1
The evolution and progression of digital printing of textiles

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1.1 Introduction

The saga of digitally printing and dyeing of fabrics, yarns and garments involves a past of a few decades, a dynamic present and likely a bright future. This introduction accounts for the origins and evolution of textile printing to digital solutions. It identifies some of the many creators and pioneers of these technologies and assesses their impact on the textile printing industry. It discusses a few of the false starts that in turn contributed to sustained successes of digital printing technologies for textile decoration. It uses the exhibitions that have witnessed the introduction of innovative digital technologies for textile printing as road marks that indicate trends and point the way to digital textile printing's bright future.

In focusing on the market demand for textile printed applications, it attempts to answer questions such as:

- What are the market forces driving the adoption of digital technologies for printing textiles?
- What are the characteristics and qualities of digital printing that either favor or discourage its adoption for meeting market demand for decorated fabric and fibers?
- What are textile applications that digital printing can supply more cost effectively than existing analog printing methods?
- How is technology evolving to address market demand?
- What are the global trends that shed light on the future of digital printing of textiles?

This chapter opens the door and invites the reader into the exciting world of digital textile printing. It introduces this volume's tour of the many chambers of the digital textile print edifice that subsequent sections describe.

1.2 The origins of digital textile printing technologies

An early example of textile printing is found on a block-printed tunic dated from the fourth century CE.[1] Evidence suggests that carved block printing, also known as xylography, originated about the fourth century in China and initially found use in printing textiles and short Buddhist texts that believers carried as charm protection.[1,2] Sui emperor Wen-ti ordered the printing of Buddhist images and scriptures in an imperial decree of 593. The British Museum houses the oldest known block-printed book, the Diamond Sutra, dated 868 CE from Dunhuang, China. Block printing of textiles began to flourish in Surat in Gujarat (India) during the twelfth century for the printing of wall hangings, canopies and floor spreads.[3] The printing of textiles spread around the world along the Silk Road and through the spice trade.

While we can only infer the origins of textile printing from the few artifacts that have survived, digital printing evolved in an age of record keeping. In 1686, Edme Mariotte suggested the basis for inkjet printing with the publication of his seminal work on fluid dynamics, 'Traité du movement des eaux et des autres corps fluids'. It included observations on drop formation of fluids passing through a nozzle. Ebenezer Kinnersley added to this foundation when he demonstrated that electrical current could pass through water in 1748. During the following year of 1749, l'Abbé Nollet examined the effects of static electricity on the flow of drops from a capillary tube. Lord Kelvin (Sir William Thomson) received the first patent for an inkjet printing system in 1867, 'Receiving or Recording Instruments for Electric Telegraphers'. Eleven years later in 1878, Lord Rayleigh (Sir John William Strutt) described the role of surface tension in drop formation. The 1920s and 1930s witnessed patent applications and issuances for inkjet recording devices, including notable inventions from Richard Howland Ranger and Francis G. Morehouse in 1928, Clarence W. Hansell[4] for an electrically charged recycling device in 1929, and Kurt Gemscher in Germany in 1938.

During the same year, 1938, Chester Carlson invented analog electrophotography in Astoria, Queens, New York. It took Carlson and his subsequent partner company Haloid over 20 years and a few intermediate steps along the way, such as the Haloid A1 in 1949 and Copyflo in 1955, to deliver a successful office plain paper copier with the Xerox 914 in 1959. The A1 failed for the purpose that Haloid intended it as an office copier, but succeeded as a plate maker for commercial printing. Digital laser versions of electrophotography produced transfers in the 1980s to decorate fabrics, particularly T-shirts and other sewn garments and accessories. Researchers at Georgia Tech and North Carolina State University investigated the feasibility of printing fabric with electrophotography with some success.

In 1959, the Research Labs of Australia began exploiting its invention of developing electrostatic images with liquid toners. Xerox and others developed a similar liquid toner variation on electrophotography for wide format printing, electrostatic printing. In 1979, Xerox introduced its 2080 engineering copier. Xeroxcolorgrafx, Raster Graphics, 3M, Nippon Steel-Synergy Computer Graphics, Calcomp, Silvereed, Phoenix Precision Graphics and others advanced this technology with the development of E-stat printers during the late 1980s and 1990s. Almost all of these companies have discontinued production of their electrostatic printers. Only 3M of St Paul, Minnesota, USA, currently supplies and supports an electrostatic printer, the Scotchprint 2000. Hilord supplies both pigment resin and sublimation dye toner for electrostatic printers. Beta Color of Ontario, California, and others have developed processes for using Scotchprint 2000 for cost-printing polyester and Nylon 6.6 fabrics with sublimation toners.

In 1949, Elmquist applied for a patent for 'Measuring Instrument of the Recording Type'. Two years later in 1951, Siemens released the first commercially produced inkjet printer based on the Elmquist patent, the Elema Oscilomink. Carl Helmuth Hertz and Sven Eric Simmonsson applied for patent on high-resolution continuous inkjet in 1965. This invention and other inventions of Dr Hertz and his colleagues at Sweden's Lund Institute of Technology led to the development of the Stork and Scitex Iris proofing systems. This type of continuous inkjet technology features mutual charged droplet repulsion that produces very fine ink droplets at a very high frequency. It can produce high apparent resolution images with many gray or halftone levels. It suffers, however, from slow print production speed, a slight background from stray droplets, and the complications inherent with recirculation of unprinted toner drops. This process uses dye-based colorants that lack the level of permanence that pigments provide. The textile and fashion design industries have used these systems since their introduction. Stork also developed a successful proofing system for the commercial print industry in conjunction with DuPont.

In 1967, Professors Sweet and Cummings of Stanford University in California applied for a patent on a binary continuous inkjet array. In 1968, printer manufacturer A.B. Dick commercialized Sweet's invention with the Videojet 9600. This device launched the marking and coding industry on its digital path. While early applications of this technology were primarily for coding cans, containers and other packaging, it was capable of marking fabric as well.

1.3 Digital carpet printing

In the early 1970s, Milliken of Spartanburg, South Carolina, USA, developed a digital carpet printer, which it launched in 1975 as the Milliken Millitron. This device fires continuous streams of dye from an array of nozzles along the full print width. Targeted streams of air deflect drops that do not contribute to the image are recycled. Undeflected drops continue on to strike a web of white carpet. Milliken advanced this technology from its early 10 dpi resolution to over 70 dpi. In 1976, Zimmer announced its carpet printer. Today, most printed commercial carpeting is digitally printed.

1.4 Sublimation

In 1973, RPL Supplies Inc., a company now in Saddle Brook, New Jersey, USA, developed a process for transfer printing digitally generated video images to fabric. This company and others developed this process with impact and thermal sublimation dye ribbon for use in customizing and personalizing gifts and promotional products.

1.5 Thermal inkjet and textile printing

In 1977, Canon's Endo discovered the principle of thermal inkjet when placing a flame on the side of a pipette containing liquid that then emitted a drop of that liquid. Soon after, researchers at Hewlett-Packard encountered a similar phenomenon. Canon and HP applied these discoveries to the development of thermal inkjet print heads. Canon called its version 'Bubble Jet'. In 1984, HP introduced the first commercial desktop inkjet, the HP Thinkjet. Canon's Bubble Jet office printer followed in 1985 with the introduction of the BJ-80. Canon and HP licensed their inventions to each other and to other manufacturers, including IBM, Siemens, and others. Lexmark took over the IBM license when it purchased IBM's printer division. Canon developed a Bubble Jet textile printer in the mid-1990s that printed fabric up to 1.6 meters in width at a throughput speed of a square meter per minute. The unit did not gain market acceptance due to its high sticker price and limited production capability, but it demonstrated a model for designing, printing, and processing textiles digitally that others have followed. Canon used a material transport system from Ichinose, which later introduced its own twelve-colour inkjet textile printer using HP thermal inkjet print heads that it exhibited at ITMA 1999 in Paris. This device also did not gain market adoption. Ichinose later partnered with DuPont to produce the Artistri 2020 printer using modified Seiko Instruments piezoelectric print heads. This device has won significant market adoption with about 160 printers installed by February 2006.

Perfecta, in conjunction with Zund, debuted a textile flatbed printer using Hewlett-Packard thermal inkjet print heads at FESPA 1996 at Lyon, France. Encad offered an inkjet textile printing system using Lexmark thermal inkjet print heads for proofing and short-run production in 1997. Despite a strong marketing effort, market adoption did not match company expectations and Encad eliminated its textile division.

In 1984, Canon introduced a digital laser copying system, the NP-9030, following its 1979 development of its LBP-10 laser beam printer. Canon continued to develop laser technology, resulting in the release of its CLC1 colour laser copier in 1987. This technology provided a means for producing four-colour process heat transfers for garment, accessory, and promotional product printing.

1.6 Seiren

In the early 1980s, the largest textile printer in Japan, Seiren of Fukui, began developing the possibility of inkjet printing of fabric directly. In 1989, it undertook to build a manufacturing facility for printing fabric digitally. By 1991, Seiren had added inkjet printing to complement its analog operations. It had a few hundred piezo inkjet printing devices constructed for its digital printing operations. It brought its considerable expertise with fabric inks to build a digital textile printing business with an annual gross sales volume in excess of $100 million by 2000. Seiren digitally prints textiles for automotive upholstery, active and swimwear, banners, and apparel. It has also developed the process of digital dyeing. Seiren opened Viscotecs™ stores where customers could order fabrics tailored to their needs. It has also developed information technology (IT) to supply online response to consumer and industry demand for printed and dyed products. Seiren created a model with its Viscotecs™ digital system for agile manufacturing that connects its mass customization production operations directly to the market. It has extended its digital printing of fabric around the world with production facilities in Japan, the United States, China, Thailand, Italy, Belgium, and Brazil.

1.7 Digital grand format and textile printing

During the 1980s, a number of companies developed digital methods to print billboards, building wraps, and large banners. In 1987, Gerber Scientific built large-drum digital grand format printing systems for billboard maker Metro Media Technologies (MMT), which has since become the largest supplier of digitally printed large and grand format graphics worldwide, with digital production locations in North and South America, Europe, Asia, and Australia. MMT prints on textiles in addition to paper and plastic substrates. In 2002, MMT unveiled two of the world's largest inkjet billboard printers with their MegaDrums that measure 63 feet in circumference and 32 feet wide.

MMT's competitors in the advertising and billboard markets quickly followed with their thrust into digital printing. In 1989, Vutek introduced its 801 digitally controlled airbrush billboard printer and in 1990 offered its 16-foot wide 1630 billboard printer. Other equipment manufacturers, such as Belcom, Data Mate Company Ltd, LAC Corporation, Matan/Scitex, Nur Macroprinters, and Signtech/Salsa also developed grand format printers for MMT's competitors. These manufacturers have employed a variety of digital printing technologies including airbrush/valve jet, continuous inkjet, and piezo inkjet. Fabrics and fabric-reinforced vinyl have provided the primary substrate for grand format digital graphics banner and building wrap applications.

Geoff McCue filed a patent in 1990 for an inkjet computer to screen mask printer. Gerber Scientific acquired the rights to the McCue patent and produced a device to print a photo mask on photo emulsion coated screens. Stork of the Netherlands and Luescher of Switzerland combined to acquire the patent from Gerber. The inkjet masking systems based on the McCue patent provided the advantages of digital imaging to improve the cost and speed of analog print pre-press.

In the fall of 1993, a group of engineers led by Patrice Girard formed Embleme that developed a continuous inkjet garment-printing device that used water-based UV-cure inks, Imaje CIJ print heads, and Fusion Systems curing lamps. Embleme established the feasibility of printing garments and operated a shop that offered customers digital printing of customer generated designs on sportswear.

1.8 FESPA 1996

As previously noted, Perfecta introduced a TIJ textile printer at FESPA 1996. Idanit exhibited its high-speed 162 Ad that demonstrated the advantages of large arrays of print heads for production printing, albeit targeting paper and vinyl sheet printing.

Around the same time, Matthew Rhome of Bradenton, Florida, applied for a patent for an inkjet printer (on 19 July 1996) and the US Patent office awarded him patent number 6,095,628 on 1 August 2000. The original Rhome printer used thermal inkjet print heads. More recently, Mr Rhome developed a T-shirt printer using Brother PIJ print heads, which the company exhibited at the ISS Exhibition in Atlantic City, New Jersey, during March 2005.

In the early 1990s, Sawgrass of Mount Pleasant, South Carolina, USA, won a number of patents for thermal transfer and inkjet sublimation printing. In the late 1990s, it developed an indirect process called Natura for printing garments using electrophotography for use on white and pastel colored cotton and cotton–polyester blend garments. This process produces lighter hand and more vibrant color than resin-based toners. Other manufacturers have developed electrophotographic printers to produce sublimation transfers for receptive garments, accessories, and fabrics.

1.9 FESPA and ITMA 1999

FESPA (for screen and digital printing) in Munich, Germany, and ITMA (for textile production and decoration) in Paris overlapped during June 1999.

Perfecta exhibited its flatbed textile printer using XAAR XJ-500 print heads at FESPA.

1.10 ITMA 1999

Stork displayed its full line of digital printers at ITMA 1999 in Paris. It exhibited its Amethyst, a seven-color continuous inkjet that Stork developed for use with reactive and acid dyes for printing cellulosic and protein fibers. The Amethyst generated a 254-dpi matrix with gray levels for very high apparent resolution. It could print at a maximum throughput speed of 17.5 m^2/hr. Stork also exhibited its Zircon drop-on-demand piezo inkjet based on the Konica eight PIJ print head printer. Stork configured this device to print disperse dyes. It produces 360 dpi and throughput of 6.9 m^2/hr. Stork also exhibited its Amber PIJ printer based on the Mimaki seven-color 360–720 dpi TX device. Stork offered the Amber for printing reactive dyes for cellulosic fabric printing. It also exhibited a dual chamber steamer for fixing digitally printed dyes. Stork ran into technical hurdles with the Amethyst, resulting in its discontinuation. It continues to rebrand Mimaki and Konica printers enhanced with Stork software.

Encad showed its four-color TIJ 300 dpi textile printer at ITMA. In addition to Stork's versions, Mimaki exhibited its seven-color TX PIJ inkjet and Konica exhibited its eight-color 360 dpi PIJ printer configured for either disperse or reactive dyes. A number of other value-added manufacturers, including DGS of Como, Italy, developed improved material handling and software for the Mimaki printer. As mentioned previously, Ichinose Toshin Kogyo Co. Ltd demonstrated its 12-color 300 dpi TIJ Image Proofer printer outputting 4–12 m^2/hr. Perfecta Print AG exhibited its Print Master four-color inkjet. Salsa (formerly Signtech, now part of Nur Macroprinters) exhibited one of its solvent printers as a digital textile banner printer.

1.11 Drupa 2000

At Drupa 2000, DPS and Aprion unveiled their Magic PIJ print head system that will subsequently drive the Reggiani DReAM printer.

1.12 Heimtextil 2001

DuPont introduced the Artistri 3210 at Heimtextil in Germany in January 2001. It used Spectra's water tolerant Nova Q PIJ print heads shooting DuPont Artistri inks on a Vutek 3.2 meter wide media platform. Its print width is 3.05 m. DuPont promoted these devices for the printing of home furnishings. In 2002, DuPont unveiled its Artistri 2020 printer using DuPont modified Seiko Instruments PIJ print heads on an Ichinose sticky belt textile transportation system.

1.13 DPI 2001

In the spring of 2001 at the Atlanta DPI Exhibition, Leggett and Platt (L&P) introduced its Virtu series of UV-cure printers that it built for printing mattress ticking and for other applications.

1.14 ITMA 2003

ITMA 2003 at Birmingham, UK, during October 2003 marked the introduction of a number of breakthrough developments for digital printing on textiles and the beginning of production digital textile printing of yard goods. The key developments involved companies with considerable experience building conventional textile printing equipment, including Ichinose, Reggiani, Robustelli, and Zimmer.

- DuPont Ink Jet exhibited two of its Artistri 2020 printers with its Japanese partner and machine builder, Ichinose Toshin Kogyo Co. Ltd. The Artistri 2020 uses 16 Seiko Instruments PIJ print heads arranged with eight heads on each of two gantries. This configuration enables the use of two different ink types or using the same ink on both gantries for greater production speed. The device prints rolls of fabric up to 1.8 m wide at print resolution of 600 dpi at a production rate of about 30 m^2/hr. Its roll-to-roll adhesive print blanket system enables printing on woven, and knits, including elastomeric fabrics. The Artistri system and inks can print on nylon, silk, cotton, polyester and blend materials including DuPont Lycra blends. The 2020 stood out from other production inkjet printers because its 2020 devices were printing pigmented and disperse dye ink sets while competitive devices were printing less challenging acid and reactive dyes. DuPont also offered fiber reactive and acid ink sets for its inkjet printers. DuPont™ Artistri™ inks are available in cyan, magenta, yellow, black, light cyan, light magenta, orange and blue for reactive dye; cyan, magenta, yellow, black, light cyan, light magenta, red and blue for disperse dye and pigment; and cyan, magenta, yellow, black, red, blue, green, orange, fluorescent yellow and fluorescent red for acid dye. The DuPont dyes require post-print fixing typically used for conventional fabric printing. The Artistri system also includes the DuPont™ Artistri™ Color Control and Management System (CCMS) and RIP software. ITMA marked the emergence from beta testing and the commercial launch of the Artistri 2020. By February 2006, DuPont had placed about 160 Artistri 2020 printers in locations around the world. Sign and banner manufacturers in addition to other product samples and small to medium production fabric printers have acquired this device.
- L&P introduced a UV-curable dye for use with its Virtu system. Subsequent versions of the Virtu print line have achieved print speeds of about 200 m^2/hr.

- Mimaki unveiled its TX3 fabric printer with more robust material handling capability than the Mimaki TX2 to tension and print difficult-to-handle fabrics such as elastomeric fabrics. The TX3 provides advanced material handling like that provided for the TX2 on the DUA Graphic Systems Srl (DGS) Cromos textile printer.
- DGS of Como, Italy, also exhibited its other software and textile printer offerings at ITMA. DUA Graphic Systems expanded from a supplier of software solutions to the screen engraving industry, to a digital printing software provider and value-added manufacturer of advanced textile handling devices for existing digital printing systems. In addition to the Cromos printer based on the Mimaki TX2, DGS offers the Star G8, based on the Encad Novastar 850, the Colorspan Fabrijet XII, and the Luxor 7 based on the Mimaki TX printer. DGS supplies these systems with its Match Print II software. In February 2005, DGS and DuPont announced a marketing partnership for the sale of the Artistri 2020 and Match Print II software.
- Reggiani, in cooperation with Scitex Vision and Ciba, introduced its DReAM textile printer using 42 Aprion 512-nozzle PIJ print heads for this six-color digital textile-printing device. Reggiani reports that the DReAM can print 600 dpi throughput at a rate of 150 m^2/hr. Reggiani had installed over a dozen of these devices by May 2005, most of which are located in Italy.
- Robustelli, in partnership with Epson, launched its Monna Lisa textile printer. This device is capable of printing very high-resolution images for which Epson print heads are known. The Monna Lisa features half again as many print heads as the Mimaki TX2, along with improved material handling. Robustelli has placed about a dozen of these printers in Italy.
- Zimmer exhibited its Chromotex printer using arrays of 'Flatjet' piezoelectric stimulated spray nozzles. It also showed its Chromojet carpet mat inkjet printer.

During 2003, Mimaki exhibited its GP 604 garment-printing device with 60 cm (24 inch) print width. Mimaki also offers the GP 1810 inkjet garment printer with 1.8 m (73.2 inch) print width.

1.15 Drupa 2004

One digital printing device at this quadrennial exhibition in Duesseldorf presaged potential developments for digital textile printing. Sun Chemical and Inca Digital introduced a high-speed single pass inkjet printer for decorating corrugated cardboard for the packaging industry. It employed a full-width array of Spectra PIJ print heads. This half-meter wide demonstration model points the way to digital high-speed production printing for a wide range of applications including textile printing.

1.16 SGIA 2004

At SGIA 2004, held from 6 to 9 October 2004 in Minneapolis, Minnesota, USA, Kornit Digital of Moshav Magshimim, Israel, exhibited two robust inkjet garment printers using Spectra AAA print heads, the single platen 930 and double platen 931. Kornit configures its Spectra AAA print heads to shoot 77 picoliter droplets, thus enabling fast printing and greater ink deposit and color saturation. Kornit uses mild solvent-based inks with its 930 and 931 printers, but its versatile print heads can also fire water-based and UV-cure inks. Kornit has configured its printers to yield 450 × 450 dpi, 540 × 540 dpi, and 630 × 630 dpi. Kornit has focused its production efforts on its 931 printer in response to market demand for a high production T-shirt printer. It also increased the frequency of drop generation from its print heads, thereby increasing print throughput to about 300 printed garments per hour for its 931.

Also at SGIA 2004, the US Screen Printing Institute (USSPI) introduced its Fast T-Jet™ garment printing device based on the Epson 2200, and Jumbo Fast T-Jet™ garment printer based on the Epson 7600. These devices print at 360 and 720 dpi resolutions. The Fast T-Jet is the lowest cost inkjet garment printing device available. It can print a double-hit 12 inch by 12 inch print at 360 dpi in about two minutes and the same size image at 720 dpi in about four minutes. USSPI also offers a number of platens for its printers including a cap platen.

1.17 FESPA 2005

Equipment manufacturers introduced a number of new garment and textile printing systems at the FESPA 2005 Conference in Munich, Germany. The US Screen Printing Institute of Tempe, Arizona, USA offered four T-shirt printing devices. USSPI sold about 300 of its Fast T-Jet printers between their introduction at SGIA in October 2004 and the beginning of FESPA on 31 May 2005. USSPI listed this device at US$10,995 and reportedly uses about $0.40 worth of ink per image. It can print about 15–20 12 inch by 12 inch images per hour. USSPI offers its Fast T-Jet LF-2000 Jumbo for US$24,995. This device can print up to 23.5 inches by 36 inches for oversized T-shirts and beach towels. The company exhibited its Fast T-Jet XL-600 Giant with a price tag of $84,995. This eight-color printer reportedly can print 60–120 T-shirt images per hour with ink that costs less than $0.40 per image. USSPI also presented a video depicting its adaptation of the DuPont Artistri printer for T-shirt printing. USSPI claims that this new device can print from 300 to 400 T-shirts per hour. It utilizes carts with 10 mounted platens (five per side) for holding shirts. Operators place the shirts on the platens and remove them away from the printer after printing. USSPI claims ink costs per print range from $0.10 to $0.30 and lists the printer for US$240,000.

Kornit Digital Ltd exhibited its Kornit 931 dual platen inkjet T-shirt printer and introduced white ink for printing dark-colored garments. Kornit indicates that it has enhanced the production capability of its 931 printer to produce from 320 to 400 T-shirts per hour. Its light solvent ink and fabric coating permits printing a wide range of fabrics. Kornit recently added 360 × 360 dpi capability to its list of higher print resolution capabilities. This lower resolution enables faster production with image quality that suffices for most T-shirt printing. The 931 with white lists for about €200,000.

Textile printing and processing equipment manufacturer, MS s.r.l. of Caronno Pertusella, Italy, has introduced its MS-One T-shirt printer. MS reports that it can print an A4-sized image in 30 seconds and an A3-sized image in 60 seconds. The MS-One prints resolutions from 360 × 360 dpi to 1440 × 1440 dpi, lists for €14,000 and comes with a two-year warranty. MS offers its JetPrint material handling system for use with wide format plotters currently on the market. This permits material transport adjustments for improved image quality. MS includes a blanket-washing module with blanket drying, a print drying module, motor-driven fabric winding and unwinding, a pressing cylinder, an anti-static bar, and a material spreading and uncurling device. MS also offers two inkjet coating and printing devices: the MS-Coat & Print and the MS-Coat & Print SG Plus. These devices pretreat and print simultaneously inline. The MS Coat & Print SG Plus adds fixation and steaming.

Colorprint snc of Gallarate, Italy, exhibited its Twister hybrid T-shirt printer that can print images up to 40 cm wide. This carousel device combines a multi-station screen printing press and a multi-color piezoelectric inkjet printer. It can screen print a white as a base for the inkjet printing process when decorating colored garments. It can also add screen printed effects, such as glitter, puff, and metallic colors, to enhance and add dimension to digital garment printing. Colorprint's Twister inkjet printing device offers eight pigmented colors – yellow, magenta, cyan, black, red, dark blue, green, and gray – for its water-based device and a maximum resolution of 1440 × 1440 dpi. Colorprint also offers the Twister as a solvent-based inkjet system. It claims a throughput speed of 100 T-shirts per hour and lists the Twister for €60,000.

ATP Color of Senago (Milano), Italy, has developed its M-series three-platen T-shirt printer that the company reports can yield up to 50 T-shirts per hour with 600 × 600 dpi resolution with four-color process inks. It uses Epson printheads and lists for €50,000. ATP Color offers its T-series dual gantry Epson-based sticky belt textile printing system capable of printing resolutions up to 1440 × 1440 dpi. It provides both the T- and F-series printers in versions that can handle media widths from 162 cm to 320 cm. The double gantry T-series lists from €120,000 and the single gantry from €74,000. The F-series lists from €54,000.

Algotex s.r.l. of Crevalcore (Bologna), Italy, introduced its Rainbow Jet four-color process inkjet printer series. Algotex offers three devices each with XAAR piezo inkjet print heads and solvent based inks for printing textiles, flags, and banners in addition to vinyl and paper. The RB 250 uses eight XJ 128 PIJ print heads and can print 185–370 dpi images on materials as wide as 2.5 meters. At its lowest resolution the RB 250 can print 27 m^2/hr, and at its highest image quality about 15 m^2/hr. The RB 325 also uses eight XJ 128 PIJ print heads and can print 185–370 dpi images on materials as wide as 3.2 meters. At its lowest resolution the RB 325 can print 32 m^2/hr, and at its highest image quality about 18 m^2/hr. The RB 325 TOP uses 12 XJ 126 PIJ print heads and can print 200–400 dpi images on materials as wide as 3.2 meters. At its lowest resolution the RB 325 TOP can print 42 m^2/hr, and at its highest image quality about 25 m^2/hr.

As mentioned earlier, at ITMA in Paris in 1999, Stork of Boxmeer, the Netherlands, exhibited a number of continuous inkjet printing systems that it had developed and two drop-on-demand piezoelectic printers that it had rebranded and enhanced with Stork software. While Stork has since discontinued its efforts to develop a continuous inkjet short-run production printer, it has refocused its efforts on enhancing digital printing systems that other manufacturers have built through its Stork Digital Imaging BV division. Stork continues its partnership with Lectra of Paris, the world leader in textile and apparel software. Mimaki supplies its TX series of printers to Stork, which has branded them as the seven-color Amba and eight-color Sapphire and Sapphire II. It also continues to offer the Konica, now Konica-Minolta, PIJ wide-format textile printer under its Zircon brand name for disperse dye printing of polyester and other receptive polymeric fabrics.

Stork Digital Imaging BV exhibited its Sapphire II at FESPA 2005. Stork also promoted its Digital Print Asia (DPA) joint venture with the Yeh Group that has its production facility located in Samutsakorn, Thailand. Stork has developed a certification system with DPA called Stork U See® that guarantees its customers that design samples produced in one of Stork's sampling service offices can be reproduced accurately at its bulk production location in Thailand. Stork has located its sampling service offices at Boxmeer in the Netherlands, New York City and Giridara Kapugoda in Sri Lanka. Stork offers its sampling production up to 50 meters long at its service offices and production over 50 meters long from its Thai production center. This business system combined with inkjet printing offers customers the possibility of shorter print runs, less inventory risk, production to match shorter fashion cycles, unlimited colorways, and no repeat length limitation.

Hollanders Printing Systems BV of Eindhoven and Boxmeer, the Netherlands, introduced its ColorBooster textile production inkjet printer. It reports 90% production uptime based on its beta experience. The Hollander value proposition for its customers is to offer the flexible advantages of digital printing and processing in a high image quality system that can operate around the clock with a minimum of operator intervention with low operation cost. It installed 14 of these printers between June 2004 and May 2005 as beta tests and reports customer satisfaction running production operations with the ColorBooster. It employs 16 piezo drop-on-demand print heads with 180 nozzles each to produce 360×360 dpi to 2880×2880 dpi images with eight print colors. Hollanders claims the ColorBooster can print at 80 m^2/hr printing four-color 360 × 360 dpi prints (2 × 4 colors) at 25–50% coverage and 39 m^2/hr at 100% coverage. It claims the ColorBooster can print at 50 m^2/hr eight-color 720 × 360 dpi at 25–50% coverage and 22 m^2/hr at 100% coverage. It prints fabrics up to 2.3 m wide with images up to 2.23 m wide.

Hollanders ColorBooster employs an inline print head arrangement that maintains print order during bidirectional printhead scanning. This eliminates certain types of banding and contributes to color consistency. Its open ink system carries a five-liter reservoir and ink buffer for each of its eight print colors. It also includes an anti-sedimentation system that continuously circulates ink to keep colorants from settling out of solution, and users can replenish ink without interrupting operation. The Hollanders inkjet print heads can shoot pigmented inks, acid, reactive, disperse and disperse–sublimation transfer dyes. Hollanders Printing Systems indicates that its system with a combination of techniques can achieve a high level of print-through penetration that manufacturers of flags, banners, and silk scarves require. The ColorBooster system includes color management that Hollanders says can match colors precisely. Hollanders Printing Systems offers an open ink system with the end user selecting its ink supplier. The ColorBooster also includes a newly developed material transport system that can adjust cloth tension for each substrate and maintain tension during printing. The ColorBooster automatically step-corrects to compensate for material thickness. It includes a computer climate controlled system for the printing process. The company claims the ColorBooster can print as many as 80,000 m^2 of fabric per year. The ColorBooster lists for €145,000.

d.gen International, Inc., of Seoul, Korea, offers textile inkjet printing models based on Roland Epson-based printing systems. These include the Artrix d.gen 740 TX/Be with a maximum print width of 1.879 m and the d.gen 1000 TX/Be with a maximum print width of 2.6 m. Both use 12 Epson PIJ print heads that can generate textile prints from 450 × 360 dpi two-pass six-color prints at 28 m^2/hr to 1440 × 1440 dpi 16-pass prints at 3.5 m^2/hr. These systems employ a one-liter continuous ink feeding system for each color. Textile printers can use reactive, acid, or disperse dye inks or pigment inks with this print system. d.gen offers the 740 TX/C with a cylinder material handling system for thin fabrics such as silk chiffon for €43,000. It also offers the Teleios for direct disperse–sublimation dye printing built on the same printer bases as the d.gen 740 TX/Be and 1000 TX/Be. It offers disperse dye in cyan, magenta, yellow, black, light cyan, light magenta, orange, green, gray, and deeper black. The Teleios d.gen 1377TX/74 lists for €50,000 while the d.gen 1377TX/100 lists for €90,000.

d.gen unveiled its 7474 TX Heracle dual gantry inkjet printing systems. It employs a sticky belt and can print a maximum width of 1.879 m. It carries 24 print heads, 12 on each gantry, and can print at a maximum resolution of 1440 dpi. This device was still in beta testing but d.gen reports that it will be available by the end of 2005. It prints reactive, acid, and disperse dye or pigment ink. In four-pass, 360 dpi mode, the Heracle will print 36.5 m^2/hr, and in the four-pass 720 dpi mode it will print at a rate of 21.4 m^2/hr. d.gen has yet to announce a price for the Heracle. This sticky belt device will likely compete with the sticky belt machine from DuPont.

Kimoto Ltd of Rumlang, Switzerland, introduced four inkjet printers, which it calls the Philyasystem. At the core of each of these devices is a Roland printer with Epson print head technology producing resolution up to 1440 dpi. Kimoto designed one of these devices, the TBS-1600, with an adhesive belt transport system for controlling textile during printing. Kimoto offers the printer for use with four- or six-color water-based ink sets. It lists for €82,500. Kimoto reports having one of its Philyasystems beta-testing in Italy.

1.18 Other key elements

Many disciplines and competencies contribute to producing digital textile printing. In addition to print head design and manufacture, material handling engineering, and ink chemistry, are textile manufacture and pre-treatment, post-print finishing, design, raster image processing (RIP), and color management software.

Monti Antonio S.p.A. of Thiene, Italy, has developed vacuum heat presses that can produce print-through with digital printed images for flags, banners, and scarves. Other manufacturers of post-processing equipment are also expanding the capabilities and applications for digital textile printing.

Color matching and management software and equipment are helping digital textile designers and printers distribute and print at multiple locations around the world with colors that match exactly. Printer–ink–media profiling and climate-controlled environments are enabling digital textile printers to reproduce print images repeatedly. Digital textile printing is entering an era of greatly improved reliability that replaces personal skill with scientific and numeric precision.

1.19 Conclusion

The textile printing and equipment manufacturing industry in Italy has provided significant leadership in applying digital printing for textile applications. Key equipment developments at Italian manufacturing companies, such as DGS, Reggiani, Robustelli, MS, Algotex, ATP Color, Colorprint snc, and Monti Antonio among others, underscore the major Italian contribution to the adoption of digital printing for textile printing.

Japan has contributed much of the key print head and printer technology that has driven textile printing. Japanese-manufactured Epson, Sharp, Seiko Instruments, and Konica Minolta print heads print most of the fabric that the world prints digitally. US and UK manufacturers have also contributed with primary technology and business development. Textile print producers India, China, and Turkey are also developing digital solutions.

The pace of development has begun to advance. Inkjet textile printing is growing while growth in analog textile printing remains stagnant. Digital printing is beginning to account for an increasing share of textile print production. As the length of textile print runs decreases, and the demand for short-run production and just-in-time delivery increases, digital printing is providing the cost-effective solutions. As digital print technologies improve, offering faster production and larger cost-effective print runs, digital printing will grow to become the technology that provides the majority of the world's printed textiles.

1.20 References

1. Susan Meller and Joost Elffers, *Textile Designs: Two Hundred Years of European and American Patterns for Printed Fabrics Organized by Motif, Style, Colour, Layout, and Period*, Abrams, 2002.
2. http://www.silk-road.com/artl/printing.shtml
3. http://www.india-crafts.com/textile/printing_tradition/block_printed/index.html
4. US Patent Number 1,941,001, applied for 19 January 1929 and issued 26 December 1933.

2

A designer's perspective – digital versus traditional

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2.1 Introduction

A very important transformation is taking place in the textile industry: the digital revolution. That sounds very twenty-first century, but it started 30 years ago, and although it is essential to understand the developments and progress made in that time regarding hardware and software, I believe that we must now consider the most important part of the equation – the human element.

Visiting the major European textile museums such as those at Mulhouse, Macclesfield, Como and Lyon, one can see the progress made through the centuries and the notable influence of new machinery and new techniques on the fabrics and designs produced.

So, for example, we see the progression from the primitive Coptic looms to the Jacquard loom (based on the reading of perforated cards, the forerunner of the binary system used by today's computers), and from the first simple wood block printing to precise metal engraving, then the photographic techniques used to engrave flatbed screens, rotary cylinders and copper rollers. Now we're only at the beginning of the digital age and this new technology will be just as important, if not more so, as the arrival of the Jacquard loom so long ago. It will change the face of textile production and distribution, and it will empower the designer in a way never seen before.

All developments, whether mechanical, technical or chemical, have always brought about important changes in the characteristics of the textiles produced. Not only have they improved the quality of the product, visually and in many other ways, but above all they have offered ever greater levels of creativity. So clearly progress cannot be completely attributed just to the tools available – it has always been the people involved in the process who have used the new developments with creativity, enthusiasm and perception, thus establishing the most important centres of textile production.

Como in Northern Italy is a good example. For the last 50 years it has been the most important centre of textile production excellence. Post-war Como took over from the French textile industry in Lyon, starting with beautiful silk

Jacquard fabrics, then progressing to flatbed screen and rotary printing, to be recognised as the best in the world. So how did they do it? In the whole textile sector there in the mid-1970s, everyone involved used the new technologies with creativity, enthusiasm and specialist knowledge – even inventing newer things in order to pursue the excellence the world expected of them. That's why, although it is essential to consider the progress made with hardware (or machinery) and software (or working technique), the most important element of all must be considered – the human element. It was this and the character, the dedication and the specialist knowledge of everyone involved – the stylists, the designers, the colour separators, the sales people, the creative entrepreneur – which made the Italian difference.

But now the world is rapidly changing and it is truly global. The same technology is available to everyone, from Korea to China, from Hungary to Turkey. The production centres are moving from the traditional areas, so how will Italy survive? Well, it certainly will continue to buy British creative textile designs as it always has. It's going to have to adapt to a new productive reality, and that could be a big problem for the industry in Italy, because the new digital technologies mean that textile designers no longer have to rely on large-scale industrial processes in order to reach the market – any market, from one-off pieces, limited edition bespoke runs, to hundreds of thousands of metres if necessary. Now inkjet-printed textiles and computer-aided design are capable of production speed. All that is needed now is to bring in creativity, enthusiasm and specialist knowledge, and then things will change. New markets will open up, distribution methods will change. It's happening in many different industries thanks to the digital revolution.

There are huge implications in what this digital technology has opened up to everyone in the creative field, from the artist to the craftsperson and the designer. But it is necessary to look at the 30-year history of computer-aided design and how it developed in order to avoid the mistakes of the past.

The first CAD system arrived in 1970. Up till then the method of production was similar to that for woven Jacquard. Designs were translated to graph paper, a very complex technical task, then cards were punched to control the machines. The difference computers made was notable. Designers had complete control – they could sample the fabric at the touch of a button, change it, keep it, produce 1 metre or 100,000 whenever needed. CAD for printed textiles arrived in 1976, but it was more for computer-aided manufacturing than computer-aided design. Films for engraving screens were produced on laser plotters permitting precise register and the most difficult challenge of all for hand-drawn colour separations – a straight line.

2.2 What difference does digital make?

The best way to explain the difference that digital will make is to show how a textile collection is produced using firstly traditional methods, then digital technology.

Any textile manufacturer producing a twice-yearly collection of designs works in the same way as a freelance designer. In order to sell designs for eventual production, they must show samples of their work at the major world trade fairs, where mainly clothing manufacturers choose the styles they want the manufacturer to produce for them.

The success rate for samples being turned into mass production is about 15–20%. This means, of course, that for the manufacturer's factory to have a full order book for their production schedule, they must present hundreds of samples twice yearly.

2.3 How is this done using traditional methods?

A sample length can vary from two metres to five metres depending on the type of design. Many screen printers have very large print shops dedicated to sample production. To produce a sample using traditional screen engraving methods involved tooling up to full production standards. That is to say, the screens used to make the successful samples could immediately be used in the mass production process. The fully production-ready screens of unsold designs would be destroyed and the costs written off as a part of the sales process. Sample preparation is a long, complex and expensive process.

The screen printing process starts with a high quality piece of artwork. This art is then separated out into the composite colours and a film positive is produced. This film is then placed onto a screen coated with emulsion. The screen is then exposed to UV light in an exposure unit. After the screen has been exposed for the proper amount of time, the screen is 'washed out' with a pressure washer. This removes any emulsion that was not in contact with the UV light (the positive area). The screen is placed in a drying cabinet, and once dry taken to the press for registration. Ink is 'squeegeed' through the open areas of the screen onto the fabric below. The printed fabric is then put through the conveyor oven and cured to a temperature of 350ºC.

A collection starts with a group of design stylists deciding which designs are most likely to sell, according to trend predictions and their experience of the current fashion marketplace. Once this is decided they will use the textile design artist available within their organisations or buy what they need from external studios or freelance textile designers. This is the first phase, the high quality piece of artwork. The next phase is to separate this artwork into its composite colours, which is done by skilled colour separation artists. Colour separation using traditional methods is a highly skilled and very difficult job, and as time progresses it is becoming a problem finding people with the right skills to do it.

Colour separation is the first reinterpretation of the design, which is divided up into its composite colours in order to engrave a screen for each of these colours. A comparison could be made to the spot colours used in computer graphics and paper printing. As opposed to CMYK four-colour printing, this permits each screen colour to be changed independently, which is essential in a textile collection in order to offer various colour variations or choices for each sample offered.

The design will be put into repeat, the colours separated and at this point the most complex part of the process takes place, which is ensuring a precise register between each screen. This is essential because as each colour is printed there must be a slight overlap between each one as no fabric background should show. Making this work using traditional hand techniques such as brushes and pens with opaque inks is an extremely difficult and lengthy process and results can be inconsistent, varying between different studios and individual artists, which makes consistent quality at the production fabric printing phase difficult to achieve. Of course, it can all be done successfully, as, for example, in the Como district in Northern Italy, where an expert artisan tradition and long-established infrastructure ensure quality recognised worldwide.

Preparing well-made colour separation films comes at a cost, both financially, in the time it takes to produce them, and in the logistics involved. It takes a minimum of 10 days to get from artwork to colour-separated film ready for screen engraving. With hundreds of designs being made ready for sampling in time for a deadline such as the biannual trade fair, all happening at the same time with all the complex processes involved in the fashion business – priorities, changing of ideas at the last minute – it's a logistics nightmare.

So after a minimum of 10 days the screen is ready to be engraved. The following is a summary of technical instructions provided by various screen engravers.

Use polyester or other suitable synthetic fabric or screen material. This is one of the most exciting methods of screen printing because it offers the widest range of possibilities. It makes possible the printing of fine line drawings, large consistent colour areas, various hand and commercial lettering techniques, as well as photographic half-tone positives.

All methods of photographic screen printing require three things: (1) a screen prepared with a light-sensitive coating, (2) a film positive, or equal, and (3) a light source that will enable you to transfer the opaque images on your positive to the light-sensitive screen you have prepared.

Step A Mixing the photo emulsion

The photo emulsion is made by mixing two different liquids. Follow the mixing instructions given on both containers. Store the sensitised emulsion in a cool and dark place. Shelf life for the sensitised emulsion is four weeks at 90ºF, eight weeks at 70ºF, and four months when refrigerated.

Step B Coating the screen

Coat the screen by first pouring a bead of the solution on one end of the bottom side of the screen. Spread it evenly and thinly with the squeegee or the plastic spreader. Use more solution where necessary. Pour a bead of the solution on one end of the inside of the screen and spread it evenly with the squeegee or the plastic spreader. Work to achieve an even continuous coating on both sides of the screen fabric. Perform the final spreading on the inside of the screen. Return any excess solution to your mixing container.

Step C Drying the coated screen

In an area away from light and heat, set the screen to dry horizontally, bottom side down. This will provide the most even, flat 'film' on the underside of the screen. Most commercial engravers use specialised ovens specifically developed for this process. Allow the screen to dry thoroughly. If more than 300 prints are to be run, it is best to apply a second coating of the sensitised photo emulsion to the bottom of the screen after the first coat is dry. Remember, work for a smooth, even thin coating. Repeat the drying process away from heat and light.

Once the sensitised screen is dry, it must remain in a darkened area until it is ready to be exposed. A fan in the dark area will greatly speed up the drying of the emulsion on the screen.

Step D Preparing a positive

With dichromate systems, the maximum allowable time between application of the sensitised emulsion to the screen and the exposure is six hours at room temperature. With diazo systems, the maximum allowable time is eight weeks at room temperature.

Before removing the sensitised screen from the dark drying area, make sure everything you need to print with is on hand. At this point the colour-separated positive is attached to the photo emulsion coated screen. Register marks have been added to each positive to ensure precise register between each printed colour. The exposure lamp overhead emits controlled light intensities for specifically defined amounts of time. These intensities and times vary greatly and depend on design type and different suppliers' products. Successful engraving depends on highly skilled and experienced technicians. After exposure, remove the positive and take the screen to the wash-out process.

Step E Washing out

Apply a forceful spray of water (at body temperature) to both sides of the screen. *Do not use hot water.* Concentrate this spray on the light images on the top side of the screen. After a few minutes, these areas will become 'open'. Continue spraying until all unwanted emulsion is gone. Once you have completely washed the screen, let it dry thoroughly in a level flat position.

Hold the dry frame to the light and check for pin-holes. These can be covered with screen filler or pieces of masking tape stuck to the bottom of the screen. If screen filler is used, let the screen dry again. Photo emulsion should not be left on the screen indefinitely unless a permanent stencil is wanted. It should be washed out as soon as the run is completed.

The screens are now ready for printing samples, and if the samples sell, the design can be used immediately in production.

Here again it can be seen that screen engraving requires highly skilled technicians and, although the turnaround times from positive colour-separated film can be as short as one working day, the fact that hundreds of designs, each with several screens, are being processed at the same time for the same deadline can cause complex logistics problems.

Before samples can be printed on fabric, two full prints in reference colours in their predetermined order will be made on paper to check the accuracy of the design produced and to act as a master copy. One copy is sent to the production archive while the other copy will move between the various departments involved in sampling and production.

The colourists will use this master to prepare colour variations in fashion colours suitable for the current collection. These colours will then be given their recipe mix for each individual and unique colour, as there are no standard colour ranges in stock. Here again this is the master recipe which can later be mixed in larger quantities for the eventual production process.

The next step is actually printing on fabric. As mentioned, most medium to large producers have sampling departments the size of small factories. The printers are highly skilled artisans, printing by hand onto a large variety of fabrics using many different dyestuffs and techniques. The fabric sample is now submitted to the stylist for approval of colour, fabric handle and appearance. If the sample is approved it is ready for presentation at the trade fairs; if not it has to go through colouration, colour mixing and sample printing.

The whole process is prolonged and expensive, can be very inflexible, and requires highly skilled and unfortunately, as time goes on, less available personnel. It's difficult to estimate times and costings involved in such a varied and complex industry, but digital makes the difference.

Preparation techniques changed with the arrival of the first computers to make the colour-separated positives for engraving, but a more radical change could be seen in the precision and quality of the laser-engraved Mylar film. It enabled consistent and controllable overlap between screens and unforeseen and precise register. It really caused a quantum leap in quality and an even bigger one in creative output, as the CAD was let loose on the design community when they saw they could go beyond what was possible by hand preparation, using the software available on the systems.

Though designers were desperate for immediate hard copy of their designs, in order to see results they still had to go through the whole screen engraving and printing process. The quality of the colour-separated positive had changed but the whole process was still long, expensive, unwieldy and complex. Preparation of the films by computer in fact added to the complexity. The computer-controlled plotters were very slow, and just two plotters could be working on hundreds of separations, which caused a bottleneck compared to the hundreds of separators and engravers working by hand.

It took many years to change the system radically and that happened when inkjet technology for fabric printing arrived around 1995. CAD systems and software and specialised designers were already in place; all that was missing was this long-awaited technology.

In the Northern Italian area of Como, manufacturers quickly saw the advantages and savings that textile inkjet printing offered them over the traditional system described previously. In a two-year period in the late 1990s over 100 printers were installed there, while in the same period in the UK only around two or three were installed.

2.4 How do they compare?

Direct inkjet sampling cut out long, expensive and complex industrial processes. Full preparation of colour-separated positives or screens, and printing of fabrics in huge print rooms, was no longer necessary. Register between screens and colour control were no longer a problem. Inkjet sampling gave the designer direct control over the appearance of the design on fabric, without reinterpretation by separation artists. Last-minute decisions could be made as little as a few hours before presentation, or even during presentation, and there was no waste of screens prepared for unsold designs.

A few problems remain. Colorant type is still limited compared to screen printing. Inkjet printers cannot use flocks, glitters or devore techniques yet. Fabric variety is still quite limited. Final production and markets must be carefully considered. Clothing manufacturers need colour variations: CMYK four-colour processing will not do. Unfortunately many salespeople are commissioning many more samples, because it's cheap, fast and easy and improves their success rate enormously. However, there is one very big problem emerging here, since when the successful samples arrive at the production part of the process, in 99.99% of cases they will still be produced on traditional printing machinery. Unlike in the traditional process, they are not ready for immediate production, as they have to go through the screen engraving process. Since ITMA 2003, there has been production machinery capable of 100 linear metres per hour, but integration is still a way off.

Bad computer-aided design for inkjet-printed samples can cause massive problems at the factory production stage. Often the computer-produced designs are impossible to prepare for production machinery, or the data files given to the computer-aided manufacture separation artists are so complex and mixed up that they have to rescan the printed sample in order to produce the separated colour film properly. It's so tempting for salespeople and stylists to rush out thousands of samples made available by this new, fast, flexible technology, but caution must be taken.

Ultimately the responsibility lies with the designer. Always start with and remember the final means of production, then design accordingly. The argument isn't necessarily digital versus traditional: it should be digital *with* traditional – at least for the near future.

2.5 How can the designer use these twinned technologies?

It is necessary to understand the potential in these systems. Reproduction of a design is fine but you need to go beyond the normal hand-drawn images if using the programs on the system. The Ratti group set up a centre for study and research, which aided in the group's success; the keywords being innovation, sophisticated product, unique product and lead, never follow. Although these early CAD programs were not at the levels of the first knit programs, they were able to produce paper colour proofs which could be transferred to production screens when successful. Although it all worked very well it wasn't easy, because in the 1970s people were working with relatively primitive and very expensive computers compared to now. Only big industry could afford them. The computers ran at a fiftieth (or less) of the speed of any PC available on the high street today, and the RAM was only 32 MB with a hard disk of 200 MB. It was a unique studio experience and not available to many. But things have changed – finally with inkjet technology, a designer can produce fabric at the touch of a button, just like in 1970.

2.6 Freedom

Resistance from the established designers was quite high at first. Some saw computers as restricting creativity, although the screen engravers embraced it and in fact remain world leaders due to their early involvement with the technology. But the results produced were what changed things. It didn't take words to convince them – just innovative design and quality. It's the same position today; it's time to demystify the myths surrounding digital technology. It doesn't limit creativity, it doesn't make the process less human – in fact it's exactly the opposite. Finally there is the freedom.

New generations don't have as many phobias about these technologies and techniques. They understand that they don't have to lose time photocopying, cutting, pasting, and struggling with repeats. They have more time for the truly creative part of a designer's work. Now designers are in direct control.

With today's technology there is no longer a barrier between creativity and the production of the design on fabric or any surface. This new technology allows designers to take control of the end result, to prevent it from being changed down the production line. All the industrial preparation processes can be eliminated; it will be faster, more competitive, more creative.

Designers such as garment and interior designers can also work with customers in a much more efficient and integrated way. Digital methods give the advantages of speed, communication of ideas, last-minute ideas, and beating the competition on the catwalk with a unique product. The process can start with words, then a list of ideas, then the designer can develop them on the computer, trying new variations, secure in the knowledge that the final result on the market, whether 1 metre or 100,000, will be exactly as originally wanted – and instantly. Designers and customers have total control over the final product.

2.7 Thinking about creativity

Working by hand can make many beautiful and innovative things, but with a computer creativity can go beyond that, even to places where unimaginable ideas and images become available. Before this technology the human touch was stifled. Layers and layers of industrial process have now vanished – it is no longer necessary to rely on a far distant factory, and the full range of possibilities is now directly in the designer's hands.

So where does that leave designers? They have the power of the new technology – will they use it in a creative way or will they stay with old ideas and attitudes? The new technology has to be embraced, as the competition doesn't hesitate. For example, in Korea they really are up to speed on this technology; they recognise the potential. A design can be completed on the other side of the world and 36 hours later a disc with the design on it can be in a factory in South Korea, slotted into an engraving system, and in production a day later. That's serious mass production, from limited edition boutiques to high streets all over the world if required. It is no longer necessary to rely on cumbersome industrial processes – it's time for mass customisation.

2.8 Resistance

Unfortunately there is still resistance, but it will surely change. More people need to adopt the technology and learn how to use it to increase efficiency and avoid one person doing the work and four others telling them where to cut and what to move. By getting hands-on experience, people have more control; the programs are getting easier and easier to work with. New professional and craft roles are being defined. More and more unique creative skills are being transferred onto this new technology. Now the technology can be used to make whatever we want to – it is becoming completely transparent and global.

2.9 Transparency

This technology allows designers so many opportunities. It's so important that skilled designers transfer their skills to the excellence that the technology allows. The final means of production must always be taken into account although inkjet printers are now up to production speed, the majority of products will still be produced on a large scale by low-technology methods such as screen printing. It is also necessary to take into account how the market works at present. The market expects a collection of fabrics to have prints with colourways, groups or families of colours, clearly separated backgrounds, etc.

This sums up the present situation, with inkjet printers being used mostly for design sampling as they save expensive screen-making time and costs, but this can cause problems. A design made on the computer can create more problems than it solves. It is necessary to start from zero and think like a textile designer, deciding from the start that the design will have, for example, three greens, four reds and a background, and that it should be adaptable to different colourways.

The future will be very different. The reason why the Italian textile industry was so successful over the last 50 years was that it always used the latest technology available in the best creative way. That's why it's so important that the creative process advances alongside, if not ahead of, the technology. This way, new markets will evolve like, for example, mass customisation – limited editions produced in small batches in mass quantities, with the possibility of changing the design every 10 metres, for example – all thanks to computer-aided design and inkjet technology.

History tells us that the connection between art and industry is very important. Andy Warhol didn't have the technology of today, but with what he had – screen printing – he started to make limited editions, maybe even invented the concept of mass customisation. Or maybe it started with the lithographers. An artist could now create a design on a computer, print 10 copies and sign each copy of the print to make it unique, with the classic 1/10 numbered inscription of the lithographer. Once the print run is finished, the original file will be destroyed – that's added value, for sure.

We can also now produce limited edition garments as we don't have to engrave screens or keep a stock or a warehouse full, or manufacture thousands of garments to sell only a percentage of them. The new technologies allow true production on demand. There are also new and exciting developments that link the creation of a textile design and the pattern, cut and design of the garment. This opens up the possibility of textile designs that follow, or decide, the form of the garment. Not only the most advanced European design research projects, but major players like Levi's are now using body scanners to produce individual patterns for garments based on each person's measurements. Link this to CAD textile design and inkjet printing and things will really change. New opportunities appear every month.

2.10 The new market

Obviously it is necessary to take advantage of all that this technology offers, but there are many dangers. Take the Internet, for instance – designs can be shown on the web and the customer can order 1 to 100,000 metres of printed fabric. It is necessary to scramble it so it can't be downloaded directly, but these ciphers can be overcome. So rather than relying on this kind of protection, it's more important that the designer makes sure that a copy obtained in this way will only ever be an obviously bad copy, which means working like a textile designer – not a graphic designer.

Work methods will surely change – interaction between garment designers, even graphic designers, is now completely possible; software graphics programs cost nothing; powerful systems are getting cheaper and cheaper. So there's nothing stopping anyone, working from anywhere, from producing high-quality unique work, available to the mass market or the limited edition market. Or to go even further, why not supply the production system with a disc ready to plug in with each colour separated, in repeat – ready to go?

And finally, in the fashion business, when most people hear the words digital design, the first thing that pops into their minds is designs made by robots. Digital design is not just this – how many such designs in a collection today would you sell? Many people do not even realise that designs have been produced digitally, thanks to the human touch.