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Publishing applications for color laser technology

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Abstract

This project is designed and written for graphic designers, artists and publishers, that are interested in publishing to color printing devices. The first part of this project will be an investigation into the role of non-impact printing technology in the 1990s. It will focus on color laser technology as being the most promising for publishers. I will discuss the technology, the advantages, and the disadvantages. Readers might be interested in what is available on the market today and what is expected in the future.

The second part of this project will be to create a children's book that is personalized in both text and illustrations. The purpose of this book is two-fold— to act as a vehicle through which technical problems of publishing with a color laser printer can be explored and to investigate a business opportunity that could apply traditional publishing concepts to new technologies.

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Chapter I
An Introduction to Color Output Devices

The field of non impact printing has been growing quickly over the last ten years. Progress in information processing and the integration of text and graphics has created a need for output devices capable of generating high quality documents rapidly, even "on demand." The push for color in documents is beginning, and it will only intensify as people come to expect it. One of the most significant and successful of all non-impact technologies, laser xerography, has and will continue to influence electronic publishing the most. This paper will look at the color output devices that are currently on the market. It will focus on color laser technology, the problems it still faces, and its implications to the publishing industry.

The influx of color printing devices is certain to change the way we view and use color. "Color printer sales are expected to triple by the year 1996 reaching a market value of $3.5 billion. This means 1.4 million color printer installations by the year 1995."[1] Until recently, color printer technology has been used mostly for presentation graphics and occasionally in the office for spot color. In addition to presentations, color output devices are also valuable in creating comps (short for comprehensive—describes a layout a designer shows to a client) short print runs, and industrial training situations. The next two years will bring improved color output quality and lower prices as well as high resolution and near photographic quality output below the $10,000 mark. The rise of machines that print color on demand, the ability to print on plain paper, lower prices and faster devices are all going to usher desktop publishing into a new age.

Before discussing color laser technology, it is important to understand the other devices that are on the market. This will help in later evaluations of the strengths and weaknesses of laser printers. It will also help readers decide if color laser technology is really best suited to their needs. Currently, there are only three

major technologies used in publishing that are capable of incorporating color, continuous tone images. They are thermal transfer, ink jet and electrophotography.

Color output devices are generally compared in terms of output quality, speed, price and resolution. Another important consideration is what substrates the device is capable of outputting to. The advantages/disadvantages and applications of thermal transfer and ink jet will be discussed in the section below. The second part of this paper gives an in depth discussion of color laser technology and its impact on publishers.

Thermal Transfer

Thermal transfer is not a new technology. It has been used for years in the textile industry to transfer patterns to fabric. There are two types of thermal printers, thermal dye transfer and thermal wax transfer; both types work on the same basic principles. "A donor sheet or ribbon coated with colorants and binders is placed on top of a receptor sheet. The sheet or ribbon has a separate block of color for each color in the subtractive color process—cyan, yellow magenta and black. The two sheets are passed through a pressure roller and a linear array of resistive heater elements (each element corresponds to a single, printable pixel). The number of elements determines the resolution of the printer; it is usually around 300 [dots per inch]. As the writing elements are energized, the colorant transfers to the receptor sheet. Four successive passes of the receptor sheet through the writing station with different color portions of the donor ribbon working creates a full color image."[2]

A significant advantage of this technology over ink jet is that the print heads span the width of the page, letting an entire raster line be printed without moving the print head. Ink jet and dot matrix need to move the print head across the page to print. This requires more complex mechanisms and causes registration to become a critical issue.

Although the principles are similar, the type of colorant, the method of applying color, and the characteristics of the receptor are different for the two types. The differences are explained below.

Thermal Wax Transfer

Thermal wax technology uses a coated ribbon to transfer color. The coating is composed of wax which acts as a vehicle and binder for pigments that are transferred to the paper. This ribbon is sandwiched between the print head, which contains thousands of heating elements, and the paper. Commands from the CPU (central processing unit) or printer turn on and off tiny semiconductor resisters in the print head to melt (and re-solidify) the ink, allowing individual dots to melt the ink onto the paper in the appropriate areas. The paper passes by the ribbon and print head four times, one for each process color.

Thermal wax transfer is a bimodal printing process, meaning that either a dot is placed or it is not. Color is created with patterns of tiny dots. "Control of the heating elements is very important. The semiconductor resistor must be made of materials that heat and cool rapidly. If they heat too slowly they may miss some dots in the pattern, or the printer may work too slowly. If they cool to slowly, retained heat could continue to melt ink an leave errant dots in the pattern. "[3]

"In pigment-based systems, most of the light in the color spectrum is absorbed by the printed surface and the light that is not absorbed (i.e. is reflected) is visible to the eye. "[4] Hence, the range of achievable colors may be limited.

The advantages of thermal wax technology are many. It can use plain paper, although it must be extremely smooth or the image suffers because of the coarse surface. It balances high quality with a reasonable price ($.45-$.60 for paper, $1.25-$2 for acetate). High printing speeds and high resolutions are attainable. The device also offers format and size flexibility. The high saturated color palette can be an advantage or disadvantage depending on the application. The color can also be calibrated very close SWOP standards if need be. SWOP (Specifications Web Offset Publications) is a set of standards for separations, proofing and printing process color.

Thermal wax transfer also has its disadvantages. Resolution is limited by the color and transfer mechanism; that is the number of heated elements needed to transfer the wax. This also causes the technology to have a limited color palette.

One of the biggest disadvantages, however, is the lack of continuous tone printing capabilities.

Other shortcomings include a print head that might have a limited life span and the dithering process. Print heads are expensive to replace. The dithering process used to create shades of color reduces the effective resolution. Dithering is a way of altering the values of adjacent dots to create the effect of continuous tone values. The more dots there are, the greater number of color combinations the printer is capable of creating.

Despite these limitations, thermal wax transfer technology has many useful and practical purposes. It is an excellent way for designers to make colorful, professional comps to show a client, and it is great for in-house production of presentation graphics. Although thermal wax transfer probably won't be used for contract proofing, it can be used for checking color because a close calibration to SWOP standards is possible. The best applications for this technology are those that need fast, high quality reproduction of images containing large areas of color.

Dye Transfer

Thermal dye transfer, sometimes called dye sublimation, is similar to conventional color photographic printing in that it involves chemical reactions between color dyes and coated imaging materials. The technology differs in that it is based on heat, rather than light, sensitivity. Thermal dye transfer is a continuous tone process.

"Use of dyes rather than pigments is a major distinction between thermal dye transfer and other color printing technology, notably wax transfer. Unlike pigment-based systems, dye-based imaging systems allow the light to pass through the colorant, reflect off the printing substrate, and reflect back through the dyes (where unwanted colors are absorbed), resulting in more brilliant colors."[5]

To understand how this process achieves color intensity, the reader might compare the printed dot to a pixel on a monitor. A monitor varies the voltage to each screen pixel to achieve a certain color—the higher the voltage the greater the

intensity of the color. In a similar fashion, the printer produces varying amounts of heat by adjusting voltage to the many tiny resistors in the print head. Ink or dye converts from a solid to a gas when it is heated, hence the name dye *sublimation*. The amount of heat determines how much of the dye is converted to gas and is applied to paper, varying the intensity of the printed dot. Dye released in proportion to the amount of heat results in a continuous tone image.

The advantages of thermal dye transfer are many. The near photographic quality offers a digital option to instant photography. It can achieve a density range that most color printing devices cannot. It can also create multiple color levels per pixel without complex image processing, dithering or halftone screening. This allows the hardware to remain relatively simple. Another advantage is that the dye is not easily scratched or removed because it is embedded into the paper, not left on the surface. Dye transfer devices can be calibrated to SWOP standards.

As in any technology, there are also disadvantages. The chemically-matched receiver sheets make supplies expensive, causing the cost-per-sheet to be relatively high at $3-5 per page. It also limits output size and choice. Images output using dye transfer technology have a tendency to fade when exposed to high levels of heat or light. This is not a new problem, and if prints are stored under the proper conditions, the stability is about the same as a color photographic print. Although the system can be calibrated to SWOP standards, it is difficult to simulate press conditions because colors are not produced with halftone dots. Slow printing speeds, due to dye diffusion rates and signal processing, do not make this technology practical for publishing large volumes of data quickly. Finally, these devices consume much power because the amount of dye that is transferred is dependent on energy.

Despite its disadvantages, thermal dye transfer technology does have some real applications. It is a great tool for video and camera output. It has given artists who create and manipulate images electronically a high quality, relatively inexpensive source for hard copy output. Kodak is using thermal dye transfer to provide thumbnail images with their Photo CD packages. It allows the inclusion of good continuous tone images in presentation graphics. The best applications for thermal dye transfer are those that require few copies of high quality, continuous tone output.

Ink Jet

The concept of ink jet technology is simple. It produces and controls a spray of ink so that it breaks up into droplets to form an image. There are two different types of ink jet printers, "drop on demand" and continuous tone, both are bimodal systems. It is difficult to asses the advantages/disadvantages of each because the devices have such a large range of price and printing quality characteristics.

Drop on Demand

Drop on demand devices have a pressurized reservoir of ink that is held directly behind a nozzle, or orifice. Ink droplets are propelled from a nozzle when an electrical signal initiates the action. These devices are also referred to as conventional ink jet. There are three types of drop on demand printers: piezoelectric, thermal and phase change.

"Piezoelectric is similar to thermal. A small piezoelectric crystal is present in each nozzle outlet. An electrical signal applied to the crystal results in a small dimensional change that creates a pump like action, pushing the ink droplet out of the nozzle and propelling it toward the paper. When the electrical signal is removed and the crystal relaxes, replacement ink enters in preparation of the next print droplet operation. For faster operation, some ink jet printers increase ink pressure with air assists."[6]

Thermally-activated ink jet mechanisms are gaining popularity due to developments by Hewlard Packard and Canon. In these devices, also called bubble jet, "a small amount of ink is present in each nozzle and is in contact with a resistive heating element near the outlet of the nozzle. When an electrical signal is applied to the heating element, a small amount of ink boils and begins to vaporize, creating an ink bubble. As the bubble expands, it pushes ink out of the nozzle and the ink is propelled to the paper. The resistive heating element heats up quickly, expelling the ink droplet within 1 millisecond. As the droplet exits the nozzle, new ink from the cartridge replaces it." [7]

A third variant, solid ink jet, uses a wax-like solid pellet which is melted, expelled as a liquid, and 'frozen' on contact with the paper." [8] Phase change ink

jet is a form of solid ink printing. "The printer holds the inks in the chambers of a heated reservoir, where they remain liquid until a special ink jet print head ejects them onto the paper. The ink droplets solidify almost immediately on contact with the paper due to the temperature differences between the reservoir and the surface of the paper. Unlike liquid inks, solid inks don't wick through the fibers of regular paper. They produce bright colors on a wide variety of paper weights and finishes because they solidify so quickly that most of the color remains on the surface of the paper." [9]

The biggest benefit of solid ink is that, since special paper isn't needed, color can easily and quickly be added to documents on the same paper. It also allows comps to be produced on the same paper as the finished product. This feature makes it more like laser technology than the other categories of ink jet.

Continuous Tone Ink Jet

Direct mail printers pioneered continuous tone ink jet technology, a low resolution process. This class of devices includes the Iris system, which is the first color continuous tone printer.

"The technology operates by forcing pressurized ink into a cylinder through nozzles in a continuous stream of each primary color, producing about 1 million microdots per second. The ink stream is unstable and breaks into individual droplets. The droplets either reach the page in the desired pattern or are deflected into a "gutter". Dots are only about 15 micrometers in diameter, so the multiple microdots are combined to form one dot of the printers standard resolution (e.g., 300 dpi). Because the printer is able to vary the amount of each primary color applied to a dot, it can generate its entire gamut on each dot without dithering. At 300 dpi, the result is near photographic quality output."[10]

Continuous tone ink jet printers such as the Iris are still too expensive for the office environment with prices that range between $75-$120,000. They are being sold to the color proofing market. The quality rivals that of laser technology, but it is much slower.

As mentioned before, the range of price and device characteristics within ink jet technology make it difficult to asses the uses. There are, however, some general characteristics that can be examined. In general, supply costs for ink jet are lower than thermal technology. Typical cost per copy for desktop printers run between $.50-$1.50 for paper and $1- $3 for acetate. There are few hardware limitations to format size, and system costs are generally lower. Since the system puts down all colors at once, there are fewer registration problems than thermal or laser technology.

Ink jet can usually print on plain paper, but in most cases wicking of the ink droplets reduces the crispness of the dots. Coated paper or transparencies have a smooth, non-wicking surface which preserves the shape of the dot and provides the best color quality possible. The exception to this is solid ink which "freezes" on the surface of the paper.

A disadvantage of ink jet is that it is difficult to increase resolution because the technology relies on new variable dot size developments to create shade variations. There is also no way to vary the density of individual pixels.

The third color output device used by electronic publishers is color laser technology. Since it has and will continue to have the greatest impact on the publishing world, it will be discussed in chapter two of this paper.

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[1] Carol Hildebrand. "Color Printer Market Blossoms." *Computerworld*.. 11 November 1991. 4.

[2] Naomi Luft Cameron. *Dye Diffusion: Thermal Transfer Technology*. Datek Information Services. August 1988. 52-3.

[3] Michael D. Nelson. " Hot Colors." *Byte*. October 1991. 178.

[4] Cameron; 18.

[5] Ibid.

[6] A.J. Rogers. "Ink Jet Takes Off." *Byte*. October 1991. 164.

[7] Ibid.

[8] Cameron; 55.

[9] Rogers.; 168.

[10] Rogers; 164.

Chapter II
Color Laser Technology

Chester Carlson invented the Xerographic process in 1938 as a quick, dry process to run on inexpensive office copy machines. Today the process of xerography can be found under the heading of electrophotography. "Electrophotography is a term that evolved in the 1950s to include imaging systems that first create images in charge and then render these images to hard copy images in opaque particles called *toner*, that are fused to paper or film".[11] There are three other technologies found under this heading, Electrofax systems, laser xerography (including laser printers and LED printers) and electrostatic/magnetostatic systems.

"In the mid 1970s, xerography was adapted to non-impact printing by several large companies such as Xerox, IBM, and several European and Japanese firms. In all of the developed systems the image, stored digitally in memory, modulates a scanning laser that exposes the xerographic drum or belt to make hard copy. The process has become known as laser printing, and it is a mainstay of electronic publishing, the printing of multiple-page documents or books without the use of printing presses. "[12]

The Process

There are seven basic steps to color laser technology; charging the drum, exposing the image, developing the image, transferring the image to paper, fusing, cleaning the drum and erasing the electrostatic image. These steps are the same for monochrome or color printing and are explained in further detail below.

1. Charge

The first step in the electrophotographic process is to distribute a charge across a photoconductive surface such as a drum or belt. "A photoconductor is a material that is an insulator in the dark, and becomes a photo-induced charge generator or

conductor in the light."[13] This charge is usually generated using a corotron, a thin wire that has an large electric field around it. The field produces ions that move from the wire to the photoconductive surface, leaving a charge upon the surface.

2. **Exposure**

This step involves removing the charge from the non-printing areas (white areas) using a laser or other light source such as LED or liquid crystal shutters. "As the drum rotates, the scanning prism mirror rotates to focus laser pulses through a cylindrical lens and onto the drum. The charge is stripped away where the light hits the drum, creating a latent image." [14] The exposure process works very much like film which is exposed to light and then developed with chemicals.

"The role of exposure is to transform an optical input image from some source that is to be copied into an input exposure onto the surface of the photo conductor. The exposure subsystem includes both the exposure source and the optics required to provide a focused image of the input document. Sometimes the input image is an original that is located digitally in a computer. This is the case for all computer output, whether it be from mainframe or a microcomputer with a word processor. For this type of input image, the input exposure is by a laser that scans across the photoconductor's surface and writes the electrostatic image through pulse modulation directly on the surface of the photoconductor."[15]

3. **Developing**

After exposure, the latent image is developed into a real image using toner particles. Toner got its name because it develops or "tones" the latent image. The exposed portions of the drum, which now carry an electrical charge, attract toner to the drum. Toner is attracted to the charged areas only.

Development systems are classified by the method in which toner is transferred to the latent image. "These methods include powder cloud development, liquid or electrophoretic development, two component magnetic brush, or single component development."[16] Although the development system may vary from machine to machine, the basic principles are the same. Most publishing systems use single component development to transfer toner to the latent image.

Color laser printers use a four chambered developing unit that holds plastic toner particles; each chamber has a different color. The four colors, cyan, magenta, yellow and black, are the same four subtractive colors used in the traditional printing process. "The xerographic process require the use of developer materials that exhibit a precise balance of chemical, mechanical, physical and electrical properties matched to the machine that is designed to develop the latent image. This balance becomes more delicate as machines increase in speed, and as copy quality becomes more important."[17] Consequently, toners are developed specifically to match the needs of a particular system.

Toner particles are charged pigment polymer particles that contain two main ingredients, a thermoplastic and a colorant. The amount of charge the particle carries is determined by the chemical structure of the polymers. Other ingredients such as the polymeric coating on the carrier beads, and charge control agents can also affect the amount of charge a particle contains.

Thermoplastic is chosen primarily for its fusing capability; its role in the toner particle is to help fix, or fuse, the image. Cost, charging capability, toner processing and system compatibility are other factors that determine the type of thermoplastic a toner contains.

The amount of colorant in a toner is also influenced by the needs of the system for which it is being designed. Some factors considered are contrast, density and charging requirements. Colorant can be a pigment, a dye, or a mixture of the two. "The colorant for black, the most widely used toner, is usually carbon black particles that are finely dispersed in the bulk of the thermoplastic."[18]

4. Transfer

"Transfer is accomplished by placing the paper in contact with the image and corona charging over the paper with the same polarity ions used to charge the photoconductor. If this field is intense enough, it will break the adhesive bond between the photoconductor and toner. The toner will redeposit onto the paper. Transfer can also be accomplished with biased pressure rollers."[19]

5. **Fuse**

A permanent image is created on paper when the toner is fused to the paper or film. This is accomplished by using heat, pressure or a combination of the two. The temperature and pressure is dependent on the throughput speed and the chemical components of the toner.

6. **Clean**

"Cleaning is usually performed by a electrostatic brush. This brush is then cleaned by a vacuum system using a wiper blade that lifts and transfers the toner from the surface of the photoconductor."[20]

7. **Erase**

A discharge lamp bathes the surface of the drum to ensure complete removal of any residual charge left by the electrostatic image.

Manufacturers of Color Laser Printers

Most companies are hedging the commitment to color laser technology, but there are a few companies that have taken the initiative and have products currently on the market.

Canon

Canon is the original player in the laser color printer market and, until recently, the company has been without any serious competition. The Canon CLC 500 is a 400 dot-per-inch color laser printer that makes plain paper copies or transparencies at letter, legal or 11x17 sizes. It acts as a color flatbed scanner, and it can scan slides with the correct attachments. It also allows the user to manipulate colors and images.

The CLC 500 uses a multipass indirect electrostatic process—one pass for each process color, to print CMYK on plain paper. It uses a microspot laser to create a latent image on a charged photosensitive drum. "In a timed sequence, the toner is transferred to the paper one color at a time, as it makes a figure eight around the photosensitive drum, and around a transfer drum for each color. After all

four colors have been laid down, the paper passes through fixing rollers where heat and pressure is used to fix the color."[21]

"Canon uses the same color laser engine in both the copier and the laser printer. To convert the copier into a laser printer an Intelligent Processing Unit (IPU) is needed. This IPU expands the copier's memory from 12mb to 24mb, provides it with more complex image editing capabilities and allows interfacing with other electronic devices."[22]

There are currently three IPUs on the market. The IPU-48, which is a general purpose interface bus. This model is priced between $7,000-$25,000 and is not Postscript compatible or suitable for networks. It does however, produce continuous tone images. The second model, the PS IPU includes a Postscript language interpreter. It will operate on a network but supplies only halftone to the printer. The price is $15,000. The third IPU is currently the only option if you need both Postscript and continuous tone output; it is EFI's Fiery controller. Although it has ethernet and localtalk networking capability built in, it is expensive at $35,000.

Xerox

The Xerox 5775 has technical features similar to the Canon CLC 500. Each color in the document is imaged to the photoreceptor separately, then offset to a transfer roller which transfers the complete image to paper at the end of the cycle. Both machines attain resolution of 400 dpi and store 8 bits, or 265 levels of grayscale information.

The Xerox and Canon machines offer the same basic features in size, image and document manipulation features. The 5775 uses the same technology for copiers and printers. Xerox is currently in partnership with EFI to develop a specialized fiery controller.

There are three areas in which Xerox claims its system to be superior to the Canon: performance, operating cost and reliability. The 5775 can run 7.5 copies per minute (cpm) while the Canon only 5 cpm. Operating cost is cheaper per copy, but supplies for the 5775 have not been priced. Thus, it is hard to determine

just how much less expensive. Xerox claims that its system is three times more reliable than the Canon, but no real numbers substantiate these claims.

Colorocs

The Colorocs CP4007 is a 300 dpi color laser printer. Although it has a lower dpi resolution, it can produce 40 copies per minute, versus 10 for the Canon. Another advantage is that it is priced under $30,000, including the Postscript interface. On the down side, this system does not offer grayscale printing.

Unlike the Canon, Colorocs uses a separate engine depending on whether the system is being used as a copier or laser printer. The printer already has everything it needs to interface with a computer, including a Postscript-compatible color controller. Unlike the Canon, this system uses a single pass process with two flexible belts to transfer the image to paper. The print head uses a LED rather than a laser. An LED is an array of light emitting diodes. It exposes the image on the photoconductive surface by emitting bursts of light from each site on the array. It differs from a laser in the fact that works as an array rather than a single beam of light. "LEDs are asynchronous and can accurately and quickly control color placement."[23]

This printer is also different in that it transfers the image to paper by way of a transfer belt. Transfer takes place using a combination of pressure and voltage. "When the image is complete (i.e., all four CMYK colors have been laid down), the transfer belt puts it to paper in one step. Then fusing rollers combine heat and pressure to fuse the image to the paper. The use of a transfer belt as an intermediate surface enables the paper to make a short straight pass through the printer: from the paper tray, past the transfer belt, through the fuser, and out."[24] The single pass to paper process solves the registration problem, helps avoid paper jams and allows use of a wide range of paper.

Kodak

So far, Kodak has been a minor player in the color electrophotography market. The company does have one applicable product, the Coloredge LED printer. Coloredge prints 17.5 color pages per minute and is designed to handle 10,000-30,000 color pages per month. It is priced at $100,000-$150,000. Kodak has found that Coloredge is too fast and too expensive for the general market. It is using the

engineering information to develop future products, possibly in conjunction with another vendor (Canon).

The Problems

Before color laser printers become commonplace, there are some problems that need to be worked out. Some of these problems are specific to the technology and some are issues which challenge users of any color output device. Color laser technology is a much more complicated process than the monochrome version. There are several factors which have held it back from being an readily accepted means of output.

Price: The color laser printers, most of which are off-shoots from color copiers are currently priced between $30,000-70,000. In some cases the computer interface is an additional $30,000. Many experts agree that in order for color laser technology to be competitive in the U.S., prices have to drop below $10,000.

Registration: In monochrome laser printers, the paper only makes one pass through the machine and the job is done. With color, the process is more complicated. Each color must be laid down separately, and registration is critical. Putting four colors on paper using laser technology is not an easy task, and no one has mastered putting all four colors down in a single pass. Each time the paper is passed through the machine, there is a chance for registration to be off.

Contamination: Color contamination is also a problem. In a multipass situation, the toner is not fixed to the page until after the transfer is made. Four different toners can fall off or move around on the page. Although not everyone in the industry agrees that contamination is a major problem, Warren Nicalson of QMS, Inc. believes that contamination is one reason we are not seeing a lot of color lasers. He explains that "toners have some magnetic particles of developers in them. When the developer extends a toner brush, the toner itself is supposed to be electrostatically charged but magnetically neutral. There are however, some impurities, and when these particles intermix, they contaminate each other."[25] Contamination causes colors to shift and print quality to soften or bleed.

Duplex printers: Currently there are no color laser printers on the market that can print on both sides. The 4850 from Xerox corporation will do black plus one

color on both sides, but this is not a four color process. Xerox claims that the 5775 can be run through a monochrome laser printer and then through the 5775 without harming the machine. Canon says that duplex printing on their machines is sure to warrant a service call. All the major players realize the importance of this feature to the publishing industry, and they are working on the problem. Industry sources believe that Canon is due to announce color laser printers that have better quality, larger paper sizes, and duplex printing.

Competition from other technologies: Currently one of the biggest reasons that color laser technology has not taken off is the competition it is getting from other, more affordable technologies. Devices such as the Tektronix Phaser III PXi, have made affordable, high quality output a reality. As the market continues to mature, there will be more plain paper output devices to compete with laser technology.

The Possibilities

Continuous tone quality, speed, and low cost per-page make color laser technology very attractive to those who rely on color to convey their messages. Below are a few applications that would benefit from this technology.

Color documents

Traditional items , such as documents or instructional diagrams, can be much more effective when color is added. Until now, most of the affordable technology used special paper. The inclusion of color pages in multiple copies of a document was just not time efficient. All of the color laser printers on the market use plain paper and include typical copier features such as sorting. A color section can be added to a document quickly and efficiently without interrupting workflow.

On-line information

Today many people depend on on-line information, CD-ROM, or periodicals for research. Computer Select, a database that deals with the computer industry is a good example. At RIT's library, Computer Select is attached to a dot matrix printer for output of user-selected documents. Many of the articles included on the compact disk discuss color issues, working with color on the computer, or include color diagrams and side-bars. Currently, viewers get none of the diagrams or pictures—just text. But often the colorful diagrams are an important

aspect of the story. If the computer were attached to a color laser printer, a person could choose to pay for selected color items.

Textbooks on demand

Imagine a professor teaching a class in electronic publishing. The professor has a difficult time getting current textbooks to use because the information and technology is changing faster than authors can produce. Many of the books might handle only a few areas well, others not all. The professor constantly stands at the copy machine duplicating articles for students and wonders how far the 'for educational purposes' clause can be stretched.

Well, what about textbooks on demand? The role of large publishers may be changing to that of information manager. Professors may soon call to create customized books. Pull chapters from respected books; add articles from periodicals or journals, and add lecture notes. The publishing house takes care of all the legal and financial issues. The publishing company also has the responsibility of gathering and assembling the information in a final format (picture and graphs included). The new books can be updated without much effort.

Now imagine a student who has just walked into the college bookstore to purchase books for the semester. On the shelves are a few books, but the student goes to the information counter. The person behind it enters a course number into a computer and, a few minutes later, comes back with the requested text. The book has only the information specified by the professor, and it contains all color pictures and graphs.

The student benefits because the text costs much less than buying many books separately. The bookstore is happy because it does not have to order, ship and store many books it might not sell. The publisher profits from not carrying the more extensive overhead of publishing and storing books. Environmentalists approve because the process wastes less. Some of the big textbook companies, such as McGraw-Hill, Inc., Houghton -Mifflin company and Addison-Wesley/Benjamin-Cumming are already experimenting with this technology.

Real estate sales

Xerox uses an example of how color laser printing technology could change the way we buy houses. Today there are many "home" books sold or given away that contain listings for hundreds of homes. These books are mostly black and white newsprint, have terrible quality and few pictures. It is difficult, if not impossible, to find a house through these listings. Xerox envisions that in the future, house-shoppers will walk into a realtor's office, give the specifications of an ideal house (i.e.: price, location. number if bedrooms, etc.) Later that day, or the day after, the house hunter might receive a book that includes only the houses meeting specifications. On each page, the book will have a small color picture of the house, a map of the city showing the location and the important specifications for the house. All of this information is available today from commercially-bought databases. It might not be the realtor who assembles the books but a small publisher, endowed with color laser printing technology, working for several realtors.

Personalized greeting cards/ invitations

Customers walk into their favorite card shop. There are no racks of cards, just a kiosk (an electronic information device similar to a bank machine or the interactive information centers you find in the grocery store) in the corner. They walk over and flip through an electronic picture library to find the right image for a custom-made card. Perhaps one customer brought a photo from home. In that case, the photo is placed on the glass bed of the machine, just like a conventional copier. The customer then chooses a joke, poem or sentimental message in the kiosk's database. The customer might even select a typeface. After the appropriate address has been entered, the kiosk delivers a colorful, personalized greeting card complete with addressed envelope.

Resumes and Portfolios

Creative people, such as artists, photographers and illustrators, have always found the dissemination of portfolios to be a difficult and expensive process. Many times they find it hard to accurately describe their style or talent in words. Promotional pieces, while effective, are expensive to produce and do not allow for much customization targeted toward each potential employer. Color laser technology will allow inexpensive, customized portfolios to be created and sent

to prospective clients. If recipients like what they see, they can send for originals. Artists might also create resumes that reflect the style of their work.

Electronic thumbnails

Anyone who has worked extensively with electronic images knows how frustrating it can be to remember what each image on the disk looks like, let alone the subtle differences in each. With color laser printers, photographers using this medium can quickly make a contact sheet that has a thumbnail rendering of each image. This would save much time flipping through files.

MacTees

One company, Graffoto, has introduced a new product that allows for the printing of t-shirts from images created on the computer. The product, called Paro, uses a special paper for transferring images from the Macintosh to fabric by way of a color laser printer. Images are not limited to solid colors; color photographs may be used. The image is printed on the Paro paper, then transferred to fabric using a heat press. This allows for personalized or short run t-shirts. It even provides for proofs without beginning the silk screen process. Currently the Paro paper is only available for the Canon CLC, but Graffoto is also developing it for the Xerox 5775.

Personalized children's books

The personalized children's book industry is a ten million dollar industry. These books are currently being created and sold by franchises that own little more than a computer and monochrome laser printer. Pages which are pre-printed with the books' illustrations are run through the laser printer to add personalized text. Using color laser technology, it might be possible to create books that are personalized in both text and graphics. Printing would be accomplished on a color laser printer. This idea is discussed in depth in the following section.

Although color laser devices offer high quality color output, high quality is a relative term. The technology does not rival what is possible with traditional printing methods and for many applications will not be acceptable in terms of color balance and resolution. Some applications that will continue to be reproduced using traditional means are coffee table books, large consumer magazines, and high-end advertisements. Color laser technology will find

opportunities in office documents, short print runs, customized information and a variety of other applications. There are many great business opportunities for creative people, one of which is emphasized in the next section.

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[14] Ben Smith. "Printing With Electrons". *Byte*. October 1991. p.185-192.

[15] Neblette; 139.

[16] Neblette; 138.

[17] Neblette; 163.

[18] Neblette; 178.

[19] Neblette; 139.

[20] Ibid.

[21] Jane Morrill Tazelaar. "Color Laser Printing." *Byte*. October 1991. 154.

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Chapter III
Personalized Children's Books

In the late 1970s, personalized children's books began to enter the market. At that time, they were sold exclusively by one publisher, ME-Books Publishing Company and were purchased through mail order only. Within five years, over three million books had been sold. This is an excellent example of a successful publishing venture that took advantage of new computer and printing technology.

ME Books Publishing is no longer in business. But today, an individual can buy a similar franchise for around $2,000 dollars and publish personalized books at home using a personal computer. The first books were soft cover and were produced using dot matrix printers. In 1986, consumers saw the first hardbound children's books produced with laser printers. This was also the beginning of the "books while you wait" trend. Typical book pages are pre-printed by the parent company using traditional methods; customized text is added at the franchise level by running printed pages through the laser printer. The production cost per book can be as low as $2.15 while they usually sell for over $10. Profit margins on these books remains high.

There are three groups of purchasers of children's books; professionals, adult consumers and child consumers. These books would be marketed towards the adult consumer and due to price, would most likely be bought as a gift for the child. According to the *1990 Study of Media & Markets*, published by the Simmons Market Research Bureau, Inc., most purchasers of children's books are white females between the ages of 25-34. They are employed full-time as professionals or managers and have an average household income of over $30,000. Most often, they are married or are a parent.

Market Size

Children's books are reported to be the fastest growing segment of the publishing world. Record high growth rates in the 1980s have resulted in the emergence of many retail stores specifically devoted to children's literature. *Book Industry Trends*, published by the Book Industry Study Group, reported that juvenile books accounted for $1.941 billion in 1991. This figure is expected to rise to $2.54 billion in 1992, and $3.08 billion by the year 1995. According to the Children's Book Council, over 5,000 new children's titles are published annually. Some factors that have helped spur the growth of the children's book market are the coming of age of the national campaign for literacy and the maturity of the baby boom generation.

According to the US. Department of Education, school enrollment for children grades K-8 is projected to rise from 34.040 million in 1991 to 35.123 million by the year 1995. There are more than 38 million children in the U.S. between the ages of 2 and 11, with more being born every day. All of the relations and friends of these children are potential customers.

Competition

Children's books with personalized text and graphics have only recently become feasible due to electronic publishing technology. Advances in color output technology have only recently made it possible to print short run documents and books in color at a reasonable cost per page. For this reason, there is currently no direct competition for this product. The closest competition would be books that are personalized in text only, personalized audio tapes, and books with photos pasted in.

> **Personalized books** are currently using traditional printing methods to produce the illustrated pages (minus text). These pages are then put through a laser printer to add the customized story. Production time for each book is down to 5-10 minutes, making profit margins high.
>
> **Personalized audio tapes** are not made for each individual child, but are pre-made for a list of popular names. If a child's name is on that list, then

parents can order a tape. Currently there is no way to get a customized tape for a child with an original or ethnic name.

Pasted Photos. The final group of books are those which most closely resemble the suggested product in concept. They personalize the illustrations by pasting a picture of the child in the last page of the book. A hole is then cut through the pages so that the child's face appears on each page of the book. Illustrations are designed around the hole in the book. Books are printed in a traditional manner and the personalization is done by the adult purchasing the book, not the publisher. There is no personalized text. Although there are books on the market that are trying to customize the picture within the books, they are not being sold as true personalized copies. The purchaser of the book must do the personalization.

There are currently only eight companies producing personalized children's books. These companies have between 2,500-3,000 franchises. The trend within franchisees is to expand product lines by offering other personalized products. Examples of some of these products are stationary, calendars and audio tapes. Although most of the companies offer an additional personalized line, personalized books are still the major product and money maker.

The Product

Children's books are most often characterized by age group since it is the best indication of comprehension level, reading ability, and interests. Typical age divisions are: young childhood (age 2-7)
middle childhood (ages 7-11)
older childhood (age 11 and older)

Young childhood, the group most likely to be readers of these books, can further be broken down into pre-readers (ages 2-4) and beginning readers (ages 5-7). The latter group of readers is the group for which these books will be written and marketed. These children prefer picture books with strong story lines, character development, simple vocabulary, and short sentences. Preferred subject matter ranges from action to humor to the world around them. Competition for the leisure time of children of this age level is immense. TV, video games, computer

games and sports are much more attractive and stimulating to someone of this age. Constant interaction with these media has caused children to become much more sophisticated at a younger age. They are often not interested in ordinary books, and need additional stimulation in order to get them to pick up a book. Personalized books encourage kids to read.

The second part of this project involved the creation of a personalized children's book. The purpose of this book is two-fold— to act as a vehicle through which technical problems of publishing with a color laser printer can be explored and to investigate a business opportunity that could apply traditional publishing concepts to new technologies.

This book is personalized in both text and graphics using color laser technology as an output device. Photographs, illustrations and text are my own, with the exception of the astronaut page which includes parts of images from NASA. It is a book written and produced for the beginning reader, ages 2-8. The story is about occupations, and has a "When I Grow Up..." approach. Each page features a different occupation such as a teacher, an astronaut, a fishing person, a business person, a doctor, a weather forecaster, or a veterinarian. Master or background images were created in Photoshop™. These images include a background and the body of a person wearing the traditional dress of that occupation. Personalization took place by adding the head of the child to the bodies on the master page. Illustrations will be designed so that family snapshots or school pictures can be used for personalization without much individual manipulation.

The book is 6x9" and is created using six 8.5x11" sheets of laser paper. It has five illustrated pages, six pages of text and a title page. Many of the books currently on the market use odd sizes or 11x17" sheets that are folded in half. Color laser technology is too expensive to make large sizes cost effective. It is difficult to map out an exact process for this type of book as of yet because it is not yet feasible to make one using current technology. The easiest way would be to create and print the book in actual page spreads. Whether or not technological advances will accommodate that is yet to be seen.

Problems

Two of the problems I ran into in completing this book were how to account for different ethnic backgrounds, and using images that have different "uniforms" for men and women. The books on the market that personalize the story by pasting a picture of the child on the last page make no provisions for children with different ethnic backgrounds. The body parts that are included in these books, such as hands and necks, are always Caucasian. This problem can be solved two different ways with a color laser printer. Several different versions of the book can be created, each featuring a major race or skin color, or different skin colors can be saved electronically and painted on the necessary areas. The first solution is the most time efficient, the second takes less storage space. The best answer however, is to avoid showing skin, by using gloves, and generic clothing.

The second concern was how to account for occupations in which men and women dressed differently, such as business people and teachers. The only solution was to keep two different pages on file, one for each gender.
Other issues I came across are general problems that electronic publishers struggle no matter what the output device. A few are explained below.

Input

One product that is sure to have a large impact on the way we view and use color is Kodak's Photo CD technology. Due to be officially released this summer, "Photo CD instantly solves the resolution and storage problems of working with color images. With its release, it is instantly putting 250 million (the number of 35mm cameras currently in existence) new input devices into the world."[26] Now anyone, without the cost of expensive scanners and storage devices, will have access to high-quality color images for a low price. Scanners often give people who are not accustomed to working with them unsatisfactory results. Photo CD will eliminate the need for many publishers to buy and learn how to operate scanners. The Photo CD technology will be able to be played on any CD-ROM expanded architecture-compatible (XA) drive.

File size versus resolution

One problem that all people working with color images face is that of large file sizes needed for quality output. Resolution of the input device, such as a scanner, is critical in understanding file size.

Resolution can be broken into two major components, spatial and tonal resolution. Spatial resolution describes how the image is divided into pixels (picture elements) and, in this case, describes a two dimensional space with a fixed height and width. The finer this resolution becomes, the closer to the original scene it is. In other words, at a constant size and viewing distance, a 1024 x 1024 image is finer than 512 x 512 because there are twice as many pixels in the same space. The 512 x 512 resolution is the current standard for television equipment in the U.S. Image processing equipment, such as still video cameras, work at this resolution.

Tonal resolution refers to the depth, or number of bits of color or grayscale information, of the pixel. Is it 8-bit or 24-bit color? For example, line art is often one bit deep (pixels are either black or white), grayscale is usually 8 bits. Color photographs displayed by a computer monitor are usually done so at 24 bits.

"Because raster images are resolution independent, if you re-size an image you effectively change the spatial resolution. It works like this: say you scan at eight dots per inch and blow that image up to twice the size so that what was one inch is now two inches. If you have eight samples in an inch before sizing, you now have eight samples in two inches after sizing. Eight samples in two inches means that your spatial resolution is now four dots per inch. Resizing only effects spatial resolution, not tonal."[27]

The formula below will help the reader find the effective spatial resolution:

Initial spatial resolution/Sizing resolution = Effective spatial resolution

The object is to keep the file size as small as possible without sacrificing final output quality. Sometimes it is necessary to keep the file small enough to fit on a particular storage device. A double density disk will hold about 800K of information while a high density floppy disk may hold up to 1.4mb. Removable

hard disks will hold between 40-90mb depending on the particular drive and cartridges you are using. These are the most common forms of storage at this point.

"File size can be determined by the following formula:

(Tonal resolution/8) x (Spatial resolution)^2 x (Dimensions) = File size (in bytes)
(in bits/pixel)

If you take the tonal resolution (in bits) and divides it by eight, the resulting number shows **bytes per sample**; squaring the spatial resolution gives the number of **samples per square inch**. If you multiply samples per square inch by the number of bytes per sample, the number of bytes in a square inch is found. If the reader multiplies that by the **size of the job in square inches**, the total **number of bytes in a job** may be found. Divide that by 1,024 to get kilobytes or by 1,048,576 to get megabytes."[28]

As an example, the reader might find the file size of an 24-bit, 300dpi, 8" x 10" image.

$$(24/8) \times 300^2 \times 80/\ 1{,}048{,}576 = 20.59\ M$$

Below is a chart of some common photo sizes and corresponding file sizes at different resolutions: All images are based on 24-bit color images.

Resolution	Dimensions					
	1 x 1.5"	**2 x 3"**	**3 x 5"**	**4 x 5"**	**5 x 7"**	**8x10**
75 dpi	25 K	99 K	248 K	329.6 K	576.8 K	1.3 M
100	44 K	176 K	440 K	585.9 K	1.0 M	2.3 M
150	99 K	396 K	989 K	1.3 M	2.3 M	5.2 M
200	176 K	704 K	1.72 M	2.3 M	4.0 M	9.2 M
300	376 K	1.55 M	3.86 M	5.2 M	9.0 M	20.6 M
400	704 K	2.75 M	6.87 M	9.2 M	16.0 M	36.6 M

Referring back to the children's book, the electronic storage of several versions of each book, to accommodate gender and race, requires much storage space.

Keeping resolution and file sizes as low as possible is important when designing and planning a book or any other document.

WYSIWYG Color

Getting the color you see on your screen to reproduce the same in a printed piece is a problem that plagues all electronic publishers, no matter the output device. Although exact color may not be very critical for presentation graphics or simple color highlights, it is usually important when working with color photographs.

The reason that it is difficult to get the screen image to match the printed piece is that monitors and printers use different methods to generate their colors. Color can be produced by light that is transmitted through an object or reflected by a surface. Monitors mix red, green and blue light to show color. This is called additive color theory. A computer monitor has a coated surface with three different phosphors that glow either red, green or blue when struck. When one combines the three additive colors in equal amounts, white results (or a shade of gray, depending on the brightness). A television set works in a similar way.

The second way of mixing color uses reflected light; it is called subtractive color theory. This deals with the pigments cyan, yellow and magenta. These pigments are used to subtract, or filter out, a portion of the white light that is reflecting off the subject. In theory, equal amounts of these three colors prohibit any light from being reflected, yielding black. In reality, the color produced is a muddy brown due to imperfect light filtering properties of these ink pigments. This is one reason why process color uses a fourth color, black.

Because of the fundamental differences between additive and subtractive color, images must go through a transformation process in which RGB values (from a computer monitor) are converted into CMYK values (for the printed version). Often information is lost or mistranslated during this process. Another problem is that printers, due to limitations in color gamut, cannot reproduce all of the colors seen on the screen. Color gamut is the range of colors that a device can produce. When an image is printed, RGB values (additive color), which are not easily converted to CMYK, must be mapped to the closest match in the device's

subtractive color gamut. This results in printed hues that appear different than those on the computer monitor.

Another problem with matching monitor to paper is that all monitors are different due to calibration (adjusting the "color" of white, red, green, and blue), age and make of monitor. There is calibration software on the market, but even that cannot ensure even, consistent color.

The best way to achieve accurate results from screen to paper is by calibrating a monitor to a specific output device. This can be done through most of the paint programs on the market, such as Adobe Photoshop. Each program handles this procedure a bit differently, so it is best to follow the user manual's instructions. Doing so enables the user to calibrate the monitor so that printed output on a given device yields hues that appear as they do on the screen. The monitor is adjusted to look like the printed piece so that it can be used to judge printed output.

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[26] Stephen Stepnes. "Solving the Picture Puzzle: Kodak's CD System." *Desktop Publisher's Journal.* February 1992. 20.

[27] Jim Hamilton. "Scanned File Size." Technical Information from Linotype Company.

[28] Ibid.

Conclusion

Color output technology has come a long way in the past few years. The number of companies committed to developing technology and putting new products on the market will ensure many changes in the future. If presentation graphics or a splash of color in business documents is all that is desired, there are affordable devices on the market that can handle these applications well. If plans for a color output device involve the inclusion of color photographs, then maybe investment in a color printer should wait. Although there are printers on the market that can handle this need, in most cases, prices are still high and important features still missing, to warrant making the investment. Those businesses that can sit back and wait until new devices hit the market should do so. The next two years will bring improved color output quality and lower prices as well as high resolution and near photographic quality output below the $10,000 mark.

Although it will be some time before color laser technology falls below $10,000, it offers many opportunities for those involved in publishing. Traditional publishers now have a way to expand business into the short run, on-demand market. Using color laser printers, businesses can include color photographs and illustrations in documents quickly and efficiently. Finally it offers opportunities for business ventures never before possible. The possibilities with color laser technology are only limited to a person's imagination and enthusiasm.

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