Productivity of Digital Printing Devices

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Abstract

In the commercial print market, digital production presses are providing a viable option for short-run work. The speed and quality of these devices are attaining a level where profits can be made and the work sold based on the same quality expectations as a traditional offset press.

The speed and quality expectations of digital printing presses are typically communicated and sold using language that in some cases can be misleading or not understood correctly. This could be due to the specifications being developed based on test criteria that is not communicated or do not represent the end user's typical use of the equipment. Other factors that impact the productivity of the equipment includes processing of the files, color conversion, and RIP configuration. Again factors such as these have a direct impact on the productivity of the equipment.

In order to investigate some of these factors, a benchmarking study was developed by Printing Industries of America to capture how images are prepared, processed through the RIP, and how the digital press itself performed in terms of speed and quality.

Results in this paper focus on the productivity of the printing operation and equipment. This is based on the same job being printed by all participants. The job printed included challenges such as matching spot color, front to back registration, and color, which has been shown to impact the RIPing process, create problems on press, and potentially impact productivity leading to a reprint of the job.

The results from this study show that the productivity of the equipment is directly related to the workflow. If a printing operation is not processing the files correctly, inspecting single sheet proofs for quality, this can directly impact the productivity of the equipment, negatively impacting productivity and profits.

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Introduction

The impact of high-speed digital printing on the commercial printing market has been substantial. Those printing companies with a competitive edge over their competition have either adopted digital printing to subsidize the short-run work and/or have adopted the technology to provide new offerings, such as fast turn-around times, variable data, or the ability to produce very short-run finished products like perfect-bound books or direct mail pieces.

In terms of technology, the high-speed digital printing market is currently dominated by toner-based systems with the clear outlook that other technologies like inkjet may gain market share shortly. Speed of the digital toner-based presses does vary somewhat, but is hovering around 100 to 120 pages per minute depending on substrate. In order to increase productivity using this printing method, a sound workflow must be in place as well as the ability to quickly identify defects or other issues that may cause the job to be rejected.

Developing a workflow goes beyond the RIP and the printing unit itself; how the files are delivered, inspected, and processed severely impact productivity. Surprisingly, those selling this equipment and those purchasing sometimes overlook the importance of workflow prior to the job hitting the RIP.

This benchmarking study, by design, captured information regarding the production of the same print job, by various printers from around the world. Data was captured from the time the files (provided on DVD or FTP download) were first worked until the final print landed in the delivery. To provide an accurate comparison on the performance, the same job was used. By printing the same job, variables such as image content, problematic files, and font-related issues were eliminated. There were, however, several design aspects built into the images that were intended to be challenging but, if printed, would not disrupt the printing process by erroring out the job.

Participation in the benchmarking study was open to all printing operations that had equipment they could identify as a digital device used for a production purpose. The goal was to have a broad scope of digital printers to include those listed as book printers, packaging printers, digital-only shops, those that specialized in variable data, and those that had other printing equipment like offset or flexography.

In order for a company's data to be included in the study, they were required to achieve several requirements. This included filling out a questionnaire fully and completely. If a company neglected to capture pertinent data, they were excluded from the results. Each participant was also required to print 100 good sheets that were submitted to Printing Industries of America for analysis. If they neglected to print the sheets, they were also eliminated from the study.

There were over forty participating companies, encompassing a broad scope of front-end equipment and digital presses. Included in the study results were some digital press manufacturers and universities.

Methodology

This investigation was to evaluate the productivity of different workflows, RIPs, and digital printing presses. The test image was designed to qualify this based on a two-sided design, to maximize the press capabilities. The front side of the form, ***Figure 1***, contained a number of visual elements, to include RGB and CMYK images within the same form, fine reverse text with drop shadows over the top, heavy coverage, a combination of color naming structures, including having spot color and CMYK simulations of the same colors, and varying levels of transparency for spot colors. A color control bar was also included in the design so that colorimetric measurements could be taken to investigate color consistency of a single device and capture color variation across the broad range of presses included in the study.

Figure 1. *Image side of test form.*

The second side of the test image was a two-page Printing Industries of America Digital Test Form 5.0, ***Figure 2***. This includes a number of items for assessment of print quality and also the DFE. Those included on the form and included in the analysis are positive and reverse text, a line resolution target, opposed line targets and the Printing Industries of America Proof Comparator that has multiple components and was used for the measurement of gray balance in the image.

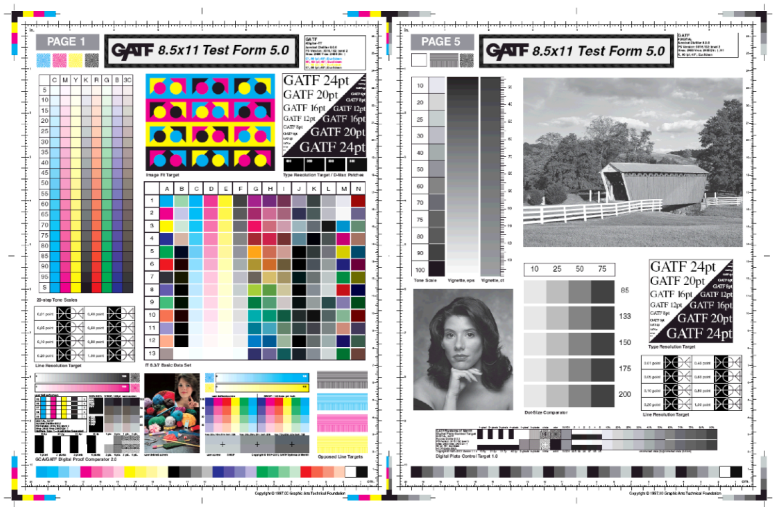

Figure 2. *Test form side of test form.*

The files were made available to the participants via an FTP site or on a DVD transported by traditional mail methods. This ensured consistency of the files being delivered to the participants.

The requirements for running the job were the same for all participants, and these are outlined in ***Table 1***. The total run length was 100 copies, of which 50 needed to be retuned to Printing Industries of America. There was no specification on the workflow, as one of the primary objectives of the study was to evaluate the workflows and digital presses in terms of productivity.

Press requirements	Any digital toner or inkjet press capable of producing a 4/4 job.
Screening	This is to be determined by the printer.
Paper	60lb. to 100lb. C2S #1 or #2 grade, any finish.
Job sequence	Sandwich the benchmarking job between live jobs or insert as the final job of a shift.
Color OK	No proof is supplied. The goal is to meet a print specification in noted or pleasing color.
Total run length	100 good sheets to be produced.

Table 1. *Specifications for the print run.*

The job was to be run in the middle of normal production. There was no proof supplied, as this is often the case with short-run digital production jobs. With no proof supplied, the participants were asked to produce pleasing color or target

their internal quality requirements, be they CIELab, density, tone reproduction, or any other target specification.

The questionnaire was developed to first document the company's demographics and then the equipment that was used to produce the job in both the prepress and pressroom. To evaluate the productivity, the times to perform each step through production were broken down by task in the questionnaire. These times covered from insertion of the DVD or downloading of the files from the FTP site until the end of the 100-sheet production run.

Results and Discussion

Discussion of the results and findings within this investigation will be broken into sections based on sequential events. First to be discussed will be the configuration of the RIP and setting selections known to impact color and/or quality. Next to be discussed will be the productivity results. Productivity has been separated into prepress and press activities and then further broken down into subsets within these two activities that further captures the functionality of these processes.

Prepress Configuration/ Settings

In order for the participating parties to fully utilize there defined workflows, there was the option given to either use the native Adobe InDesign files used to generate the images or to use PDFs created by Printing Industries of America. From the answers on the questionnaires, there were several reasons why one of the file formats was selected over the other. Some stated it was a productivity issue, other documented that it allowed for better control of color, and some used one file format for one side of the form and the other file format on the other due to imposition requirements.

By design, several of the images within the layout were rendered as RGB color space. This was done to see how the conversion of color was taking place and to determine where the conversion was occurring. Based on our research, the options available for color conversion were in Adobe Photoshop, at PDF creation, in the native application, during the RIPing process, or in several different applications, based on subject matter.

In the findings of this study it was discovered that the majority of printers converted RGB to CMYK in the RIP (45%), Figure 3. This allowed for better color control as all images were separated the same without the possibility of desktop user error and was an automated process, which potentially freed up operator time. Other than in the RIP, the next most popular scenarios for color conversion were either in Adobe Photoshop (17%) or during PDF Creation (16%). An interesting fact about color conversion in Adobe Photoshop is that

this process is time consuming, as this has to be done manually. At PDF creation less time in prepress was required as this was a more automated process. Depending on the image, Adobe Photoshop was not an option for converting color. In this situation, other software like Adobe Illustrator was required to convert color from RGB to CMYK.

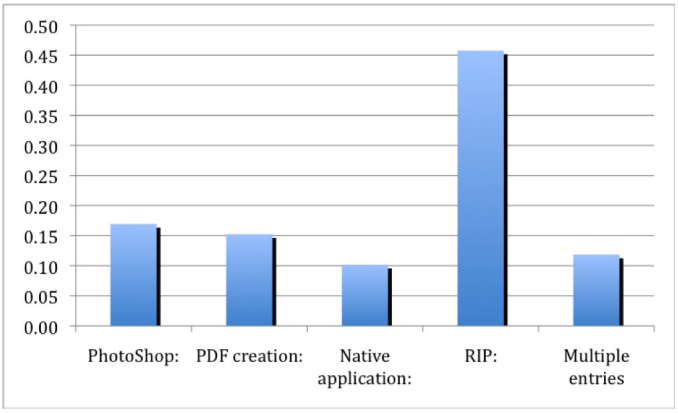

Figure 3. *Process used for color conversion.*

One of the most interesting outcomes of the study was the fact that 12% of the participants in the study converted color using multiple processes. These were mainly those converting color in Adobe Photoshop and Adobe Illustrator or those that used a combination of native application in conjunction with converting in the RIP or in PDF creation.

During the color conversion process, the ability to convert out-of-gamut colors into the CMYK color space requires the use of a rendering intent. A rendering intent is the method or process used that spells out exactly how those out of gamut colors are placed into the new color space. Currently, there are four frequently used options. These are Relative Colorimetric, Absolute Colorimetric, Perceptual, and Saturated. Depending on the content of the image, one of the options may provide a benefit over the other. Then there are those rule-of-thumb scenarios that many adopt based on others' experiences, typically published in some form of trade article.

Of those that participated in the study the most popular rendering intent used was perceptual (37%), Figure 4. This was closely followed by the 35% that used the relative colorimetric intent. Surprisingly, more than 22% of those answering the questionnaire did not understand rendering intent and did not know how it was impacting color or where to find out where this option is set in the color conversion process.

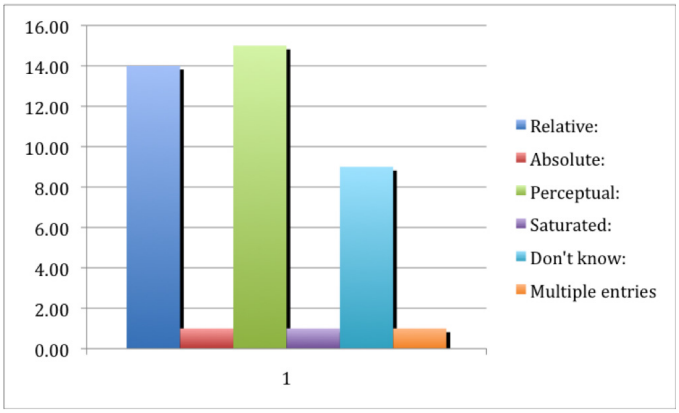

Figure 4. *Rendering intent used for production work.*

The other rendering intents, absolute colorimetric and saturated, were used by approximately 3% of the participants, and when questioned, the reasoning was based on personal preference as to the visual appearance.

Regardless of color separation workflow or rendering intent used, the ultimate desire is to have the customer accept the final piece and to match the intended target. In this study the participants were not given a proof or a dataset to match or even a printed sample to reference. However, in the questionnaire the question was asked as to what the most common target to match was.

The results of the analysis clearly show the most common match was to a proof, totalling 30% of the participating companies, Figure 5. Those proofs were either customer supplied or single print runs off the digital press used for the customer signoffs.

Industry guidelines were another popular target totalling 19% of the participants. The industry guidelines mentioned were the GRACoL 6 density and tone value increase targets, GRACoL G7™, or other industry guideline set up by the installer of the press.

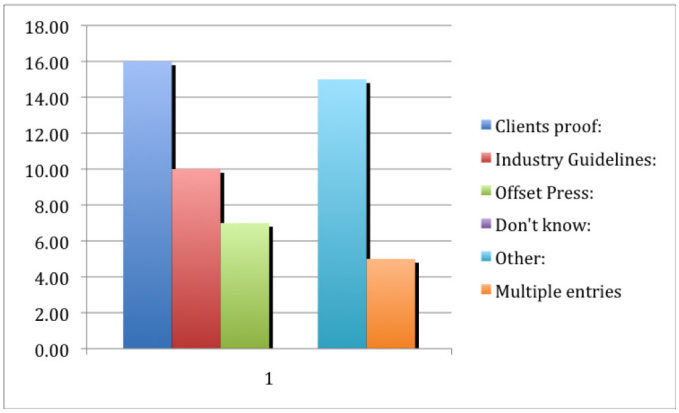

Figure 5. *Typical target to match with digital press.*

There was also a substantial amount of participants who stated they had to match traditional offset lithography, 13%. This was done to subsidize quantities, or to provide the customer product up front before the bulk delivery, or as part of a campaign.

Close to the majority when answering this question, 28%, stated they had multiple targets to match depending on the job. This could require an operator to match and offset run and then, on the next job, have to match an industry guideline, which could require recalibration of the press or the use of other color manipulation methods.

An unexpected result was that only 10% stated their sole target to match was pleasing color, typically meaning generic color control. In today's highly competitive digital printing market, especially those competing with offset, one would expect the percentage of those selling pleasing color would be far less. Of those contacted who stated they printed pleasing color, the majority stated they did this as the customer did not supply a proof, the profit margin was minimal, and the added time/cost to achieve industry guidelines was not in their best interest. Several also stated that this approach was problematic when attempting to reprint the job at a later date or if the customer later attempted to match the print to another printing process

Going beyond the printer's ability to match, digital printers commonly run into productivity related issues based on customer's requirements to match spot color or brand colors, deal with RGB to CMYK conversion issues, or match other printing methods.

According to the questionnaire results, on a scale from 1 to 5, 1 meaning it was not an issue and 5 meaning it was highly problematic, matching spot colors was a 2.5 on average, Figure 6. Those in the top quartile were not far from the

average as this group had a rating of 2.00. The 75% quartile was at a 3.0 when commenting on the complexity of matching spot colors.

Addressing RGB to CMYK color conversion issues in a single document was given a rating of 1.85 for the average, a 1.0 for the 25% quartile, and a 2.65 for the 75% quartile. Here it was shown that those dealing with file conversion issues either did not have much of an issue. When comparing these results to the process used to do the color conversion, those printers in the 75% quartile all did the color conversion in a native application manually with the majority not knowing which rendering intent was used.

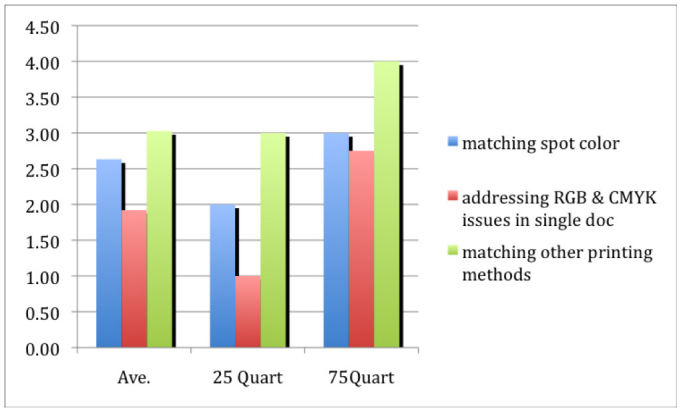

Figure 6. *Degree of difficulty for typical quality issues.*

Matching another printing process was given the highest rating showing that this was a more generic issue across all participants. This question had an average rating of 3.0, which was the same for those in the 35% quartile. Those printers in the 75% quartile rated this problem as a 4.0, meaning it was problematic to achieve and negatively impacted productivity and profits.

Productivity

The primary basis for running this study was to determine the time required to produce the same job, same quantity of sheets, using various digital printing presses at different printing operations. In order to capture the time require to perform each step in the process, the questionnaire had the operator or observer document the time to perform specific steps in the process. The total time from first handling the files until the final print was produced had to be captured.

Prepress productivity was broken down into four activities. These were: imposition, preflight and file repair, RIPing and trapping, as well as any additional time required to complete prepress activities.

Based on the time required in prepress, the categories that required the most time were preflight and RIPing/trapping. The preflight and file repair, based on the average, took 4.18 minutes, Figure 7. Those in the 25% quartile preflight handled any file repair within 1.25 minutes. Due to the short duration on time required to process the files, those in the 75% quartile were right at the average consuming a total of 5.00 minutes.

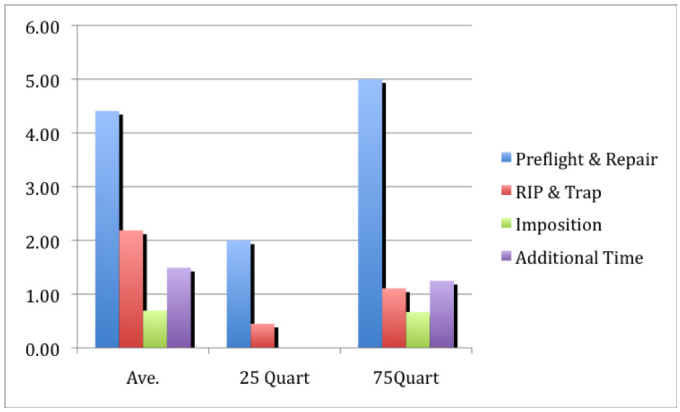

Figure 7. *Time required for prepress activities.*

RIPing and trapping for most printers was done using an automated method. There were some printers that ran into situations with RIPing and trapping, but these were overcome relatively quickly, without incident. The results show that the average for RIPing and trapping was 2.19 minutes. The fastest 25% performed this activity in 0.45 minutes. Those that had issues with this activity in the 75% quartile took 1.11 minutes.

Imposition took the least amount of time as the average company took 0.68 minutes to lay out the files. The 25% quartile had the files imposed automatically, consuming no time. Printers who chose to use the InDesign files required the most amount of time to impose the file, mainly due to the lack of imposition templates. These printers, all in the 75% quartile, took 0.63 minute to complete the imposition.

Additional time spent was used to capture any other activities by prepress required to manipulate the files into a usable format for the digital press. This question captured the time as the average participant had 1.49 minutes of additional time spent. The printers in the 25% quartile did not use any time at all in this category, as there was no needed time required. The 75% quartile showed that some printers required 1.25 minutes to address issues like RIP failures and font-related issues.

Once prepress passed off the files to the pressroom, the time required for actual printing of the job was captured. Like in prepress, the times were segregated by activity. These were production file handling, which addressed the time required by the press operator to handle the files for any reason; lapsed time for job release, which covered the time between release of the job until the first print was produced; and single sheet inspection, which captured the time where a traditional operator would release a single sheet in order to inspect for defects.

Production file handling varied significantly by participant as it was shown that the average printer used 11.62 minutes for this activity, but those in the 25% quartile only used 2.75 minutes, Figure 8. Those printers in the 75% quartile consumed 11.50 minutes. This confirms that the average printer was closer in time those in the 75% quartile, meaning that there was a clear distinction in time with this function.

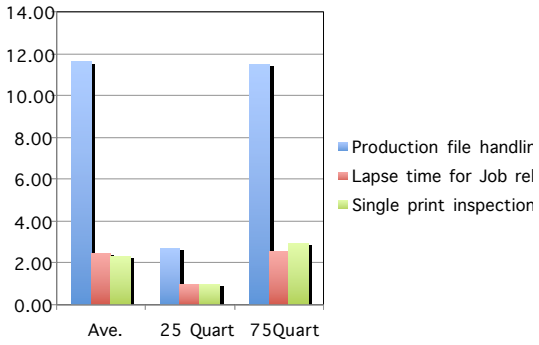

Figure 8. *Time required for pressroom activities.*

The lapsed time from when the job was released until the print was delivered also showed a clear distinction in time. The average printer required 2.50 minutes for the first print to be delivered. Those in the 25% quartile had this same operation occur in 1.00 minutes. This was a substantial savings that was attributed to the RIP and computer driving this activity. Again, those in the 75% quartile were not far from the average as the time for the 75% quartile was 2.56 minutes.

Single print inspection was done by 85% of those participated. The other 15% did not provide answers as to what their quality requirements were, leading to the assumption that these printers sell customer work on an as-is basis and do not offer corrections, or these printers could potentially send out defect prints forcing them to reprint if rejected by the customer.

Of those that performed an inspection of a single print, the printers in the 25% quartile complete this activity in 1.00 minutes. The average printer takes 2.30 minutes, with the printers in the 75% quartile requiring 3.00 minutes to fully inspect the print. Comments made about the attributes inspected include checking to ensure images are rendered correctly, colors are matched, and that font and resolution issues do not occur on the print.

Total times for each section were also tabulated and show substantial differences between participants. In prepress, for example, the participants on average required 8.24 minutes to complete all activities, Figure 9. Those in the 25% quartile were significantly faster, only requiring 2.75 minutes to perform the same tasks. The participants in the 75% quartile were much slower in this area, consuming 11.13 minutes or four times slower than those in the 25% quartile.

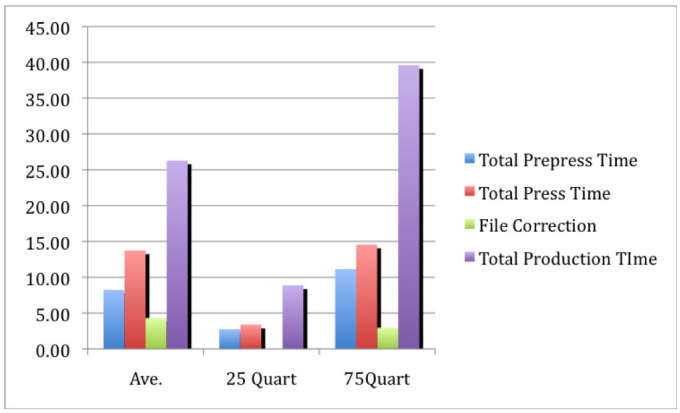

Figure 9. *Total time spent on job.*

Total press time showed those in the 25% quartile were four times faster than the average participant (13.74 minutes). The reasons for this were not directly stated, but the analysis shows the majority of this time difference was directly related to the production time spent preparing the files for print. Printers in the 75% quartile of total press time consumed 14.56 minutes.

During the printing process, 30% of the participants experienced an issue with the print quality they felt had to be resolved. Of this 30%, the average time spent correcting the files for print was 4.32 minutes, while those in the 25% quartile resolved the issues in less than 1.00 minute. Those that had problems correcting the problem were those in the 75% quartile. These participants took 2.95 minutes.

The total production times for the forty participants due to the breakdown of times per task, varied from 8.88 minutes for those in the 25% quartile to 39.60 minutes for the 75% quartile. The average time based on all participants was

26.30 minutes, with the bulk of that time consumed in the pressroom as the previous data shows.

Conclusions

This study was developed in order to help fully understand the complexity of producing a printed job using a digital press, with the main focus on productivity. The study allowed all participating parties to produce the same job with their internal equipment. The only specifications given to the participants were to print 100 good sheets and submit them back along with the completed questionnaire.

In analyzing the results of this study, it has been shown that there are clear distinctions as to how these printing companies operate, which has a direct impact on productivity. The productivity aspect starts with file handing and continues on through. The results of this project clearly show that those using PDF files were significantly quicker than those who used the InDesign files or used the InDesign files to convert to PDF for their own specific reasoning. If color conversion is required, information collected shows that in-RIP conversion is significantly faster than having to open the files in another application like Adobe PhotoShop or Illustrator to perform this operation.

The majority of prepress operators spent the bulk of their time processing the files performing preflighting and file repair. On average, this consumed approximately half the time spent dealing with the files. The additional time was spent adjusting files based on personal preferences, entering job information into an MIS system, and/or manipulating the images for appearance.

In the pressroom, handling the files in preparation for print was the most time-consuming activity. This analysis captured a wide scope of activities for the fact that each participant had a significantly different setup in terms of workflow and hardware. Even with those operations with the same digital press, in many cases they did not have the same front-end equipment, which showed differences in productivity.

Quality of the print was only confirmed by approximately 70% of the participants. The majority stated that the quality inspection was a visual comparison to the proof and took less than 2.50 minutes to perform. Those spending more than 2.50 minutes on the inspection process were those that measured the proof to ensure it met colorimetric aim points.

The final determining factor on if a job was profitable was the total time spent on the job and if the customer accepted the job. The final production times captured in this study show an average of a 13.30 minute time difference between those in the 25% quartile and those in the 75% quartile. Appearance of

the prints was inspected as part of the study, but none of the participants were rejected based on unacceptable print quality. There were, however, significant visual color differences, which will be assessed in future work.