



HP'S PATH TO THE NEXT GENERATION OF PRODUCTION DIGITAL COLOUR PRINTING

BY: JIM HAMILTON, GROUP DIRECTOR

In May of 2008, HP showed a technology demonstration of a massive 91cm (36 inch) production digital printing system with imaging technology based on HP's drop-on-demand inkjet heads. Since then, HP has moved from the sidelines to the forefront with an extensive product line that builds on a range of HP printhead, image processing, media transport, ink, and substrate technologies. This foundation provides the building blocks that allow fast innovation and the ability to reach productivity and quality levels unheard of in the production digital print market.

KEY FINDINGS

Key findings of this analysis include:

- HP is using its next-generation thermal inkjet Scalable Printing Technology (SPT) as a platform for inkjet systems that have grown in speed and quality since the first technology demonstration in 2008.
- Redundancy and fault tolerance are central to the philosophy of the design team and the resulting execution of the product line.
- The pace of innovation has been enabled by design decisions using SPT as a central building block.
- HP has harnessed its ability to engineer across a range of technology areas to raise the art of system integration to new levels.
- The addition of glossy coated inkjet substrates with ColorPRO technology, as well as the announcement of the in-line coater for UV or aqueous coatings, bring the 'pop' and shine of glossy finishes to high volume production digital printing.
- Announcements made this spring and at drupa 2012 expand the Inkjet Web Press platform and bring 244 metres-per-minute (800 foot-per-

minute) speed to the top of the line T410.

- In 2011, HP's Inkjet Web Press family increased its market share to 16% globally; placing second in the 10 million+ continuous-feed colour duty cycle segment.
- HP is leveraging its relationships with brand owners and publishers to demonstrate how the use of high volume and high quality inkjet systems can shatter existing market models and redefine the use of print.

RECOMMENDATIONS

InfoTrends makes the following recommendations:

- End users looking at the purchase of an inkjet printing system should consider the role that print quality, productivity, upgradability, substrate choice, feeding and finishing play in the success of any high-speed printing application.
- Large enterprises, book and magazine publishers, content creators, retailers, and brand owners should consider how high-speed inkjet technologies can be leveraged to publish, promote, market, and/or sell their key messages and content.

One of the top stories of drupa 2008 was HP's

technology demonstration of the Inkjet Web Press. A lot has happened in the four years since then. The product line has grown. The company has built partnerships with a broad spectrum of companies for workflow, pre- and post-press solutions, finishing, and substrates. HP has worked with publishers and others at strategic levels to envision how high-speed inkjet systems can meet everchanging market needs. In this white paper, InfoTrends will provide an update on HP's Inkjet Web Press family, delineate its market impact, and show how the resources that HP has invested in this initiative are matched with ambitious plans and strong expectations for market success at high levels of quality and productivity.

BUILDING BLOCKS FOR FAST PACED INNOVATION

Well before drupa 2008, HP had big plans for its next generation of thermal inkjet printheads. In what ultimately turned out to be a \$1.4 billion investment, HP created an aqueous inkjet platform that could be used as a building block, enabling rapid product development. This next-generation printhead, HP's Scalable Printing Technology, is at the centre of HP's Inkjet Web Press product family. HP uses this building block as part of an integration strategy that is characteristic of the company's approach to the market.

INTEGRATING A RANGE OF RESEARCH AND DEVELOPMENT CAPABILITIES

To build the Inkjet Web Press product family, HP integrated in-house printhead, image processing, media transport, ink, and substrate technologies into a cohesive whole. This is probably best understood by imagining how much of the Inkjet Web Press is created by HP employees. The nozzle designers sit next to the ink chemists and writing system engineers and are down the halls from

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the substrate experts, who are not far from the mechanical, electrical, and software engineers. Together and in smaller teams, they can look at the aspects of any design challenge holistically to implement a solution.

In addition, where outside technologies are required, HP has worked with many workflow, substrate, finishing, and converting partners to develop a range of productivity and application-enabling solutions.

The fact that HP leverages integrated research and development and manufacturing capabilities across a range of technology areas is rare in an inkjet market in which most vendors source these components from multiple partners.

MODULARITY AND SCALABILITY

A modular design provides day-to-day benefits as well as room to grow for the future. For example, in the case of the system’s printheads, rather than replacing an entire print bar across the width of the web, individual printheads can be replaced as needed. An in-line monitoring process identifies heads that need replacement and alerts the operator to do so when necessary. This ease of printhead replacement makes life simpler for the system operator, but also simplifies the transition to next generation printheads. It also enables field upgrades that allow early users to benefit from later developments and rewards those initial investments. HP’s intent with this is to assure customers that it is always the right time to adopt new technologies because the design framework allows for future upgrades that build on the modular architecture, with a view into technological advances that will arise out of HP’s research and development labs.

FAULT TOLERANCE AND HIGH PERFORMANCE

Inkjet can be a very reliable process, yet it is impossible to guarantee that every nozzle on every head is firing correctly. Therefore, an effective system design requires some level of built-in redundancy combined with the ability to monitor and compensate for misfiring nozzles. In addition, the system automatically aligns nozzles and compensates for paper dimensional changes based on the ink coverage on the page.

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A FOCUS ON QUALITY

HP stressed quality throughout the development of the Inkjet Web Press product line. As speeds have increased, quality has not been sacrificed. This is interesting since it is common for speed/resolution trade-offs to be made. Typically, if the customer wants faster speed, then he or she can have it, but the print resolution must drop to accommodate the speed increase. HP’s reliance on a robust printhead platform and a scalable system design has made it possible to maintain quality while increasing speed.

LEVERAGING THE PLATFORM

One of the most interesting aspects of SPT is that its materials, design rules, and production processes allow new generations of printheads to be built upon it, allowing speed and quality increases via the technology platform. This becomes apparent as you look at the journey that the printhead technology has taken through the early years of the Inkjet Web Press product line.

Table 1: Three Generations of HP’s Scalable Printing Technology Printhead

Table 1	First generation	Second generation	Third generation
Maximum speed	122mpm (400fpm)	183mpm (600fpm)	244mpm (800mpm)
Introduction date	2009	2011	2012
Printhead name	Unnamed	A20	A51
Printhead bore type	Circular	Circular	Non-circular
Ink type	Ink 1 (A10)	Ink 2 (A50)	Ink 2 (A50)
Products supported	T200, T300	T350, T400	T230, T360, T410

The first generation of the SPT-based 4.25-inch printhead for HP’s Inkjet Web Presses was used in the T200 and T300 and, depending on configuration, is capable of speeds up to 400 feet per minute. It was followed in 2011 by the second generation, which HP calls the A20. This head is capable of speeds of up to 600 feet per minute and are used in the T350 and T400. Along with the A20 printheads, a new set of pigmented inks was announced and designated A50. These inks were formulated to have a wider colour gamut. The yellow and magenta have higher chroma and the

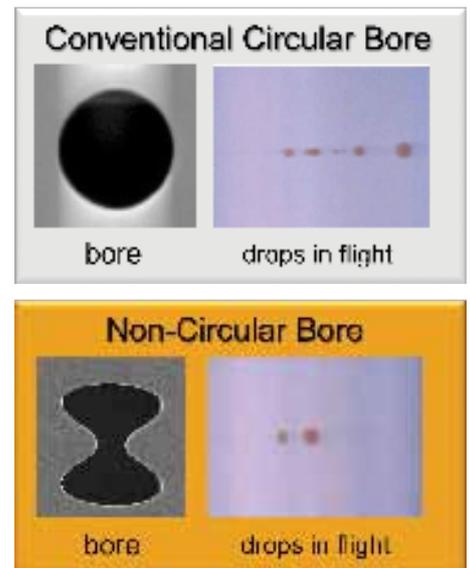


Figure 1: Circular and Non-Circular Bore Patterns

cyan ink is bluer. The result is more colourful reds, oranges, and pinks, better blues, and brighter light greens. They also hold up better when marked by highlighters and offer more environmental benefits (i.e., easier to de-ink during recycling and have reduced volatile organic compound (VOC) levels). The third generation of the Scalable Printing Technology platform is called A51. It enables speeds of up to 244 metres per minute (800 feet per minute) in the 76cm (30-inch) and 107cm (42-inch) machine configurations, and has double the drop rate of the original printheads. The A51 heads enable speeds up to 400 feet per minute (122 metres per minute) in the T230. A key enabler in this speed increase is the use of a non-circular bore or nozzle that is designed to improve the formation of drops for high quality and high speed printing. As drops are ejected by the printhead, the new nozzle shape assures that the head and tail of the droplet merge in flight to produce a round dot on the substrate. HP’s A51 printhead resolves this problem with a nozzle opening that is shaped like a figure eight. The top speed of 244 metres per minute (800 fpm) is enabled by improvements to the printhead’s firing electronics, thermal design, and drop generator chambers (which must refill more quickly than previous designs). In the end, the non-circular bore nozzle design maintains the high resolution and sharp-edged text of SPT at much faster speed than what was possible with the circular bore nozzle.

A RAPID CADENCE OF PRODUCT ANNOUNCEMENTS AND NEW DEVELOPMENTS

Building on the Scalable Printing Technology platform, first introduced in 2006 on HP’s retail photo kiosk and used in millions of consumer printers, HP announced to the world at drupa 2008 that it was entering the high-speed continuous-feed marketplace with a technology demonstration of a massive system producing process colour at 122 metres per minute (400 feet per minute) on a



Figure 2: HP Inkjet Web Press Technology demonstration at drupa 2008

91cm (36-inch) wide web. The news was arguably the highlight of the show and made the point that HP had big plans in mind.

The drupa 2008 technology demonstration laid the ground work for the introduction of the T300, the first product in the Inkjet Web Press family, which became available in 2009. With a 76cm (30-inch) web, it was unlike any continuous-feed colour system. In addition to facilitating higher productivity, the wider web opened up new applications and market opportunities. It also created new challenges for finishing vendors, who had become accustomed to a market of digital printing systems supporting 51cm (20-inch) webs. In acknowledgment of this, HP had a range of finishing partners in its booth at drupa 2008 and has continued to work closely with these partners on finishing and other process automation tools.

2009-2011: GAINING MOMENTUM

The Inkjet Web Press entered a market in which water-based inkjet systems were mainly limited to printing on uncoated stocks. Some inkjet-treated coated stocks were available, but their high price severely limited their broad use. As the T300 proceeded through beta testing and entered the market in 2009, HP worked with key paper mills to co-develop coated papers for the book market. This opened up additional opportunities beyond the

direct mail and transaction environments, where much of the early volume of production colour inkjet systems was produced.

Leveraging the advancing substrate options, 2010 was a year of advances for applications such as colour textbooks and direct mail pieces on coated media. HP also put forth technology advances, such as improved print quality through fault tolerant masks that helped the system suppress defects. Other developments included in-press paper control and moisturizing systems that balanced moisture content in substrates to assure flat pages. The year 2010 was also when two new members were added to the Inkjet Web Press family: the T200 and T350.

The year 2011 was one of product line extension and new technology developments as HP introduced enhanced printheads and inks capable of faster speed. New to the product line in 2011 was the T400. The company also included built-in forced-air/infrared (IR) dryers to the T200 and T400 families. Throughout, HP continued its co-development work with paper vendors. The new inks and printheads allow improved speed on the T200, T350, and T400, bringing those products to the next level of productivity, building on a HP commitment to offering customers a platform strategy in which newly developed technologies would benefit the early adopters.

2012 AND BEYOND

Coming into drupa 2012, HP continues its platform expansion with the announcements of the T230, T360, and T410. These announcements extend the speed gains made possible by the A51 printheads and A50 inks. In addition, HP will show a technology demonstration of a T400 running at 800 feet per minute in process colour at drupa 2012.

In 2008, HP placed no products in the high-volume 10 million+ continuous-feed colour duty cycle segment. From that starting point, it has introduced seven products in four years, increasing its share

so that it is now (with around 16% global market share) the second leading company in a very competitive segment. HP has placed more than 70 Inkjet Web Press engines and reports that these devices have printed more than 11 billion A4/letter impressions (2.5 billion of which occurred in the last quarter).

INCREASING SUBSTRATE CHOICES

HP's Inkjet Web Press uses a 'bonding agent' to facilitate ink adhesion, minimize showthrough and spread, and improve colour gamut on untreated uncoated stocks. A bonding agent is applied by the same type of inkjet printheads that apply the other colours and, very importantly, they only apply the bonding agent where it is needed (i.e., where other colours will be laid down). The advantage of using a bonding agent applied in-line with inkjet printheads is that it allows the Inkjet Web Presses to produce quality output on virtually any uncoated stock. The technology behind HP's bonding agent is another example of how HP's knowledge of inkjet is not rooted solely in printhead design. There is also a deep understanding of ink and substrate interaction, which is evident in initiatives such as ColorPRO, a paper surface treatment that acts like the bonding agent and is generally more economical for higher coverage applications.

PARTNERSHIPS WITH PAPER MILLS

Announcements from Georgia Pacific and Appleton Coated in March of 2010 were the first public indication of how HP was working with paper mills to develop high quality inkjet-treated substrates for use on the Inkjet Web Press product line.

The Georgia Pacific announcement was important because it marked the first instance of a paper mill leveraging the ColorPRO technology and brand. The ColorPRO brand denotes that the papers employ surface treatment that facilitates high-quality print output on HP's Inkjet Web Press systems. At the time, the use of the ColorPRO brand was limited to uncoated stocks. Now in 2012, that strategy includes coated stocks. Today there are eight mills making stocks with the ColorPRO brand.

A BOOK MARKET EXAMPLE

In 2009, HP higher-education book customers in the U.S. made it clear that the lack of matte coated stock was limiting their ability to move shorter run production to the Inkjet Web Press. The most basic requirement was a 45 lb. matte coated paper commonly used for educational books. HP had planned to have coated media capabilities by 2011, but based on the demand expressed by publishers, HP fast tracked this initiative. This was enabled by greatly accelerated investment and coordination between publisher, technology provider (HP), paper manufacturer (Appleton Coated), and print service provider. Within HP, the writing systems, media, and press teams collaborated to develop a substrate to meet the high print quality demands,



Figure 3: HP Inkjet Web Press Rollout Timeline

Note: The gray arrows indicate models whose monochrome speed is faster than their colour speed. Productivity is calculated as a measure of the top web speed times the width of the web in feet.

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including that the substrate lay flat when bound. The development effort included process recipes for handling the paper, writing system profiles, and special coatings. By late 2009 (two years ahead of the original schedule), Consolidated Graphics was successfully printing its first runs using Appleton Coated's Utopia Book inkjet matte paper. Since then, this solution has been widely adopted.

COLORPRO AND GLOSSY COATED STOCKS

In addition to the dull coated stocks, there is a strong demand for glossy stocks. The availability and economics of glossy coated stocks suitable for inkjet, however, has been a barrier to success early on in this market. The simple fact is that, to print on glossy coated stocks, inkjet systems required specially treated substrates. There are not a lot of these substrates and they tend to be very expensive. HP and Appleton coated have worked together to break that barrier. Figure 4 shows an artist's conception of three inkjet treatments for coated papers:

- **Traditional glossy inkjet treatments:** Common in desktop photo and some papers used for continuous-feed inkjet systems, these papers absorb ink quickly, have high image quality and durability, and provide very high gloss levels, but are extremely expensive.
- **Ink fixative:** This approach, used in many papers for continuous-feed inkjet systems today, limits showthrough and helps prevent coalescence (i.e. when ink forms pools that result in blotchy print output). These stocks are much more affordable, but the resulting print is not very durable and the level of gloss is low.
- **New method:** As implemented by HP and Appleton Coated, this method allows for inexpensive raw materials and results in high gloss levels, wide colour gamut, good performance regarding showthrough and coalescence, and strong durability.

There is a lot of potential in HP and Appleton Coated's new method, and its success is likely to open up market opportunities for applications requiring glossy stocks.

ACHIEVING A GLOSSY APPEARANCE WITHOUT A GLOSSY STOCK

Printing on a glossy stock is not the only way to

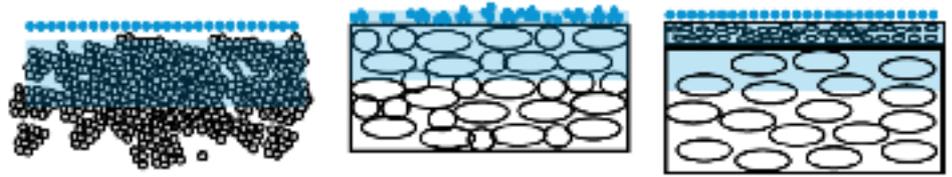


Figure 4: Artist's Conception of Three Inkjet Treatments for Coated Paper Traditional (left), Ink Fixative (centre), New Method (right)

Note: The light blue represents the vehicle (i.e., the carrier of the colorant) and the dark blue circles represent the ink colorant (for the Inkjet Web Press these are pigments)

get glossy-looking output. For many years, offset printers have dedicated one of their press units to adding a gloss coating. This is done not only to provide the shine of gloss, but also to add a protective coating - particularly in the case of print applications that are sent through the mail, as well as for ones where rough handling is the norm (e.g., menus). Units that apply a flood coating inline with the inkjet printing systems are becoming more common, with one of the latest examples being Epic's WebCoat 350, a post-print coater capable of speeds of up to 600 feet per minute. The WebCoat 350 can apply UV or aqueous coatings in line on a HP Inkjet Web Press T350.

QUALITY EXPECTATIONS AND THE FUTURE

So what is next for HP's modular structure, high performance architecture, and flexible platform? Is it safe to assume that performance increases will continue? If that is so, then the redundancy that HP has built into the Inkjet Web Press could be scaled in other directions or for other purposes. What about more colours and shades, expanded gamut and tonal range, or new substrates that open up applications and markets that are out of reach today? To set this in context, consider the high quality standards of HP's Designjet printers. A Designjet can print 12 inks at drops sizes as small as 4 to 6 picolitres. Its print resolution is up to 2,400 by 1,200 dots per inch and its quality is enhanced because of the multi-pass design in which the inkjet head shuttles back and forth across the substrate. Multi-pass methods produce great quality, but at relatively slow speeds. Compare this Designjet to a four-colour Inkjet Web Press with 6 to 9 picolitre drops and a print resolution of up to 1,200 nozzles per inch by 600 dots per inch. As you see the samples, particularly the ones on coated paper, you know

that the device is capable of high quality. Part of this is because of the nozzle redundancy that is built into HP's Scalable Printing Architecture (the same head technology, by the way, that is in Designjet printers). Higher speed is enabled by the single-pass design of the Inkjet Web Press family. Nozzle cycling and nozzle redundancy in HP's Inkjet Web Presses produce quality in a single-pass that require multiple-passes in scanning printhead systems like Designjet (which rely on multiple passes to achieve the benefits of redundant nozzles). Building on all of this capability in-house, HP has shown that the Inkjet Web Press is capable of very high levels of quality at very high production speeds. So the obvious question is what is next? What new application opportunities will this lead to?

LEVERAGING THE TECHNOLOGY TO CHANGE MARKETS

HP, unlike many companies providing high-speed inkjet systems today, has an extensive network of relationships with brand owners, enterprises, and publishers that it can leverage to promote innovative uses of inkjet. HP is also well entrenched with digitally savvy print service providers who have the process knowledge to take these tools and apply them effectively. HP calls this process 'ecosystem transformation.' Some examples will help show how HP's Inkjet Web Press is changing the way business is conducted:

- **Supply chain optimisation:** The book market is ripe for supply chain optimisation and an Inkjet Web Press customer, Courier, is using three HP Inkjet Web Press T350 systems and Muller Martini finishing to go from printed output to book blocks in signatures. The scale of the operation is impressive, but when you realize that every book coming off the line could be different, you begin to see how revolutionary this is, and how it would be impossible to match this with traditional processes. What this allows Courier to do is to offer its publishing customers a new service that builds off of an inventory model that was simply not possible with offset.
- **Mass customisation:** The next step in adding value in the production of educational texts is custom books. This type of mass customisation allows teachers to design

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their own books online by selecting from a publisher's content and combining it with content of their own. These customised educational books are one of the fastest growing business opportunities for publishers like Pearson, McGraw Hill, and Santillana.

- **Individually personalised content:** A collaboration between Hearst Corporation and Strategic Content Imaging, O'Neil Data Systems, and Brown Printing, with guidance from Cierant and HP, leveraged customer data to support a personalised, integrated marketing campaign for readers of Popular Science. The full-page, full colour, personalised advertisements contained a personalised URL (pURL) and quick response (QR) code that brought engaged readers to a personalised landing page. A special personalised full colour section was printed on the T300 and stitched into the offset printed magazine. In addition, personalised 'outserts' were printed on the HP T300, and bagged with the magazine. Spot personalisation has been possible, but never to this extent and never at this level of quality. Promotions such as this one are at the edge of a growing wave that combines compelling content with attractive offers in a highly targeted fashion. The resulting high response and conversion rates are a strong indicator of the potential such campaigns hold. Hearst immediately followed up the Popular Mechanics initiative with a similar campaign in their fashion magazine, Harper's Bazaar.

Maybe it is perspective. For too long, printers have been thought of only as craftsman, and not as communicators. Yet today, digital print and high-speed inkjet allow printheads to be used as data generators in much the same way that data is displayed on a computer or mobile device screen. This, in essence, is the challenge of how service providers take the technology and use it to make things happen that were never possible before.

INFOTRENDS' OPINION

The vast majority of printing done today is not digital. Digital printing has formed strongholds in short run, quick turnaround, and customised or personalised print, but the opportunity goes well beyond that. HP has looked at the market trajectory and has built a platform with high aspirations. Already in the short period of time that the Inkjet Web Press has been on the market, the company has moved into the number two spot in annual placements. That is not enough for HP, which is why quality is so important to them. HP sees traditional printing markets that have been relatively untouched by digital and wants that opportunity. With speeds as high as 244 metres per minute (800 feet per minute) today and everincreasing quality levels, HP is poised to define digital printing in an entirely new context. It is this vision of the future that is so impressive, HP has put the pieces in place to take digital printing to levels that have never been achieved before. Its resources, in technology and market reach, put it in an enviable position to make this dream of the future a reality. The opinions expressed in this document represent InfoTrends, Inc.'s interpretation and analysis of information generally available to the public or released by responsible individuals in the subject companies. We believe that the sources of information on which our material is based are reliable and we have applied our best professional judgment to the data obtained.

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