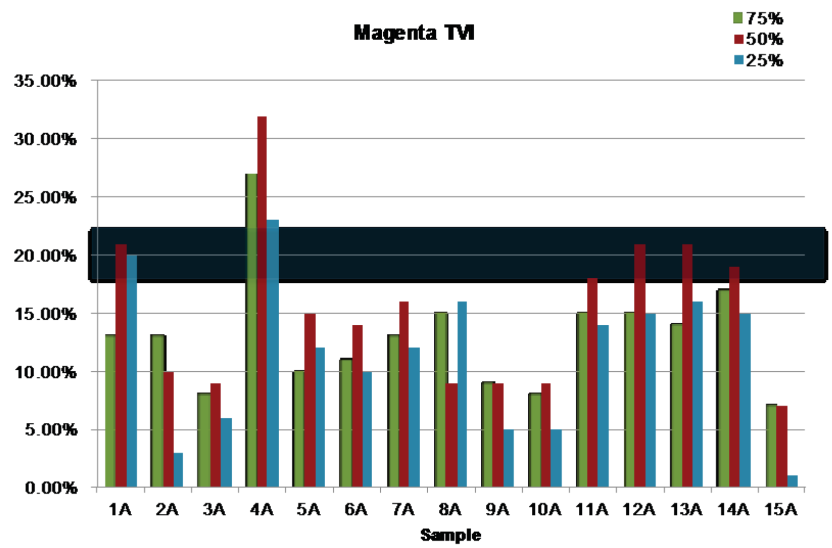

Figure 7: *Tonal value increase for magenta ink*

TVI for magenta ink should be also 20%. Sample 4A reveals a very high dot gain value for magenta. Samples 1A, 12A, and 13A are closest to the target value, while all others do not meet the recommendation. Again the highest TVI was measured in the 50% tint patch. Sample 4 is an anomaly since it showed excessive streaking which lead to these high TVI values. Many samples show actually quite a low TVI considering that fact the target value for TVI at 50% on coated paper should be 18 – 22 %

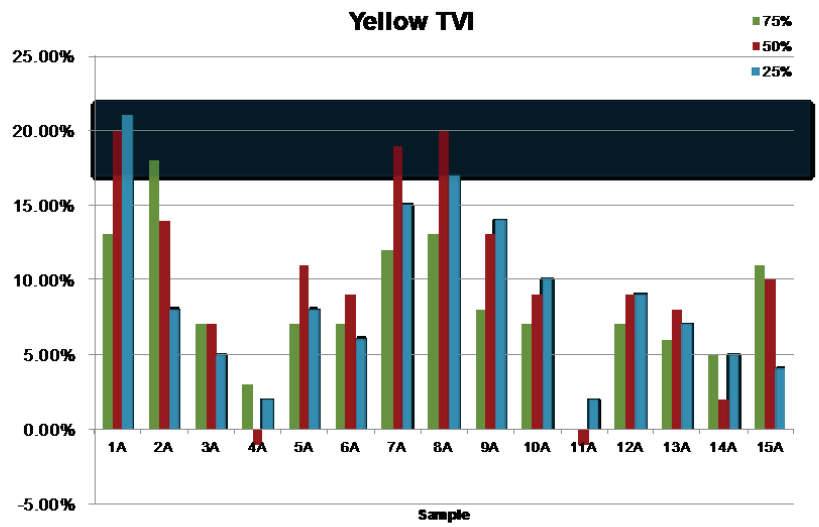

Figure 8: *Tonal value increase for yellow ink*

TVI for yellow ink should be slightly lower at 18%. The majority of samples have much lower dot gain values than this. While samples 1A, and 8A are much too high for yellow dot gain, the rest of the samples are too low. Sample 7A was the closest to meeting the recommended amount of dot gain.

The substrates chosen for this study were similar quality proofing papers. Since there are several common brands used for proofing papers, there is some variation in topographic values. As seen below in Figure 9, the lowest topography value is 673, the highest 2722. All substrates, however, are smooth and semi-gloss.

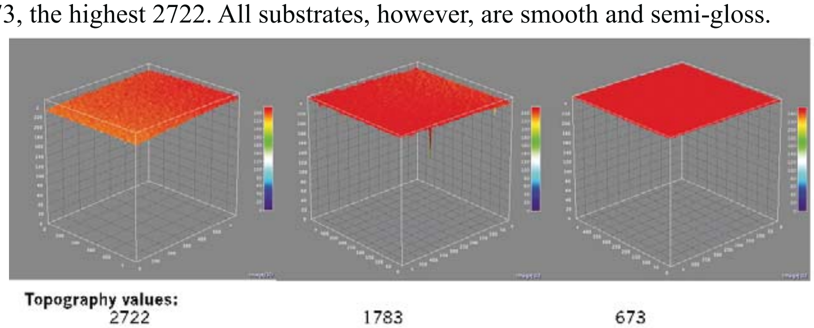

Figure 9: *Exemplary 3D topography plots.*

While topography is a key consideration in output quality as it affects dot circularity, print, contrast, and many other variables, in this study the sample with even the highest topographic value provided good results. The sample with the lowest value, also did perform the best as one would expect. Therefore, other variables must be taken into consideration when determining output quality.

Figure 10 below shows the differences in the various topography values that were measured for all 15 samples. A quite smooth surface for sample #5, while quite a rough surface for sample #15. The rest of the samples have all quite similar topography values between the values of 1000 to 1500.

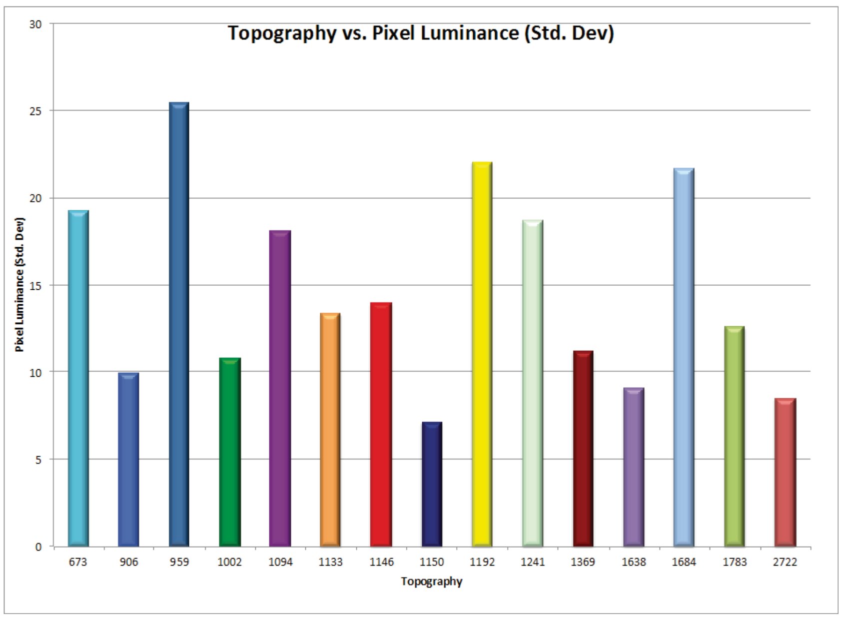

Figure 10: *Topography vs. standard deviation pixel luminance of black*

While dot circularity was tested in contrast to topography, pixel luminance provides a clearer picture on image quality. Figure 9 above shows the pixel luminance of black ink from all samples in contrast to substrate topography. The sample with the best pixel luminance has rougher surface with a value of 1150, indicating less ink wicking than the rest of the samples.

In comparison, the sample with the smoothest surface at 673 provided the fourth poorest pixel luminance, meaning more ink wicking. How smooth the substrate is, therefore, does not guarantee superior print quality. The lowest topography value actually resulted in good print contrast, good ink trap capabilities, and the second highest contrast resolution. Our findings show that the topography of paper, while important, showed no linearization on the results in this study, as paper type and coating were similar.

In *Figure 11* below, pixel luminance of black on yellow overprint in comparison to the topography values of the substrates. As the graph depicts, pixel luminance values increased overall for black overprint on yellow solid. There is an increase in intercolour bleed and wicking as the two inks are interacting with each other. The results are much different for the black/yellow pixel luminance than the black only. The sample with topography of 1150 achieved the best pixel luminance with black dots, but as shown by the dark blue bar, had a much higher pixel luminance value for the overprint test. This indicates increased intercolor bleed and ink wicking, resulting in a less round dot.

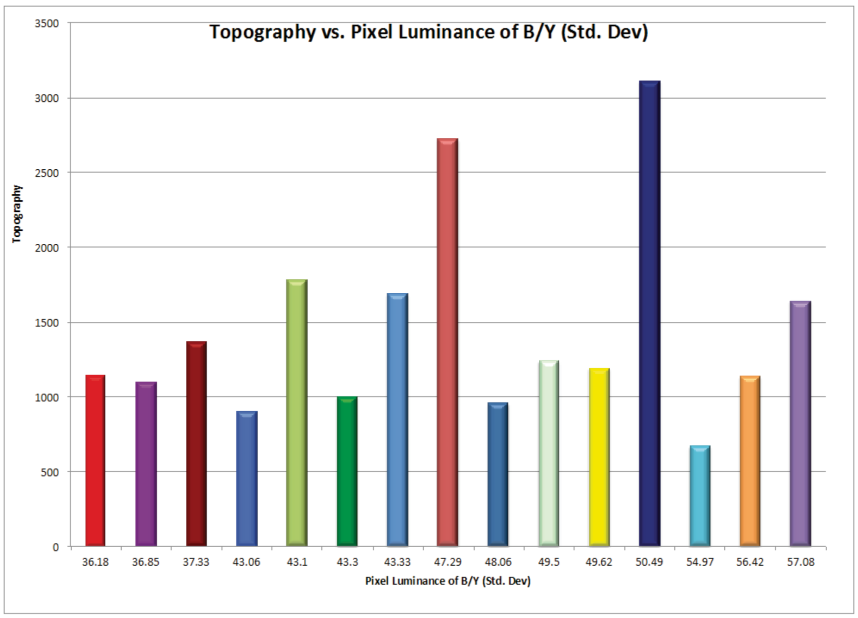

Figure 11: *Topography vs. standard deviation pixel luminance of black/yellow overprint*

The highest pixel luminance was achieved with sample 4A at a value of 57.08, but the topography value of the substrate falls in the middle. In contrast, sample 13A achieved the lowest pixel luminance of 36.85. While there is more wicking with the black/yellow overprint, it is not totally dependent on topography values.

The results of measuring the pixel luminance of each sample show some interesting results. Some of the samples with the high topography values actually produced quite low pixel luminance value, meaning quite a round dot. Similarly, the sample with the lowest topographic value produced a relatively high pixel luminance variation, meaning that a smooth paper surface is not always a guarantee for a round dot and a low intercolor bleed.

Resometer Results

Contrast resolution provides a significant quality measurement in evaluating RIP solutions. Contrast resolution is a key indicator of a RIPs ability to interpret data correctly and produce desirable results. The prices and capabilities of the RIPs tested in this experiment vary. The contrast resolution results reveal, however, that price and perceived quality of device parts should not be relied on alone. Some samples provided by average RIP software and output devices resulted in higher contrast resolution. In some cases the output device plays a more important role, and in others the RIP is the key player.

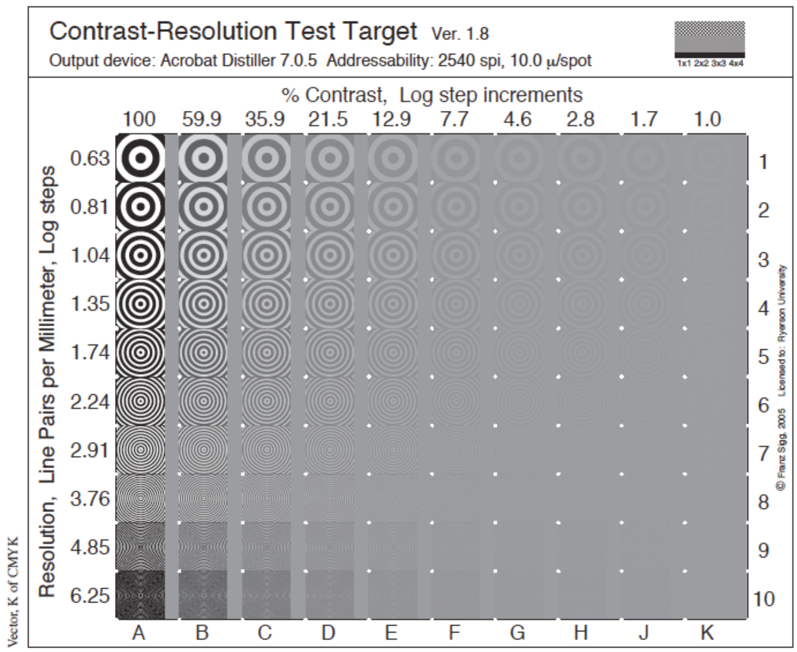

Figure 12: *image of the contrast resolution target incorporated into the smart .eps resometer file*

According to the Resometer Watch manual:

> “To avoid limitations in resolution by the observers’ vision, it is recommended to use a weak magnifying lens with a power of only about 2 X and good illumination. Observation starts from the top of column A going down, noting how gradually a moiré forms between the circles and the address ability pattern. The question that the observer needs to answer is: which is the finest patch that still can be recognized as a circular lines patch and where no lines or spaces are missing or overlap. (The lines might however be chopped up by the halftone pattern). The resolution of this patch is recorded. If too much ink or toner is applied, the spots become too big and resolution is limited.

Next, moving sideways to column 8, verify whether less resolution is obtained (because of the halftone pattern that is needed since column B has less contrast). Again, the step with the just-re solved circles is recorded. This process is repeated for the remaining columns. When doing evaluations, you may find it more convenient to evaluate row by row rather than column by column.

Because the found patches are just barely recognizable as resolved circles, they are marginal in quality, and a certain insecurity remains as to which one to choose. In fact, it is expected that different observers choose different patches. Even after training, observers do not necessarily always agree. Therefore (it makes sense to establish rules of acceptance, like for instance, a patch counts as resolved when at l east half the area of the patch shows recognizable circles. It is also desirable that more than one observer does the evaluation, and an average response is recorded. This leads to more accurate evaluations (Harper, Sigg and Granger, 2001). When reporting results, the number of observers should be stated.

(Technology Watch LLC, 2006, p14).

As indicated in Figure 13 below, samples 4, 13, 14 and 15 resulted in the best contrast resolution. All four samples are done using the same proofer, however, the RIP software used to send the information through to the device differ. This is a critical finding, as the results determine that an ideal workflow must consider both RIP and output device. No two combinations of RIP solution and output device will render the same results.

Contrast Resolution											
% Contrast	Sample	100	59.9	35.9	21.5	12.9	7.7	4.6	2.8	1.7	1
Line Pairs per mm	1B	6.25	6.25	6.25	4.85	4.85	3.76	3.76	2.91	1.74	1.04
Line Pairs per mm	2B	6.25	6.25	6.25	4.85	4.85	3.76	2.91	2.24	1.35	0.81
Line Pairs per mm	3B	6.25	6.25	6.25	4.85	3.76	3.76	2.91	2.24	1.04	0
Line Pairs per mm	4B	6.25	6.25	6.25	6.25	6.25	4.85	3.76	2.91	2.91	1.74
Line Pairs per mm	5B	6.25	6.25	6.25	6.25	6.25	6.25	4.85	3.76	3.76	1.74
Line Pairs per mm	6B	6.25	6.25	6.25	6.25	6.25	4.85	4.85	3.76	3.76	2.24
Line Pairs per mm	7B	6.25	6.25	6.25	6.25	6.25	4.85	4.85	3.76	2.91	2.24
Line Pairs per mm	8B	6.25	6.25	6.25	6.25	4.85	4.85	3.76	2.91	2.24	1.74
Line Pairs per mm	9B	6.25	6.25	6.25	6.25	6.25	4.85	4.85	3.76	2.91	2.24
Line Pairs per mm	10B	6.25	6.25	6.25	6.25	6.25	4.85	4.85	3.76	2.91	2.24
Line Pairs per mm	11B	6.25	6.25	6.25	6.25	6.25	4.85	4.85	4.85	3.76	2.24
Line Pairs per mm	12B	6.25	6.25	6.25	6.25	6.25	6.25	4.85	4.85	3.76	2.24
Line Pairs per mm	13B	6.25	6.25	6.25	6.25	6.25	6.25	6.25	4.85	3.76	2.91
Line Pairs per mm	14B	6.25	6.25	6.25	6.25	6.25	6.25	6.25	4.85	3.76	2.91
Line Pairs per mm	15B	6.25	6.25	6.25	6.25	6.25	6.25	6.25	4.85	3.76	2.91

Figure 13: *Contrast Resolution Summary*

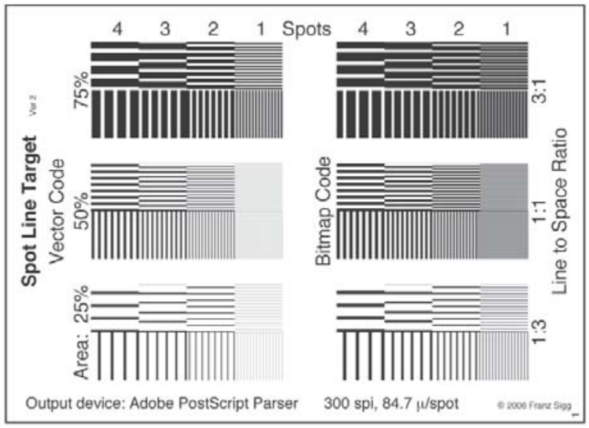

Figure 14: *Spot-Line target from the Resometer.eps file*

As shown in Figure 15 below, several samples show scattered halftone dots, while several others show solid clean vector lines made up of only black ink. Different RIP solutions resulted in different results. Samples 9 and 15 had the best line reproductions (as can be seen below). All images were taken from the vector side of the target. All of the bitmap targets on the left hand side of the spot line target image were halftone dots.

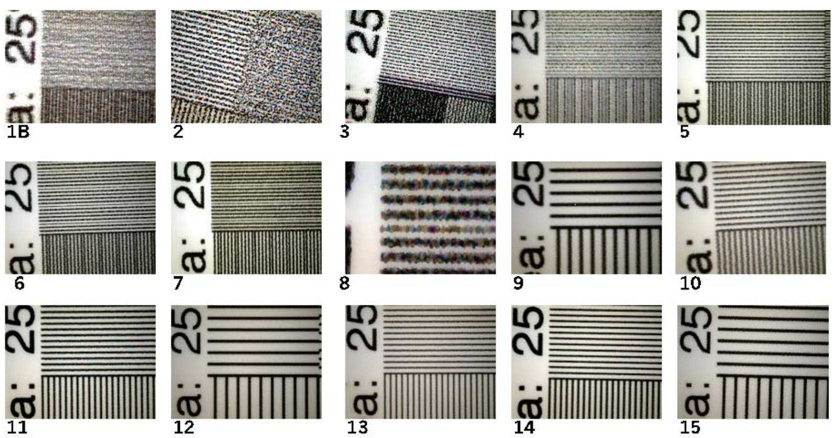

Figure 15: *Results of Spot Line Target*

The Ray spot target determines if too much toner/ink has been applied in order to reproduce an image. "Ideally there should be a back center that is smaller than the innermost white circle. If the black center is larger, then there is too much toner or ink, and the system is unable to resolve the nominal addressability" (Technology Watch LLC, 2006, p5).

As shown in Figure 16, six out of fifteen samples have too much toner/ ink. Samples 1B, 3B, 5B, 6B, 7B, and 8B as indicated by the Ray Spot Target, show that too much ink was applied to the substrate when printed. The other 9 samples show that a good amount of ink was applied. This is an interesting discovery as sample 5B had high contrast resolution, and an average TVI (tonal value increase). This suggests that too much ink is not a significant variable in determining output capabilities. This theory is also supported by the results of the dot circularity and the Spot Line Target. Dot circularity is approximately 3, and the lines reproduced in the Spot Line Target are clean solid black lines, not scattered halftone dots.

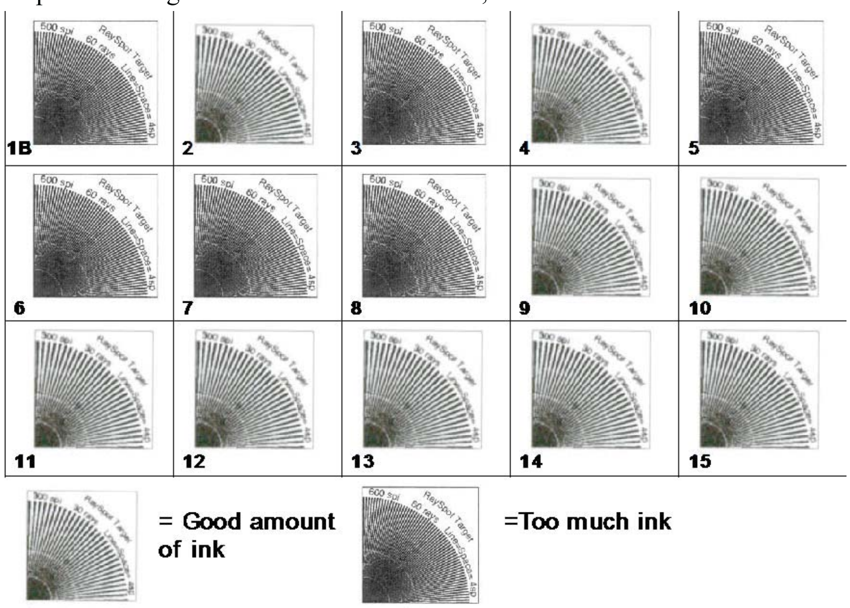

Figure 16: *Results of Ray Spot Target*

The ability to reproduce small type is essential for a RIP and output device. Figure 17 below is the type chart that is included in the resomter.eps file. The test image starts with 14 pt font and decreasing down to 1pt font.

Figure 16: *Results of Ray Spot Target*

As shown in Table 4 below, samples 8B and 12B show the highest capability of reproducing small type. Both regular and reverse type was still legible at only 1.5 points font size. RIP software and devices for these print samples were different.

Smallest type size able to be reproduced

3	3	3	2	2
1.5	1.5	**1.5**	2	2
1.5	**1.5**	1.5	1.5	1.5

Smallest reversed type size able to be reproduced

3	4	3	2	2
2	2.5	**1.5**	3	3
3	**1.5**	2	2	2

Table 4: *summary of smallest typographic reproduction*

Conclusions

There are several key conclusions discovered by the samples tested in this study. First, topography and circularity (defined by the pixel luminance standard deviation) alone do not give a clear picture if a RIP software produces a high-resolution output. Second, the standard deviation of the pixel luminance shows that topography of paper alone does not affect contrast resolution and output capabilities. Third, the Resometer test shows that even the same device addressed by different workflows give quite different results in regards to the output capabilities.

This study has determined that output resolution and image quality of common proofing devices in the industry are not consistent. The output workflows tested resulted in vast differences, revealing that no two setups are the same. It is important to test each component of your proofing workflow to ensure you are getting the best image quality out of your RIP and your output device. The results of this study reveal that a) topography while important does not determine image quality, b) different RIP solutions process output information differently, and c) output devices vary in quality. The same RIP software can be used but if different output devices are used, results will not be the same. Similarly, the same output device will not render the same quality measurements if used by different RIP software solutions. The best achievable quality is found by pairing a RIP and an output device that produce the best results of all the individual tests conducted.

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