An Evaluation of Different Strategies for Ink Savings on Press

Eric Neumann, Greg Radencic, and Dr. Mark Bohan

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Abstract

There is an increasing focus on cost reduction in the printing industry. This has led to the implementation of many quality strategies and manufacturing methodologies that include lean manufacturing, just-in-time, and six sigma. In many of these, the objective is to standardize and evaluate the workflow throughout the production workflow. By evaluating the costs of manufacturing, the press consumables will contribute significantly to the final cost of the product. The final breakdown of consumable costs will depend on the actual production piece, the market served, and the complete run length.

Considering consumables, paper is the most significant proportion of the production costs, and much work has been carried out optimizing the press configurations, product sizes, and trims to minimize the amount of waste in this area. Ink, in many cases, is a significant cost, and there is a great deal of investigation into different strategies for reducing ink usage from changing the material properties (ink, paper etc.) to ink reduction strategies in pre-press. This paper focuses on the different ink reduction strategies that are available in pre-press and how they impact the print quality and ink usage.

The ink mileage savings in pre-press can be achieved in a number of different ways. There are two main methods for carrying out the optimization process. In the first case the algorithms can be applied during the RGB to CMYK conversion. In this case, due in many cases to the gamut compression between original and destination color spaces, there will be a color shift in this conversion application. The second case that the optimization can occur will be in taking a set of existing CMYK separations and converting them to a new CMYK data set. In this scenario the objective is to maintain the original color intent from the first set of data files.

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For several years the technique of Gray Component Replacement (GCR) has been used in Photoshop and can be used on images within a color managed workflow. Default settings or custom GCR levels can be used for the separation. There has over recent years been the introduction of new commercial packages that can be easily integrated into the workflow to facilitate the file conversions, be they RGB to CMYK or CMYK to CMYK.

The study has used a number of standard test images to assess both the possible ink savings and also the color accuracy of the conversions. These represent a wide range of typical images from a commercial operation. In addition, files from a production job have also been assessed.

The different default levels of GCR have been assessed. Earlier work had shown that the custom GCR, if not properly optimized, would give rise to artifacts in the images and as such was excluded from this study. Secondly, a number of available commercial packages that can be used to facilitate the separations have been assessed. The files were run through each of the different systems using their default settings.

The resultant separation files obtained were reviewed, assessed and analyzed for two main factors, namely the ink savings obtained by the separation and secondly the color accuracy / artifacts. To aid in the assessment of the color accuracy / artifacts, proofs were produced of the images and these were assessed by a panel of experienced color experts. The results show that there are significant differences in the ink usage between the different approaches. However, in certain instances the savings come with a change in the quality of the image.

Introduction

There has been an increased demand to reduce costs in the printing industry. One area currently under investigation in the web offset area is that of reduced ink consumption. After paper consumption, this is one of the leading consumable costs for the printer.

The amount of ink can be reduced by altering the color separation either in the conversion from the RGB file or directly altering an existing set of CMYK separations. An example of the separations is shown in Figure 1. This has been carried out from RGB files since the early 1970s using Gray Component Replacement (GCR). There are proven benefits to this in terms of the quantity of ink used. However, this can also introduce artifacts in the printed image, such as banding in vignettes and changes to the image detail. These artifacts will also vary dependent on the actual image being altered. Finally, dependent on the aggressiveness of the algorithms used, it may also affect the color of the images.

Figure 1: Example of CGR application (4 color, CMY only, K only)

GCR has traditionally been available only with pre-press separations. There have been several new software introductions and innovations into the graphic arts market in recent years and this provided the motivation for the project as many printers and users were questioning the use of these approaches and whether they save ink and how they affect image quality.

Experimental procedure

The experimental procedure was developed to provide a challenging test of the different approaches. This was achieved by the careful selection of the images used for the investigation.

The images used for the investigation were, wherever possible, used in both a RGB and a CMYK format. The photographs used covered a wide range of those found in commercial printing applications and included highlight detail, shadow detail, grays, memory colors, neutral and group images. These were also combined into a single image, Figure 2, to investigate whether the algorithms in the applications were optimized for individual images or if similar algorithms would be used regardless of the image type. The Chromaticity CTI Target was also used as this is a standard image used throughout the graphic arts industry.

Figure 2: Example of images used for investigation

To simulate non photographic images, a number of synthetic images were also used; these included a simulated Munsell Color Checker (Munsell Spots), Hutch RGB Explorer, gray rails, and several standard synthetic ISO images.

The total collections of images were then optimized using each the different software algorithms, these are outlined in Table 1. Where multiple entries occur for a single vendor, this indicates that there was different software used for the RGB to CMYK and the CMYK to CMYK conversion. In this study, the optimization of the images was carried out by the vendors, and the optimized files were returned for analysis.

The files that were returned were analyzed using Serendipity Blackmagic to compute the CMYK coverage. Spectrum proofs of the images were also made using a Kodak Trendsetter. These proofs were used to assess the changes to the images in terms of color balance, image detail throughout all of the images, and artifacts that may have been introduced, such as banding. In addition, the Munsell Spots were measured using a spectrophotometer to indicate color shifts that occurred when using the different separation techniques.

Manufacturer	Software	Workflow	Platform
Adobe	Photoshop (GCR)	Photoshop	Win, Mac
Agfa	:Arkitex Intelliune :Arkitex OptiInk	Stand-alone	Win, Mac
Alwan Color Expertise	CMYK Optimizer	Stand-alone, OEM integration	Mac
Binuscan	IPM Workflow Server PDF Server	Stand-alone	Win
CGS	ORIS Ink Saver	Option (for ORIS ColorTuner)	Win
FineEye Color Solutions	ICEmaker ICEsaver	Photoshop Plug-in Acrobat Plug-in	Mac
Fujifilm	C-Fit Image Intelligence	Stand-alone	Win
GMG	ColorServer InkOptimizer	Stand-alone	Win
IQ Colour, LLC	IQ Colour	Photoshop Plug-in, Stand-alone	Win, Mac
TGLC	PerfX Color Server	Stand-alone	Win, Mac

Table 1: Participants in study

Results and discussion

The results in this paper will be presented in three sections. First the ink optimization results will be discussed, followed by the color difference between samples as measured using a spectrophotometer on the proofs. Finally, the effect on the image quality will be discussed.

The analysis of the ink coverage data for the RGB to CMYK conversion showed that there were significant reductions in the amount of ink required to reproduce the images, Figure 1, using the different conversion approaches. The analysis computed the ink savings by comparing those in the optimized separated files to a standard RGB to CMYK conversion using Adobe US Web Coated SWOP v2. In most cases the amount of black used in the separations has increased and the cyan, magenta, and yellow usage reduces from 5% to 30%. For each of the cases, the change in ink consumption is computed as the total of the changes in black, cyan, magenta, and yellow ink usage. There are significant differences in the ink savings, with the total range covering approximately three times that of the lowest savings obtained. It should be noted that there is one set of rogue results, vendor 3. This was a result of the algorithms being applied incorrectly. The vendor did not wish to resubmit their data.

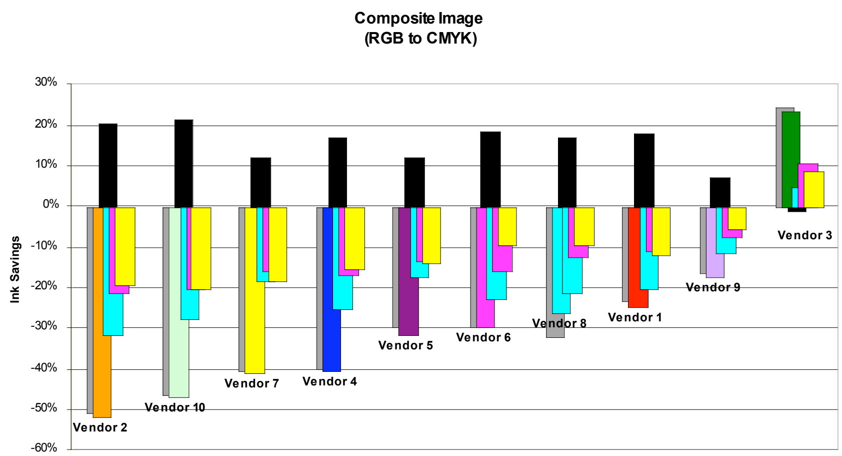

Figure 3: Composite image – RGB to CMYK

The data shown is the average for the nine images that were also used in the composite image. The results from the composite are also plotted, and these show that in most cases with the RGB to CMYK conversion that the images are all being handled in a similar manner. There are some small differences in all of the results. However, the results from Vendor 8 show significant deviation. This shows larger changes for the composite, indicating that the best algorithm was not being applied to some of the individual images.

In the CMYK to CMYK conversion, new CMYK values are computed. This can be used when the customer has supplied pre-separated files. It is normally important in this case to ensure that the visual appearances of the images are not compromised. The results from the CMYK to CMYK conversion showed that reductions were obtained by applying the algorithms. Larger ink savings were identified on the CMYK to CMYK conversion, though the largest savings remained consistent and the same vendor performed with the largest savings, Figure 4. The relative performance of the different systems changed. The results show that there is image optimization being used by vendor 2, with much greater savings from the individual images compared to the composite. The results also indicate that the different software algorithms are optimized for either RGB or CMYK, with significant changes in performance for vendors 8, 1, and 4.

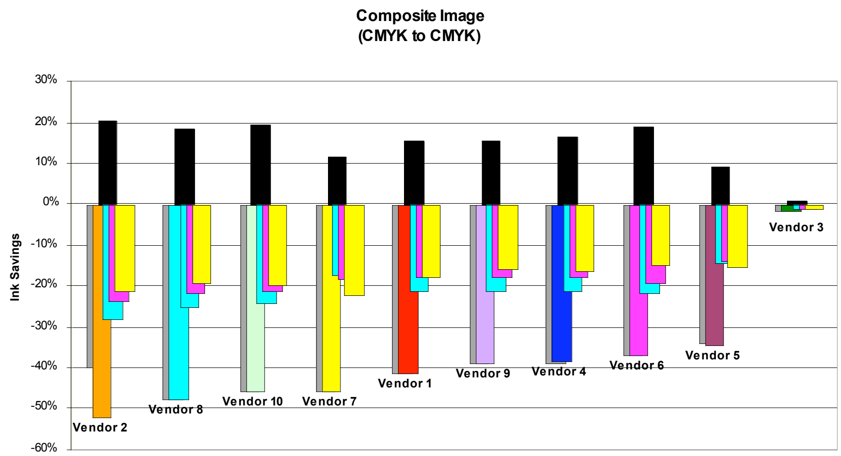

Figure 4: Composite image – CMYK to CMYK

The Munsell Spots were used to indicate the ink consumption changes that were identified for the synthetic images. The RGB to CMYK conversion data is shown in Figure 5. This image was created in Adobe CS3 and is not a photographic image. There were much greater savings indicated with this image than that from the composite image, Figure 3, with total savings of more than 80% being recorded with one system. There were differences between the different applications, with that developed by vendor 10 performing significantly better with the composite image compared to the synthetic image.

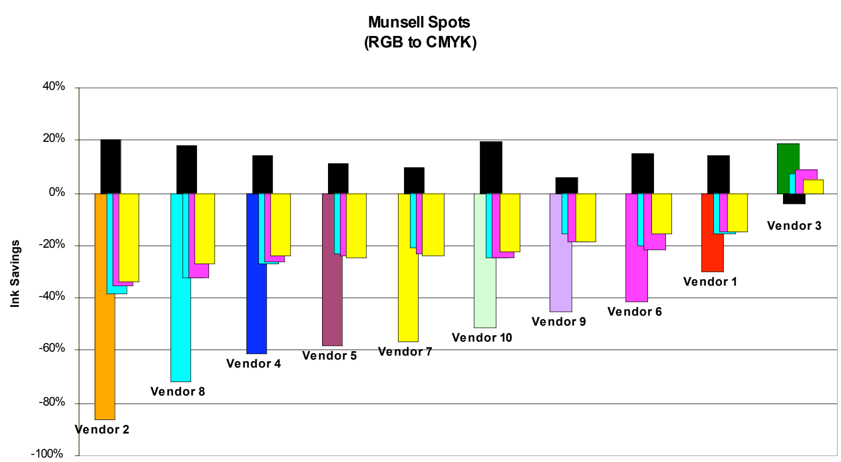

Figure 5: Synthetic image – RGB to CMYK

Similar levels of ink saving were identified on the CMYK to CMYK conversion with the synthetic images compared to the RGB to CMYK conversion, Figure 6. In all cases the ink savings were greatly improved on those from the composite image, and the results were in a similar order of effectiveness for all of the vendors, with the exception of vendor 1 which performed to a lesser degree on the synthetic images.

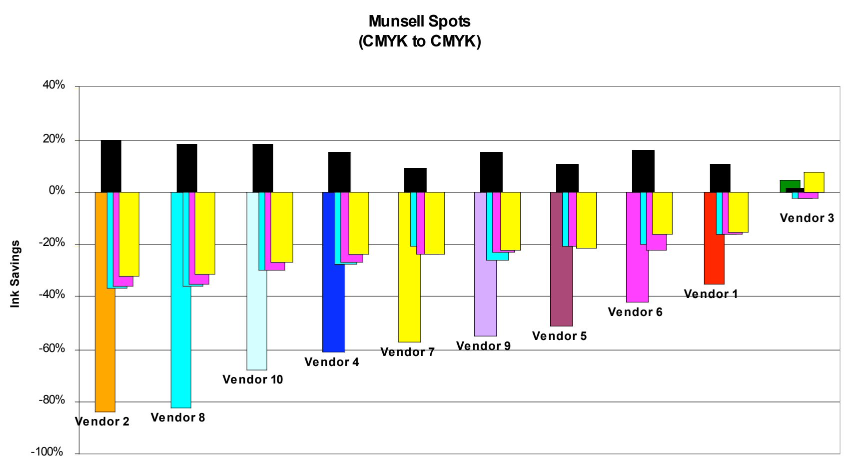

Figure 6: Synthetic image – CMYK to CMYK

The colorimetric accuracy was calculated using the Munsell Spots, with the Adobe US Web Coated SWOP v2 used as the control for the ΔE_{ab} calculations. The color difference was calculated for each of the 26 patches in the chart, with the average, minimum, and maximum color differences being analyzed, Figure 7, for the RGB to CMYK conversion. The average ΔE_{ab} varied between 2 and 9, with the largest color differences on the same patch between the optimized file and control being over 20. This color difference would be unacceptable in commercial printing applications. The analysis of the individual patches showed that the largest ΔE_{ab} were generally for the green, blue, and cyan colors. Many of these color changes are due to the manner in which the gamut compression has been carried out. In addition, it was not the objective of some of the applications to optimize for color but rather on image quality and ink savings in the RGB to CMYK conversion.

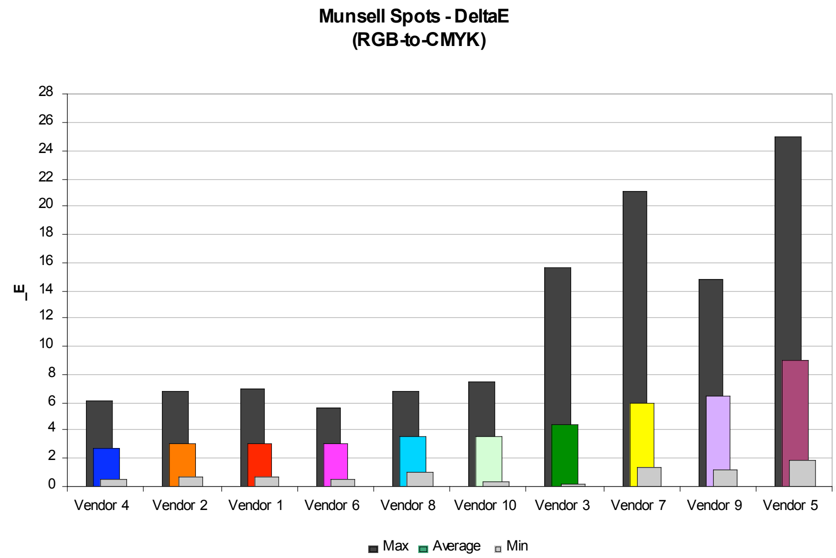

Figure 7: Synthetic image – RGB to CMYK – ΔE_{ab}

There were smaller color differences measured for the CMYK to CMYK conversion, Figure 8, where the objective in most cases is to preserve color fidelity. The colors for which the largest color shifts were measured were again the green, blue, and cyan colors. In comparing the color accuracy software effectiveness, there were much greater differences identified between the color data sequencing from RGB or CMYK than was identified with the ink savings data. The performance of vendor 3 was clearly optimized for the CMYK to CMYK conversion, as was vendor 9, while that from vendor 1 was optimized for the RGB to CMYK conversion.

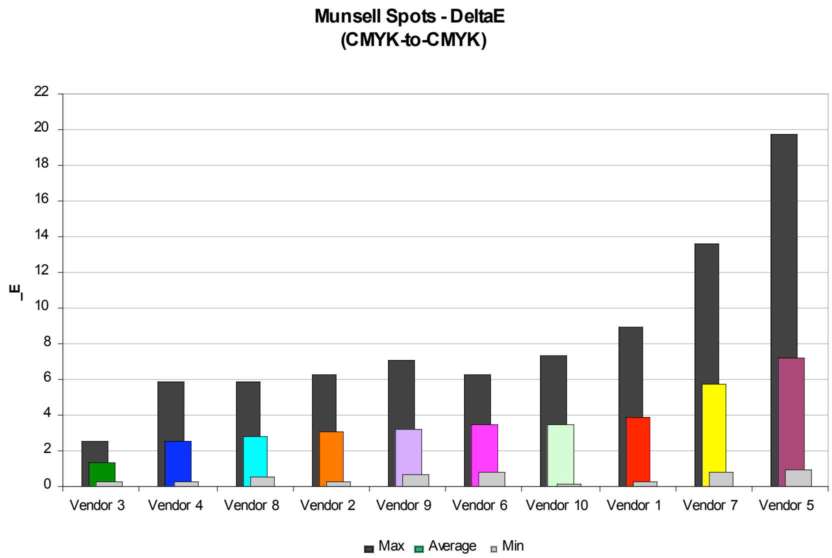

Figure 8: Synthetic image – CMYK to CMYK – ΔE_{ab}

It is important that the ink savings that are obtained are not at the detriment of the color fidelity. In comparing the data from the RGB to CMYK conversions, there were some solutions that significantly altered the image color to obtain the ink savings, most notably vendor 5. There were also certain solutions that were conservative on the conversion to maintain the color, Vendor 1 for example. A well optimized solution could be developed that maintained the color, while optimizing the ink savings, as shown by vendors 2 and 4.

In analyzing the CMYK to CMYK conversion, the solutions that had good ink savings, vendors 2, 4, and 8, also had small color differences measured using the Munsell Spots. However, in certain instances, the large ink savings have been obtained with the compromise to the final color reproduction, as indicated by vendors 5 and 7.

The visual assessment was carried out by a panel of experienced color professionals using the spectrum proofs. They were asked to evaluate five different areas of the Chromaticity CTI Chart,
Figure 9, comparing it to the Adobe US Web Coated SWOP v2. They were ranked on a 1 to 5 scale with 5 being a perfect match and 3 being a *"commercially acceptable"* match.

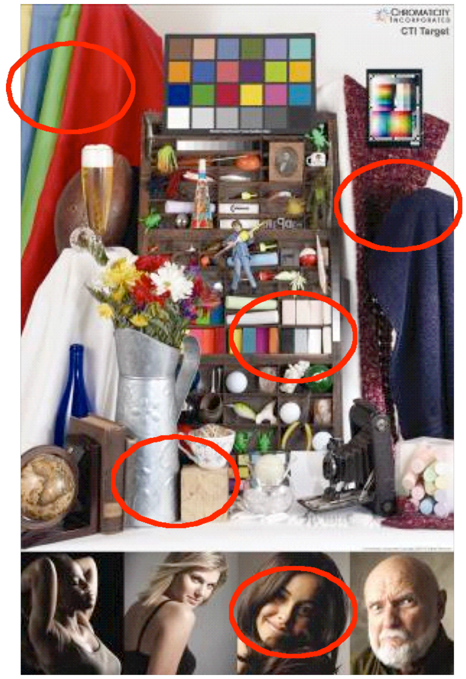

Figure 9: Visual comparison areas

The results showed that 6/10 of the solutions produced the *"commercially acceptable"* match, Figure 10. The results were affected by the area being considered with a wide range in the values obtained for each of the different areas. The compromise of the image quality to obtain the high ink savings was evident, as in the color data, particularly for vendors 10 and 7.

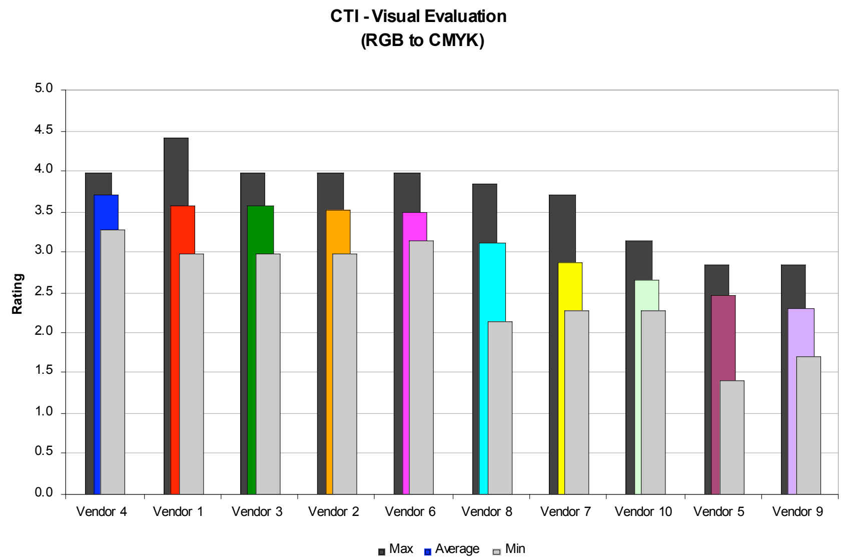

Figure 10: Visual comparison – RGB to CMYK

In evaluating the CMYK to CMYK conversion, 8/10 of the solutions provided the *"commercially acceptable"* match, Figure 11. In general, the matches obtained with these conversions were higher than that obtained from the RGB to CMYK conversion. Those with the lower ink savings tended to have the best match on this chart, with the high ink savings compromising the image fidelity.

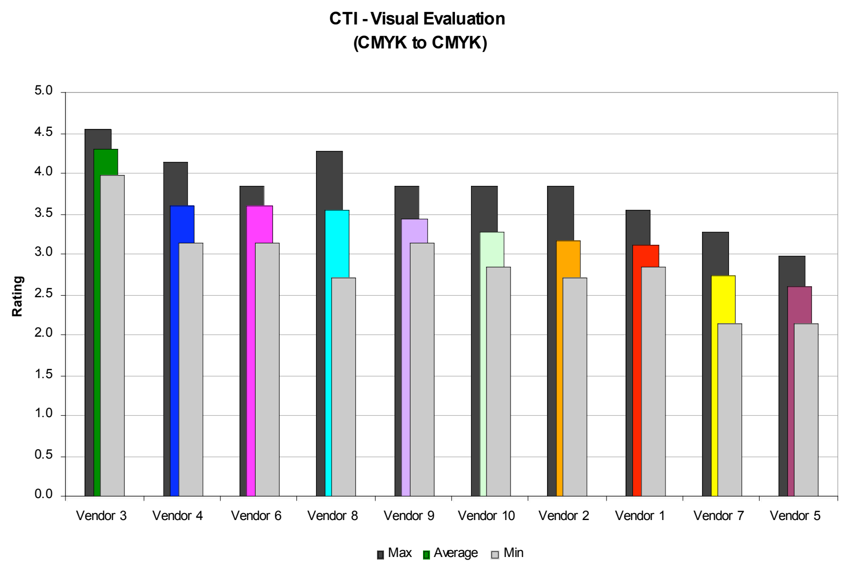

Figure 11: Visual comparison – CMYK to CMYK

Conclusions

An extensive evaluation of ink optimization software has been successfully carried out. This was completed under controlled conditions, and the changes in the ink usage have been quantified for conventional images, synthetic images, and composite images. This was completed for the conversion from RGB to CMYK and also for CMYK to CMYK conversions. The savings were quantified by using analysis from Serendipity Blackmagic. The results can be summarized as:

- ♣ All of the systems, when properly configured, produced overall ink savings.
- ♣ Notable ink savings and accurate color is possible from both RGB and CMYK originals.
- ♣ Ink savings was affected by image content and type. The cumulative ink saving ranged from 15% to 90%.
- ♣ In this study, the largest savings were obtained from the synthetic images analyzed. These were heavy coverage images.
- ♣ When the same images were composited, they yielded very similar results.
- ♣ In certain instances there were significant differences in the final appearance of the images dependent on the software used, for both the RGB to CMYK conversion and CMYK to CMYK conversion. Larger

differences were found during the RGB to CMYK conversion, where it was not the objective with certain applications to maintain the image reproduction. There were changes to color accuracy, highlight detail, and shadow areas.

- ♣ The high level of ink optimization can in certain instances lead to large color and image changes, and these changes need to be carefully assessed prior to any implementation.

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