EARLY RESULTS OF IMAGE AREA MEASUREMENTS

James R. Cox *

Abstract: Early results of image area measurements are reported. The measurements at precise locations in the image area became practical in June of 1985 with the availability of an automated densitometer with computer controlled positioning anywhere on the sheet. Methods used to evaluate quality of images are discussed. Display of image area readings for press color control is also discussed.

Background

At the 1985 meeting of TAGA I described a new measurement instrument, the AutoSmart** densitometer, that provides for the first time an easy way to measure and compare printed sheets with readings in the image area instead of using only color bars.(Cox 1985) At that time I suggested a number of uses for these heretofore unavailable measurements. In this paper I will give some examples of image area measurements made during the first few months use of this new capability and the methods used to evaluate the data.

Miles Southworth of RIT proposed in his 1984 TAGA paper (Southworth 1984) that a densitometer be used to compare the image area red, green and blue densities to those of an OK sheet and referred to several studies (Gaston 1978, Hasimoto 1979, Lake 1978) that demonstrate the shortcomings of measuring only solid ink densities and indicate that readings in the image areas may be more useful in controlling printing quality.

USA TODAY, so far as I know, was the first to use image area measurements on a large scale. They soon discovered that the big problem with image area measurements is measuring in precisely the same location on the proof and the printed product. Missing the comparable location by just a few thousandths of and inch may cause more difference in the reading than the variations in the printed product.

---

*Cosar Corporation

**Trademark, Cosar Corporation

Although the computerized processing is essential to handling the large amounts of data resulting from image area measurements, the primary new contribution made by this instrument is the ability to compare precise locations in the printed product to the equivalent location in the proof or OK sheet.

Introduction

The early applications of image area measurements have been for two purposes. The first application was to evaluate the quality of printed sheets. Three examples are described involving three different methods of using image area measurements to evaluate the quality of printing. The examples are a newspaper where there are no color bars, magazine printing where the problem was to compare two methods of production, and magazine printing where the requirement is to show the consistency of printing during a run. The second application is press control where the AutoSmart densitometer sits beside the press and is used to control the run in a manner similar to that used with a hand-held densitometer or the type of scanning densitometer that can only read color bars. In one example the image area data correctly indicates the cause of the obvious visual problem while the color bar data is completely misleading.

Newspaper Example

By now almost everyone is familiar with USA TODAY, the Gannett newspaper that has set new standards for newspaper color. The goal was color good enough to attract ads that would otherwise only be run in magazines. The dedication to quality color was so strong that mastheads were designed to help control the printed color. The stripes you see across the top and bottom of the section fronts such as in Figure 1 are, in a limited way, color bars. However, it is still impractical to sell an ad that includes a color bar and since there is no trim area on a newspaper, the image area had to be used to control the color in ads.

The printing sites, over 30 in number, are provided proofs of the mastheads and then with each ad they are provided a proof such as that shown in Figure 2 with image aim points marked by black circles. Of course the black

Figure 1. Newspaper Sheet.

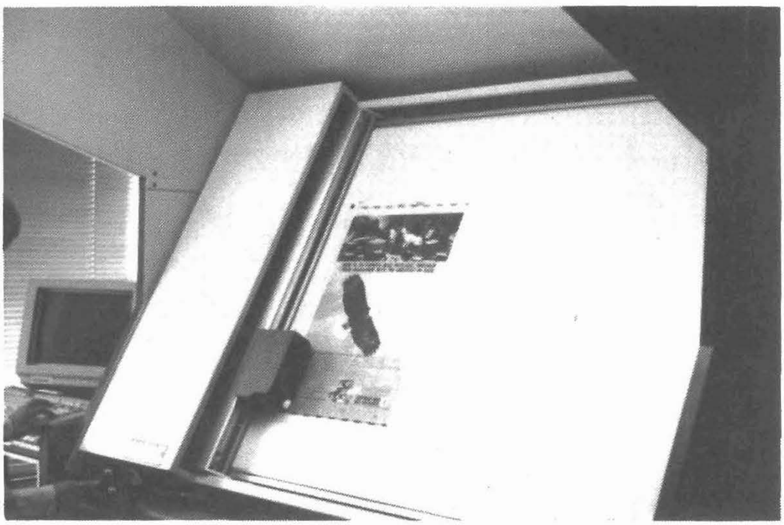

Figure 2. Newspaper Ad Proof.

circles are not on the production run and when hand-held densitometers are used the operator must use some judgment in selecting the comparable location. The result is that different operators can get different results by measuring slightly different locations causing the familiar problems generated when a quality evaluation can be either acceptable or unacceptable depending on the operator. The solution to the placement problem is automated reading that can provide precisely repeatable locations. Automated measurements have been used here to perform quality evaluations where it reduces the operator dependence of the evaluation.

Magazine Test Example

A test performed for the 1985 Spectrum meeting of GCA demonstrates the kind of sophisticated analysis that can be performed to compare two production methods. The purpose of the test was to determine how well magazine ads matched proofs when different color separation curves and proofing papers were used.

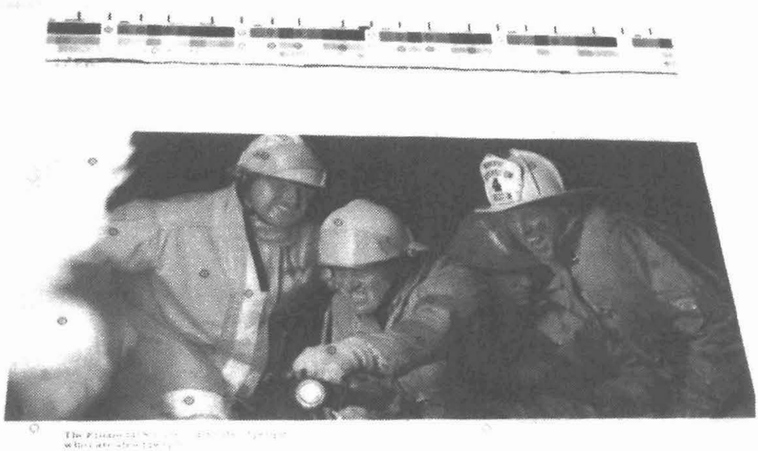

Figure 3. Magazine Ad Proof.

Proofs were read as the reference image. The 58 locations read on each proof are marked on Figure 3--24 in the image, 34 on the color bars. On the color bar solid densities were read across the sheet, dot gain in the two center repeats, hue error and trap on one of the repeats. The 24 points in the image area were selected in 8 columns of 3 points each with attention to covering the tonal range and to measuring feature colors such as the red arm bands and yellow helmets.

Every image was evaluated on this same pattern of 24 points. The evaluation was based on averages of 5 to 10 sheets to reduce the effect of sheet-to-sheet variations. Over 100 sheets were read and over 12,000 numbers acquired.

Proofs were run on two kinds of paper without adjusting the press in order to evaluate the effect of the paper. See example data sheet, Figure 4. Due to the averaging of a large number of readings on 10 samples of proofs with each type of paper a 2 percent difference in dot gain was clear. This 2 percent difference is small enough that it would have been masked by sheet-to-sheet variations if only a few readings were made. The measurements in the image area are consistently higher which in the production director's terminology confirmed his expectation that he would get a "fuller image" with one type of paper compared to the other.

What this example shows is the effectiveness of a large number of precisely controlled readings in showing small differences caused by changes in production methods and in confirming the results not just on a test target, but also in the image area.

For the same Spectrum test it was desired to compare the results live magazine ads produced using two different types of proofs. The question was "Do the ads produced using proof type A match the proof better than those produced using proof type B?", a rather simple question. In this case, since the measurements are to be made on live magazine ads, there was no attempt to control the experiment or to produce something that could be easily evaluated.

AVGD-AVGC (S70-FG) Effect of paper
on Fortune Gloss separations 8-26-85 JRC
Data taken with AutoSmart densitometer by Cosar with Status T response.

TRAP (Z1) Y/M= 3% M/C= 1% Y/C= 1%

	ZONE 1				ZONE 2				ZONE 3				ZONE 4			
	K	C	M	Y	K	C	M	Y	K	C	M	Y	K	C	M	Y
HUE ERROR		0%	-3%	0%												
DOT GAIN(40% FILM)					2%	1%	2%	2%	2%		1%	3%				
DENSITY																
COLOR BAR	0.08	-0.01	0.01	.00	0.09	-0.01	0.02	-0.02	0.10		0.02	-0.01	0.07	-0.02	0.03	-0.01
PAPER	0.03	0.03	0.04	0.04												
Z1 FLAME	0.04	0.04	0.04	0.05												
Z1 SLEEV	0.04	0.04	0.05	.00												
Z1 FLAME	0.04	0.04	0.04	0.05												
Z1 CUFF	0.04	0.05	0.05	-0.03												
Z1 COAT	0.04	0.04	0.05	.00												
Z1 BKGND	0.05	0.05	0.04	0.04												
Z2 VISOR					0.04	0.04	0.04	-0.01								
Z2 YEL					0.04	0.05	0.05	-0.01								
Z2 RED					0.04	0.04	0.03	-0.02								
Z2 GLOVE					0.04	0.04	0.04	-0.01								
Z2 HELMU					0.04	0.06	0.04	-0.01								
Z2 BKGND					0.07	0.07	0.06	0.05								
PAPER									0.03	0.02	0.03	0.04				
Z3 BKGND									0.06	0.06	0.06	0.05				
Z3 CHEEK									0.04	0.04	0.03	0.01				
Z3 BAND									0.04	0.05	0.03	0.01				
Z3 DARK									0.06	0.07	0.05	0.04				
Z3 HELMU									0.04	0.05	0.05	0.01				
Z3 BKGND									0.07	0.07	0.07	0.04				
Z4 HELMU													0.04	0.03	0.04	.00
Z4 CHEEK													0.05	0.05	0.07	0.01
Z4 COAT													0.04	0.05	0.03	-0.01
Z4 CUFF													0.05	0.05	0.03	.00
Z4 SLEEV													0.04	0.04	0.04	.00
Z4 BKGND													0.06	0.06	0.05	0.03

MEAN= 0.04 STD. DEV.= 0.02

<-.20	0
-0.20	0
-0.15	0
-0.10	0
0 TO -0.05	9
0 TO 0.05	70
0.10	25
0.15	0
0.20	0
>0.20	0

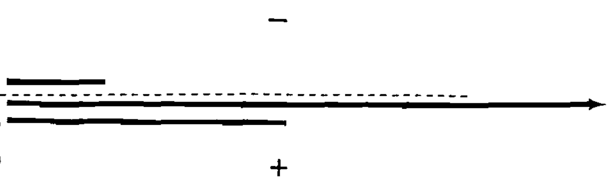

Figure 4. Example Data Sheet Showing Effect of Paper on a Proof.

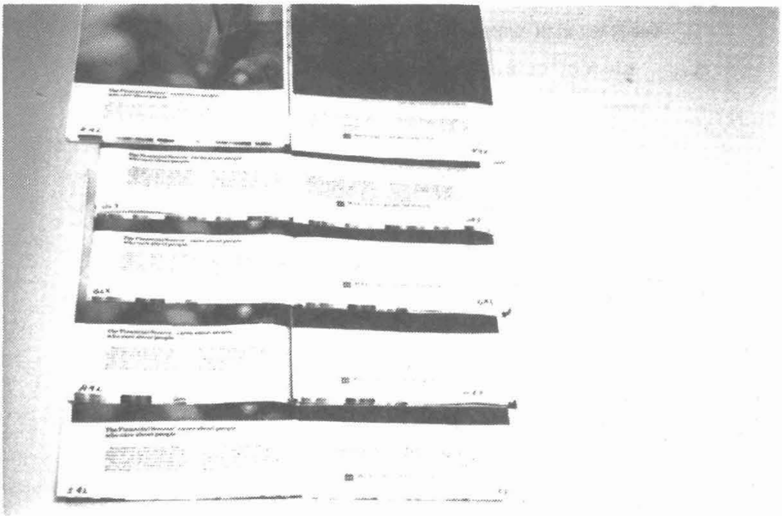

Figure 5. Magazine Signatures.

As you can see from the examples in Figure 5, the color bars are less than ideal for comparison. Some have no color bars. Some have them only on part of the sheet and some of them are damaged by the folder. Clearly not much attention was given to producing readable color bars. What is dependable is that every signature has the fireman ad image and that the press crew did their best to match the proof supplied. This was a job for image area comparison.

The data used was the image area measurements on the magazine signatures compared to the equivalent location on the proof as shown in Figure 6. Data was summarized and presented as histograms with mean and standard deviations to show the degree of match between the magazine ad and the proof. This is an objective comparison of how well the magazine images match the proofs. Backing up the summarized presentation was a data sheet like that shown in Figure 7 for each sheet set of magazine signatures. This also provides detailed data regarding the locations that affected the degree of match.

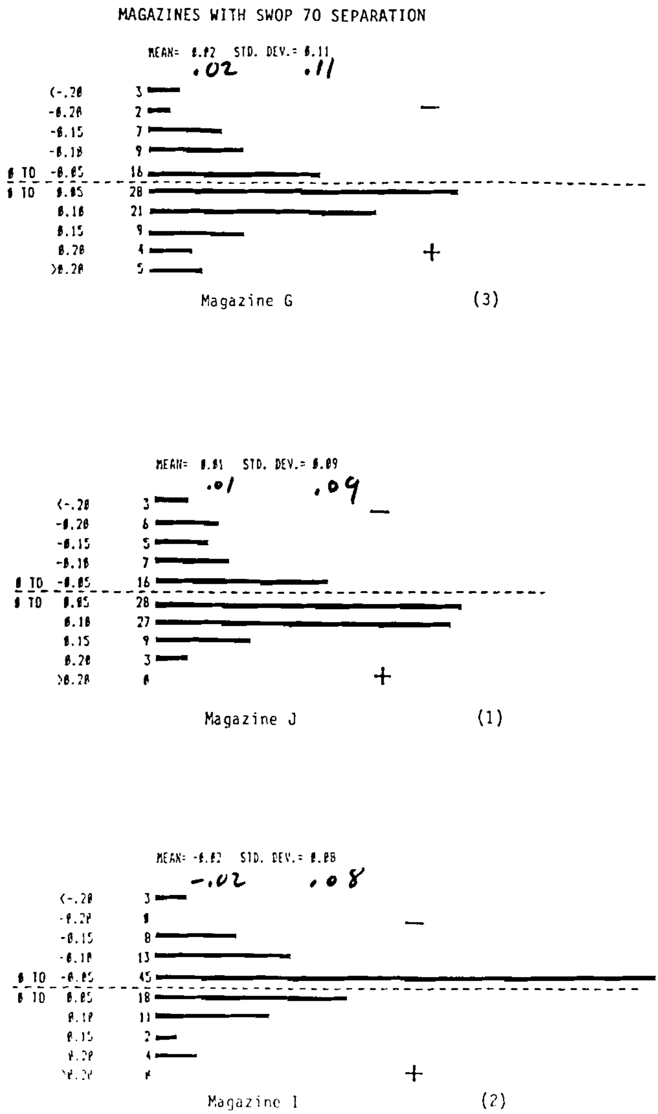

Figure 6. Histograms Comparing Magazine Signatures.

FILE TITLE DATE INIT

AVGMAGG-AVGE Differences of magazines G

DIFG compared to SWOP70 proof. 9-1-85 JRC

Data taken with AutoSmart densitometer by Cosar with Status T response.

TRAP (Z1) Y/M= -6% M/C= 6% Y/C=

	ZONE 1				ZONE 2				ZONE 3				ZONE 4			
	K	C	M	Y	K	C	M	Y	K	C	M	Y	K	C	M	Y
HUE ERROR		3%	1%	2%												
DOT GAIN(40% FILM)																
DENSITY																
COLOR BAR	0.11	-0.11	-0.13	0.05												
PAPER	0.02	0.02	0.02	0.01												
Z1 FLAME	0.09	0.09	0.08	0.11												
Z1 SLEEV	0.09	0.03	0.10	-0.05												
Z1 FLAME	0.07	0.07	0.17	0.06												
Z1 CUFF	0.04	0.06	0.04	.00												
Z1 COAT	0.06	.00	0.07	-0.03												
Z1 BKGND	0.19	0.16	0.16	0.11												
Z2 VISOR					0.03	-0.02	0.03	0.02								
Z2 YEL					0.05	0.07	0.05	0.03								
Z2 RED					.00	-0.01	-0.06	-0.10								
Z2 GLOVE					.00	-0.01	-0.03	-0.11								
Z2 HELMU					0.02	0.04	0.01	-0.11								
Z2 BKGND					0.23	0.22	0.20	0.12								
PAPER									0.02	0.02	0.02	0.02				
Z3 BKGND									0.21	0.22	0.17	0.14				
Z3 CHEEK									0.06	0.09	-0.02	-0.14				
Z3 BAND									0.02	0.03	-0.07	-0.20				
Z3 DARK									0.09	0.10	0.05	-0.03				
Z3 HELMU									0.07	0.08	0.02	-0.10				
Z3 BKGND									0.12	0.11	0.13	0.11				
Z4 HELMU													-0.03	-0.04	-0.03	-0.08
Z4 CHEEK													0.03	0.04	-0.02	-0.15
Z4 COAT													.00	.00	-0.04	-0.22
Z4 CUFF													-0.07	-0.05	-0.17	-0.39
Z4 SLEEV													-0.07	-0.04	-0.15	-0.37
Z4 BKGND													-0.03	-0.01	-0.05	-0.12

MEAN= 0.02 STD. DEV.= 0.11

	<-.20	3
	-0.20	2
	-0.15	7
	-0.10	9
0 TO	-0.05	16
0 TO	0.05	28
	0.10	21
	0.15	9
	0.20	4
	>0.20	5

Figure 7. Data Sheet for an Individual Set of Signatures.

Figure 8 shows a striking example of how informative the detailed data can be. I was asked by the production director "Aren't the ads from this magazine deficient in yellow?" The image area measurements show clearly that it is low in yellow on the right hand side but ok on the left hand side. It is also low in magenta on the right hand side. Possibly there was an in-line problem in this magazine and a compromise was made. It is also possible that a proof was not available and the printer thought this was what the ad should look like. The proof has a red cast that probably was not in the original photo, but the advertiser may have wanted to emphasize the red cast from the fire.

Figure 9 is the CRT display that the pressman would have seen on his color display if he had had image area measurement capability at his press. It's almost a reflex action, seeing this bar graph, to reach for the correct ink key adjustments.

Magazine Consistency Example

In this example, the requirement is to determine the consistency of printing during a press run. Sample signatures are pulled every hour and a comparison must be made and presented. Figure 10 shows a typical signature and Figure 11 shows a close-up of the 2 ads that will be discussed. This signature had some color bars along the side, but since they are not run in line with the image they are only useful for evaluating such things as trapping, dot gain, hue error and grayness. The evaluation of consistency of the run must be made from the image area or not at all. The important attribute to be measured is the consistency of color. It is the ads that are most important and fortunately there always seem to be good places to measure in an ad. The advertisers seem to like saturated colors.

For example, in the Coke ad the red trademark color is an obvious key color to measure. Others are the background gray and perhaps the skin tone and the blouse. In the Verve ad, The pink and blue stand out and the package colors are sure to be important to the advertiser. The problem soon becomes not how to select locations to measure but how to limit it to a reasonable number of points and how to present the data. For this signature by careful selection, just 39 key points were selected as a measure of consistency although it would have been easy to select many more.

Figure 12 is a table of the measured results. As you can see, 39 points measured through 4 filters on samples pulled at 10 time intervals creates a lot of numbers. There are 4 sections, one for each color. There are 10 columns in each section, one for each time sampled. There is a row for each point measured. The rows are partitioned according to the ad in which the point is located. The data in the table is the density difference for each point measured compared to that of the reference sheet. Each column also has a mean and standard deviation that could be considered and overall measure of the degree of match for that particular time sample. This data is very valuable and the information is all there, but a way is needed to highlight the important data to make it quicker to interpret.

Figure 13 is a presentation that supplements the numerical data and shows where to look. It is a somewhat graphical presentation that is easy to generate from the tabulation of the numerical data. Incremental differences are indicated by plus signs where densities are high and minus signs where densities are low. If the increment is selected as .05 density, then a period appears in every position where the density is within .05 density of the reference sheet. One + sign appears if the density is high by .05 but less than .10, two if it is between the values .10 and .15 and so on. Important variations then become evident. I've highlighted several. You may wonder why I didn't highlight all these plus signs on the right. Those are measurements of the black and generally no one ever complains about running black too high. The increasing use of gray component replacement (GCR) may change that.

An even clearer picture can be gained by a high resolution color graphical presentation of the data as shown in Figure 14. As you can see this quickly shows ad-by-ad where the differences are. The cross formed by the base lines is at the measurement location and the length of the bar represents the difference in a manner similar to that with the pluses and minuses. On this sheet, the Coke ad is good, the Verve ad is a little dark in the package colors and as noted before, black is run quite high everywhere.

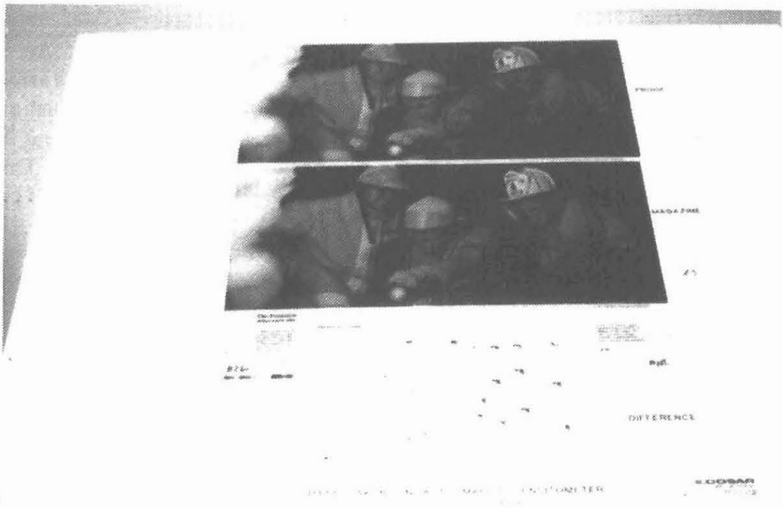

Figure 8. Comparison of a Magazine Ad and Proof.

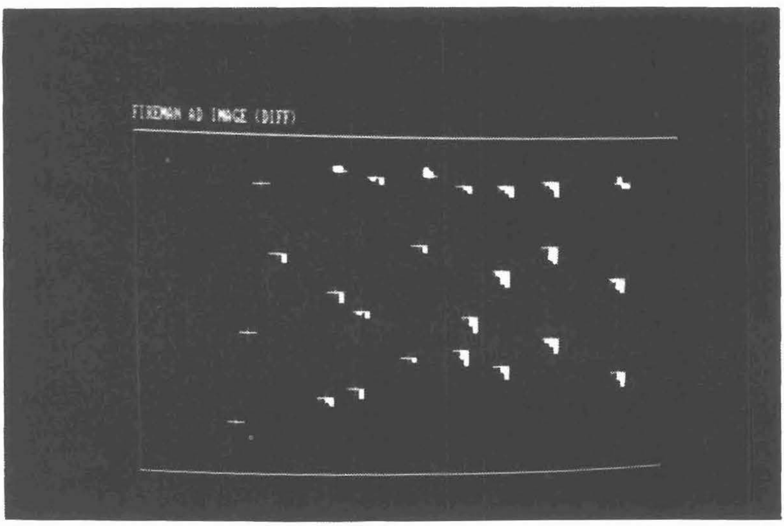

Figure 9. CRT Display of the Magazine Ad Compared to Proof.

Figure 10. Magazine Signature.

Figure 11. Close-up of 2 of the Ads.

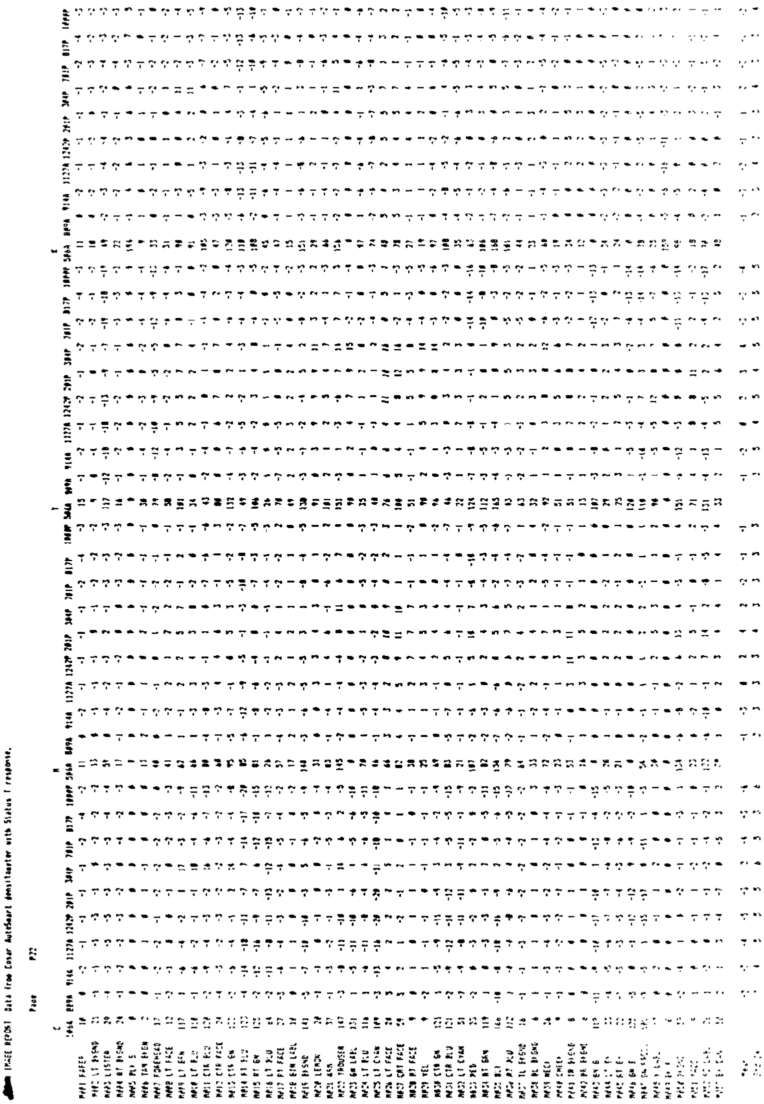

Figure 12. Consistency Data in Numerical Form.

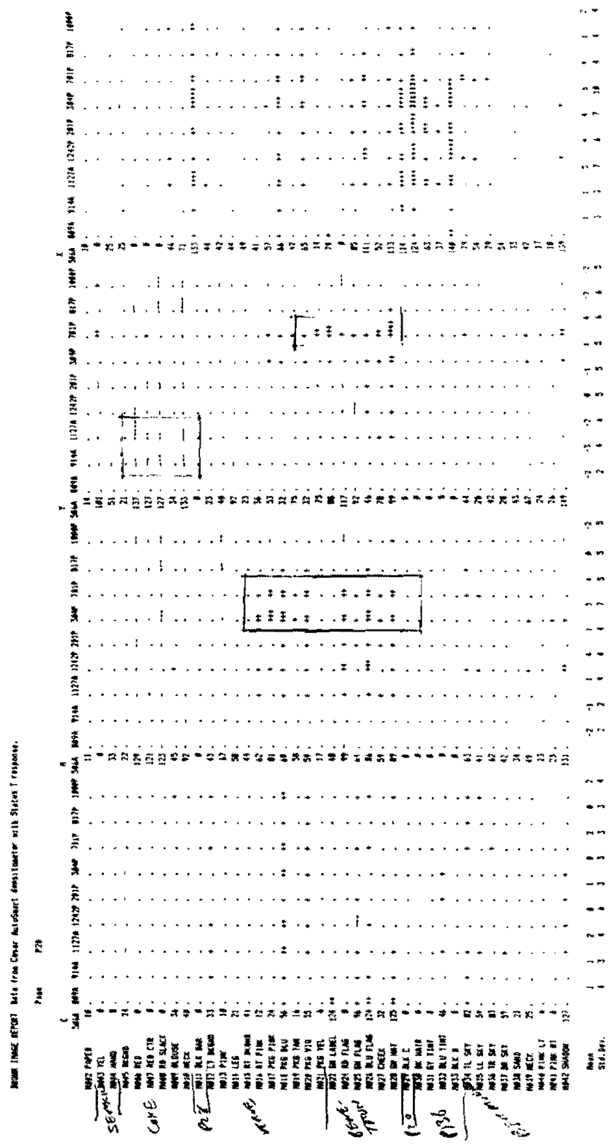

Figure 13. Tabular Data in + and - Form to Highlight Areas Needing Attention.

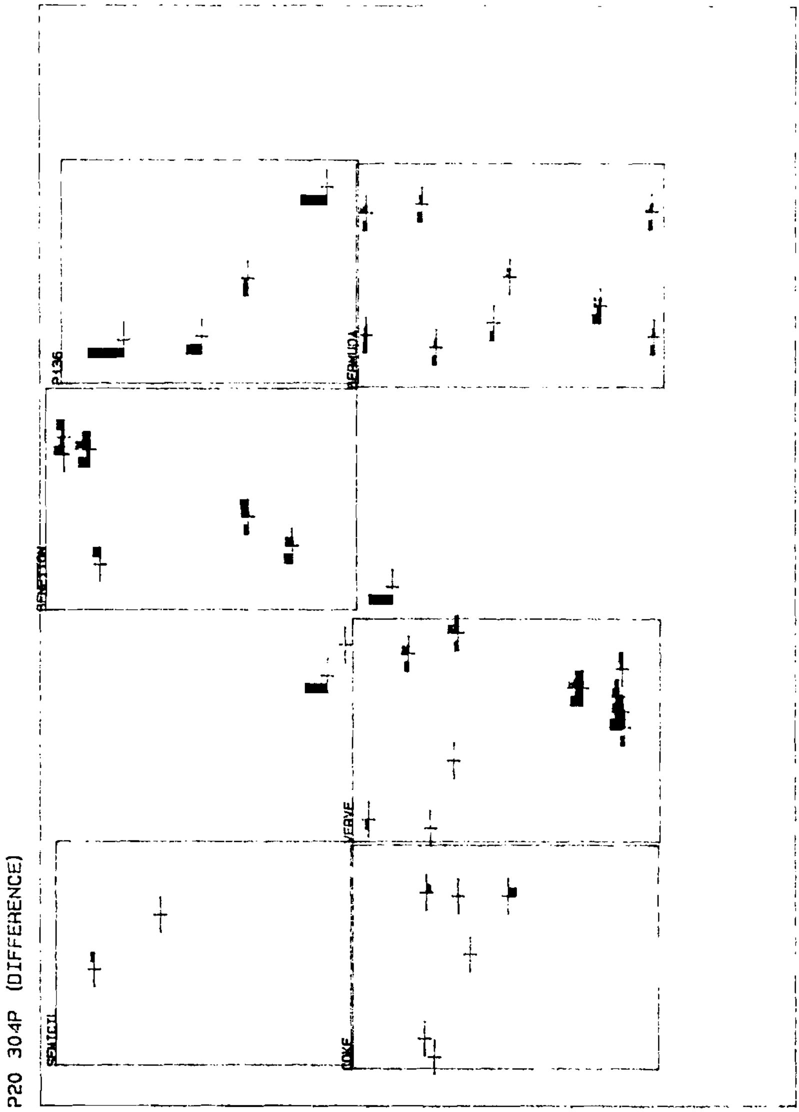

Figure 14. Data in Color Graphics Form.

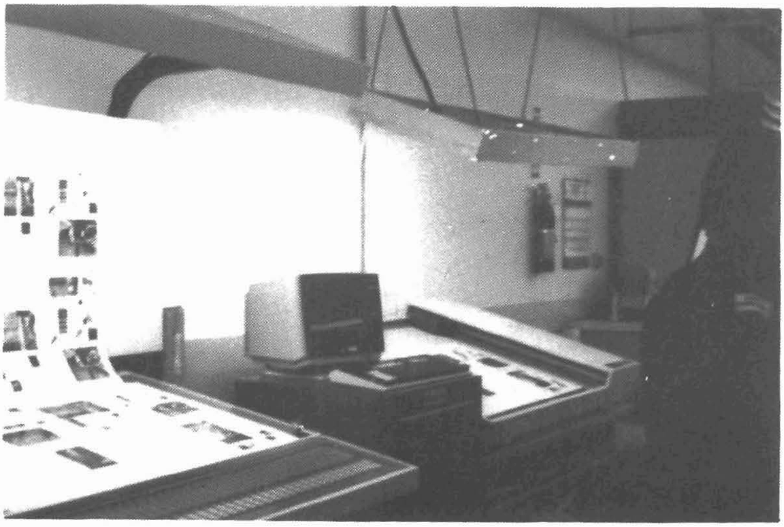

Figure 15. Press Side Control Set Up.

Press Side Control Example

The prior examples show how automated image area measurements can give a clear evaluation of the quality of the printed product but how much more important it is to control that quality as it is produced on the press. The AutoSmart densitometer was designed to be used at the end of the press as shown in Figure 15 to control the color during printing. It is the function now being performed in a very limited way by hand-held densitometers and scanning densitometers that can only read certain color bars.

For example, on the sheet in Figure 16 the color bar is only read in line with the four-color images. The process colors are shut down over most of the sheet and displaying those readings only confuses the results. The color bar is used where it is meaningful, but supplemented it with image area measurements. On this sheet a 5th and 6th color are important and they are read in the image area.

This sheet shown in Figure 17 is for a company where the decor is what is being conveyed by the picture. To me cherry wood and mahogany look a lot alike, but to a

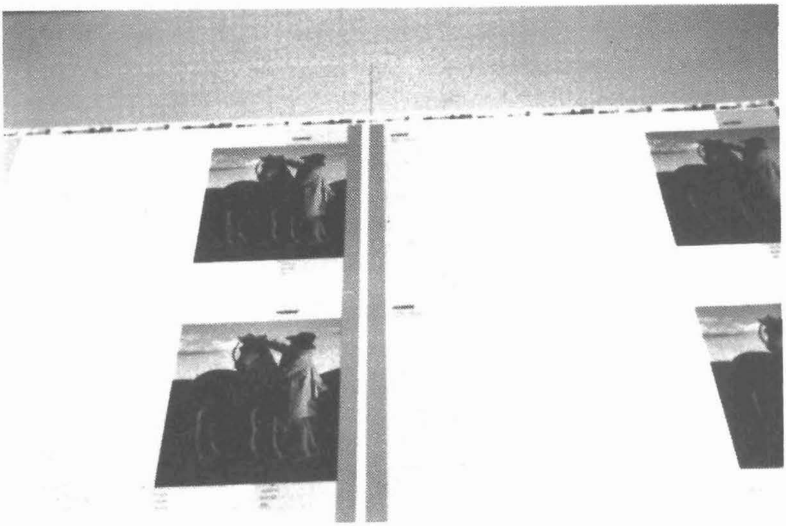

Figure 16. Cowboy Example.

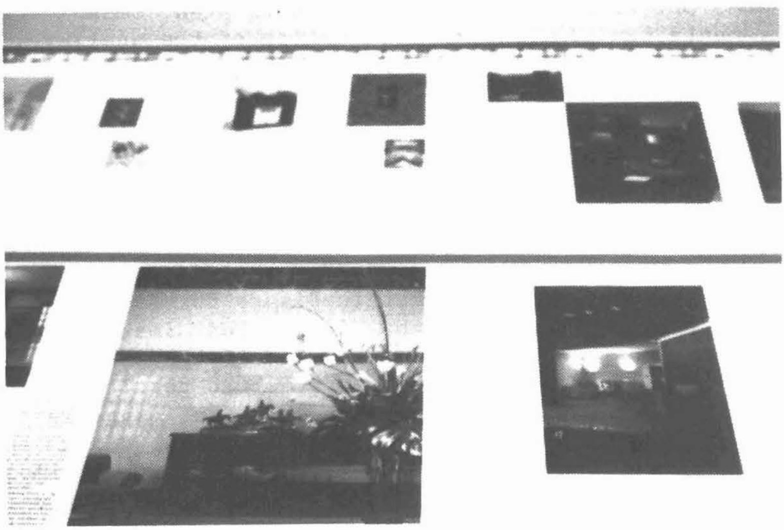

Figure 17. Furniture Example.

decorator one is simply right and the other is simply worng and the printer who changes the decorators cherry wood desk to mahogany is in a lot of trouble. On this sheet, the wood gains should obviously be measured and controlled, but to my surprise, the color expert in this plant said "The gray in that ceiling is going to be the first to go." This emphasizes that the locations to be selected for measurement and control should be selected at the press by the person responsible for the job and not by a machine manufacturer.

Figure 18 shows an example where there was an important problem, the color bar measurements were no help and in fact are completely misleading while the image area data correctly indicates the problem. This job was run, then some more copies needed to be run for some reason. The plates were put back on the press, but those bright reds, greens, and blues for some reason were no longer bright enough.

The problem, as clearly indicated by the image area measurements and displayed graphically in Figure 19, was not enough yellow. But the color bar measurements showed yellow being run much higher than that on the sheet with the bright colors! Anyone using color bar measurements would be misdirected. The problem got solved by putting more yellow in the image area but as frequently happens, a number of changes were being tried at the same time and no one is sure exactly what caused the problem or what resulted in getting the proper amount of yellow in the image area. The yellow ink was changed and also the fountain key to the right of the sheet out of the image area was opened. These two changes are the best guess as to what resulted in the proper amount of yellow, but a number of other changes were made during the same time period.

Conclusion

Early results of image area measurements have demonstrated the ability to make meaningful comparisons of the match or mismatch between printed sheets and proofs or OK sheets using simple density differences. The key requirement is that the measurements be made at precisely equivalent locations so that the measurements are comparable. This necessitates automated location such as that provided by the AutoSmart densitometer. Control of the printing is even more important than evaluation of the quality after it is produced and early results indicate that image area data is at least an important supplement to color bar data.

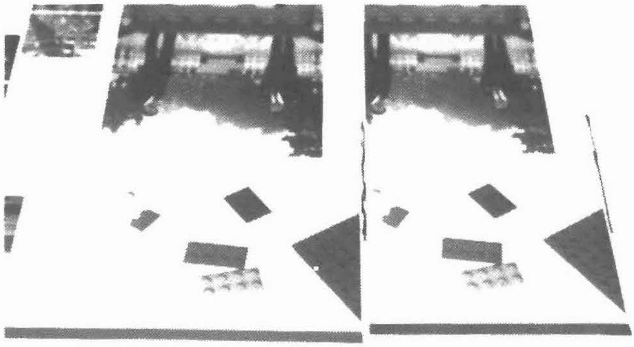

Figure 18. Example Where Image Area Data Was Important.

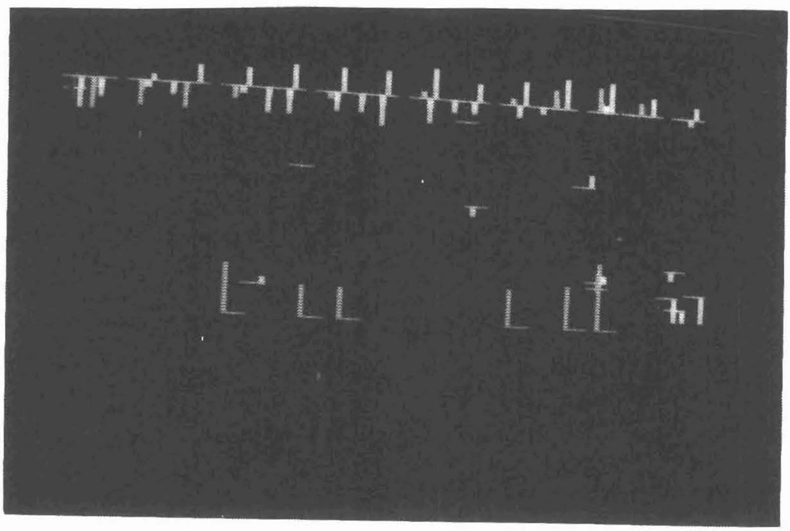

Figure 19. CRT Display of the Image Area Problem.

Literature Cited

Cox, James R.
1985 "A New Measuring Device for Automatic Density Measurements", TAGA Proceedings 1985, pp. 487-497.

Gaston, John G.
1978 "An Investigation of the Allowable Variation in Solid Ink Density as Determined by the Trained Color Observer in Process Printing", Master's Thesis, Rochester Institute of Technology, Rochester N.Y., 1978.

Hasimoto, Chikashi
1979 "Control of a Four-Color Lithographic Press by Monitoring Hue Consistency of the Reproduction with a Densitometer", Masters Thesis, Rochester Institute of Technology, Rochester, N.Y., 1979.

Lake, Daniel
1978 "An Investigation into a 4-Color Lithographic Press", Master's Thesis, Rochester Institute of Technology, Rochester, N.Y., 1978.

Southworth, Miles
1983 "Controlling Color on a Printing Press", The QUALITY CONTROL SCANNER, Vol. 3, No. 4, Graphic Arts Publishing Company, Livonia, N.Y., 1983.

Southworth, Miles
1984 "Controlling Color by Varying Solid Ink Density", TAGA Proceedings, pp. 286-292, 1984.