Digital Industrial Printing

Key highlights:

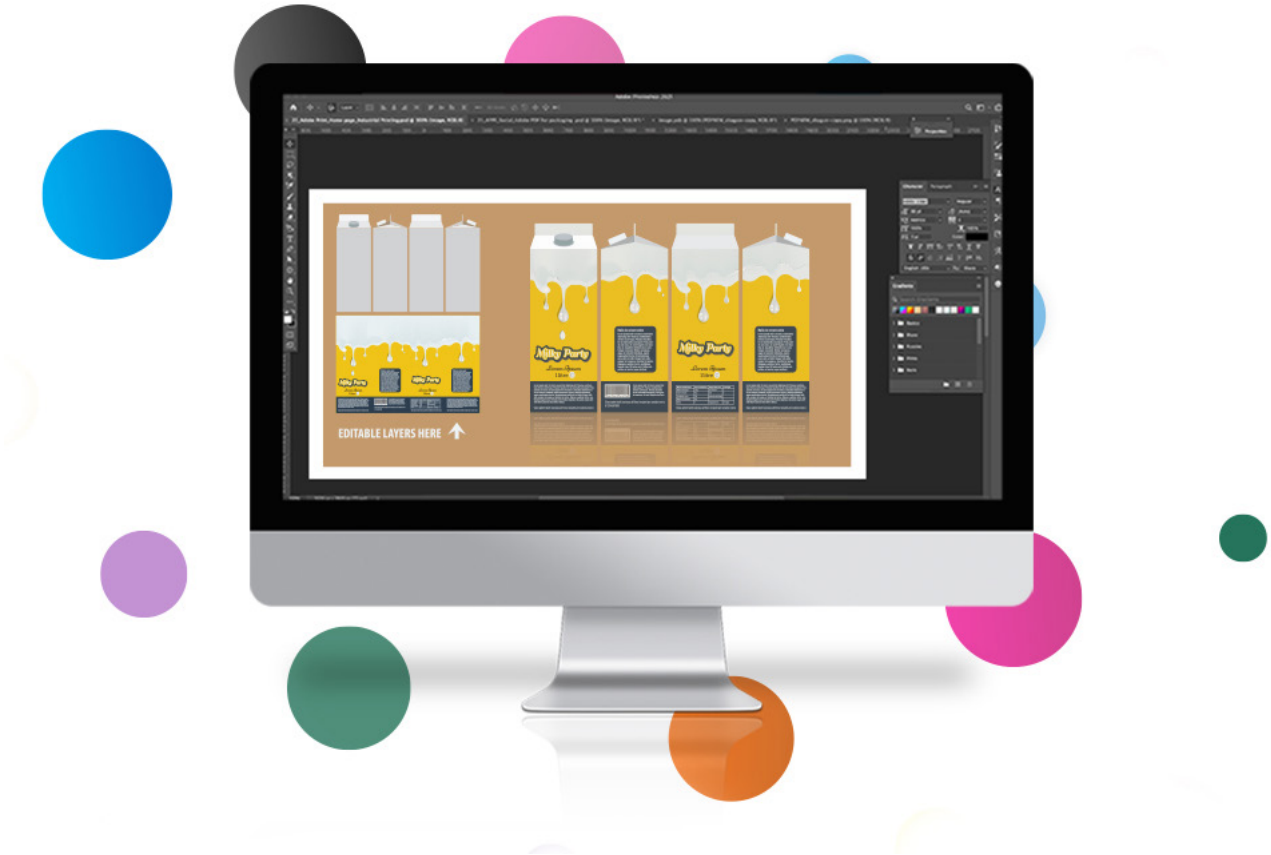
- What is Industrial Print?
- Adobe PDF Print Engine: Powering inkjet workflows
- Market leading partners
- Challenges and opportunities
- Adobe PDF Print Engine for industrial print

Technology, Innovation & The Future

What is Industrial Print?

The print industry has been around for hundreds of years. But 'industrial print' is relatively new. What does it mean? Industrial printing refers to ink imprinted onto a product as part of a manufacturing process. Print adds significant value, but its contribution is secondary to the innate value of the product itself. By way of comparison, this definition excludes all types of page printing (e.g. flyers, publications, books, booklets, forms, customer correspondence), and most other types of commercial printing e.g. brochures, photographs, signage, blueprints, security – all the familiar 'ink-on-paper' products, which are typically produced on offset presses by commercial printers. Industrial print jobs may employ offset lithography. For example: printing a design onto heavyweight card stock, before it is converted into a folded carton, which is then filled with the actual product. However, for many industrial print categories, the ink is deposited onto costly non-paper surfaces. Until recently, the main techniques employed were: flexography, rotary screen printing, gravure and indirect pad printing. Over the last decade, digital inkjet technology has made significant inroads into the industrial print landscape, disrupting long-standing businesses, and opening new horizons for product makers (manufacturers).

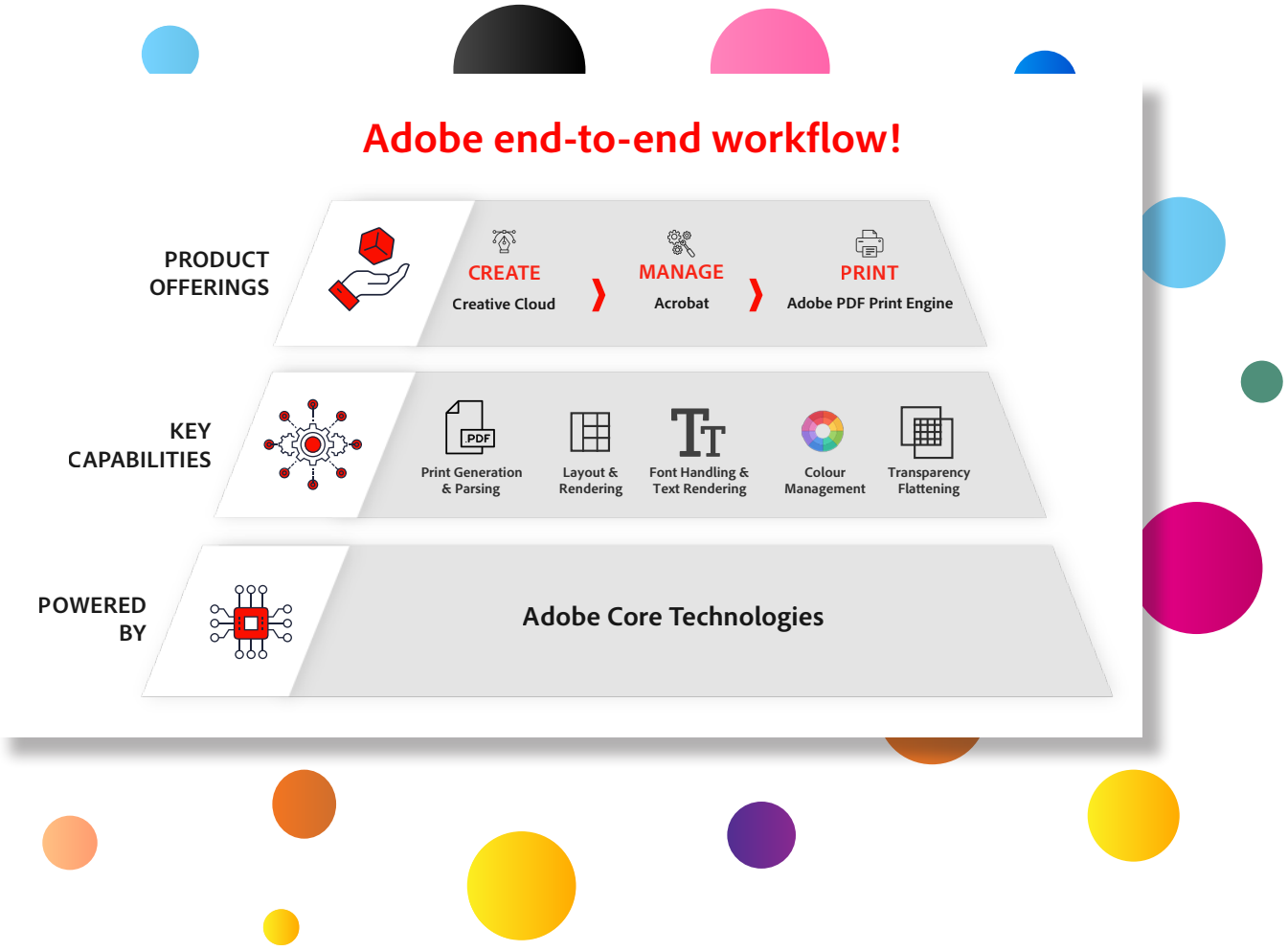
Design for manufacturing.



Like other forms of graphic reproduction, content is the essence of industrial printing. Whether it is functional (e.g. serial number), or decorative (e.g. artwork), or a combination of both, the design must be carefully crafted to produce the intended visual effect. Graphic artists will usually create an industrial print job using Adobe Photoshop CC or Adobe Illustrator CC. They know that these applications have the power, precision and versatility to build the best possible design, while working within the constraints of the physical product, and the intended printing process (e.g. available inks). At key points in the workflow, the designer will generate an Adobe PDF file to share the job with other stakeholders. Using Adobe Acrobat DC, all participants will collaborate to build consensus, and ultimately approve the design, before production begins.

Adobe PDF Print Engine.

The final critical step before printing is RIP'ing the job. Raster Image Processing converts text, images and graphics into a pixel map which specifies exactly where the ink is to be printed on the product. Adobe PDF Print Engine is the RIP software which today powers most of the world's print workflows in every industry segment. In particular, PDF Print Engine dominates inkjet printing – the non-contact technology that is transforming industrial print, driving its growth, and expanding its application to new product categories. The stakes are high, so aligning software across the industrial print workflow is the strongest guarantee of consistency and predictability. The Adobe PDF Print Engine uses the same core Adobe technologies built into Photoshop, Illustrator and Acrobat, which is key to ensuring reliability at every stage.



Industrial print segmentation.

Industrial printing can be very specialized, and jobs are often configured as part of a custom manufacturing process. Run-lengths can range from a single unit to millions of pieces. Below are the main high-level categories (with some overlaps):

Manufacturing volume – printed inline or nearline or offline

- Personalized, and on-demand (≥1)
- Custom (short-to-medium run-length)
- Large scale

Direct-to-shape – decoration & embellishment

- Flat surfaces
- Regular curved surfaces – (e.g. cylinders, tapered cones, spheres)
- Irregular curved surfaces – (e.g. molded plastics)

Product packaging and converting (and filling)

Fabrics

- Direct-to-Garment (DTG)
- **Textile** – Roll-to-Roll

Industrial print substrates.

Design and job preparation must account for the characteristics of the substrate, which can vary widely in multiple interdependent dimensions: color, opacity, weight, texture, adhesion/absorption, shape, surface energy, coating (pre and post), curing (post), etc.:

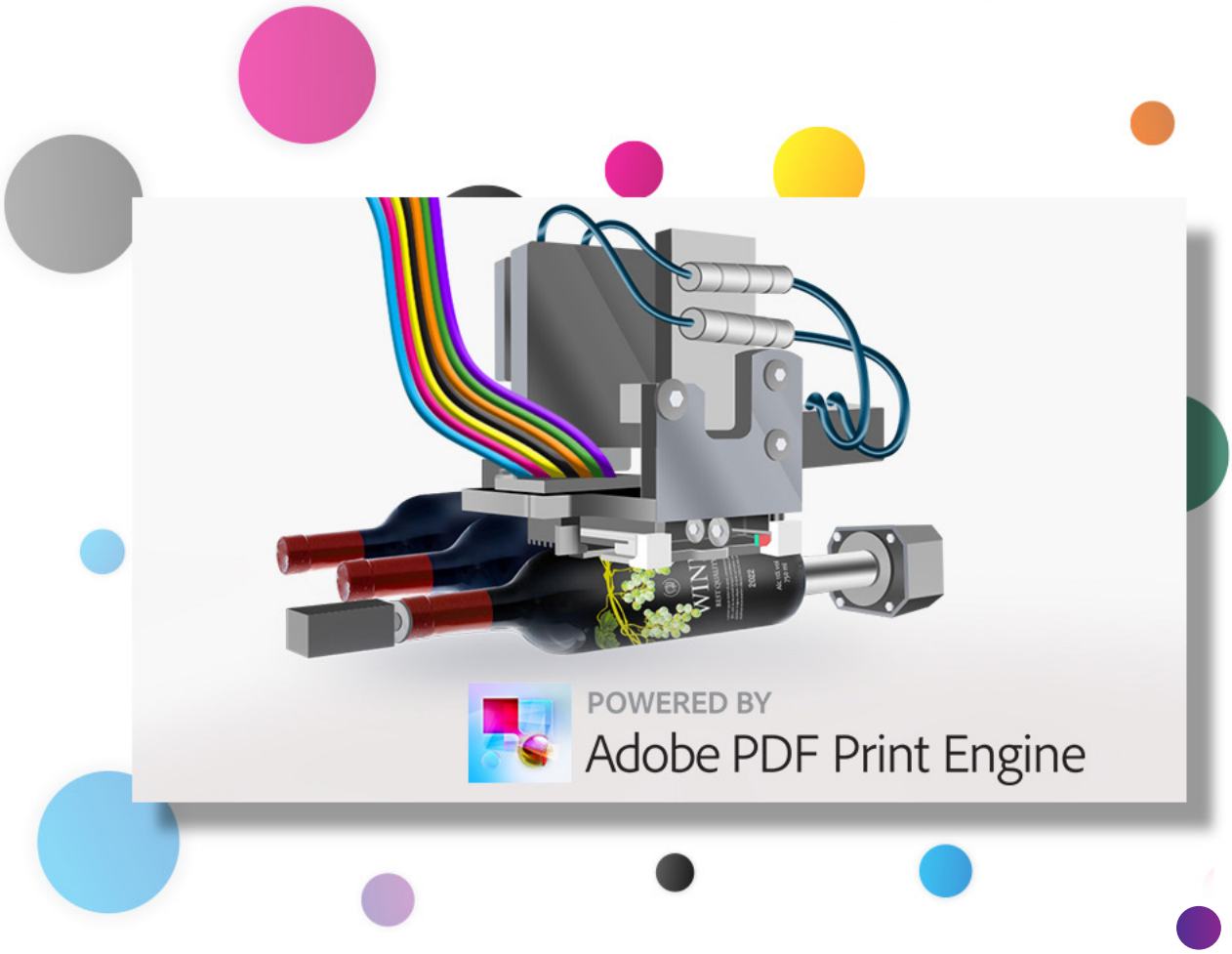
- Glass
- Plastic – rigid
- Plastic – flexible
- Plastic – film
- Metal
- Wood
- Ceramic
- Fabric
- Carton board
- Corrugated cardboard
- Vinyl
- Laminates

Industrial print job examples.

- Promotional items
- Bottles, cans, mugs
- Plastic tubs
- Lids & caps
- Wallpaper & flooring
- Parts, e.g. for aerospace, auto
- Flexible packages
- Folded cartons, Tetra packs
- Shipping boxes
- Fabrics – for décor & apparel
- Apparel, e.g. T-shirts
- Team-branded unforms

Adobe PDF Print Engine – Powering Inkjet Workflows

In 2010, Adobe launched version 2.0 of PDF Print Engine. It built on the success of version 1.0, adding a set of new capabilities to optimize output for digital presses, while raising the bar on quality and performance. It quickly became the market leader in digital print production, powering prepress workflows driving every type of inkjet press (also electrostatic and nanographic presses). Since then, inkjet technology has rapidly evolved – smaller footprint ink arrays, greater precision, variable-sized droplets, single-pass operation, new ink types, and much faster printing. These developments opened the door to novel implementations in a variety of manufacturing environments. Subsequent versions of the PDF Print Engine delivered the latest advancements in imaging science to capitalize on the potential of these hardware innovations, and to incorporate them into industrial production.



Market-Leading Partners

Adobe PDF Print Engine is the industry's fastest and most reliable rendering software. As a Software Development Kit (SDK), the Print Engine is built into solutions offered by channel partners, which fall into 2 categories:

1. **OEM Press Vendors** offer dedicated prepress solutions that are optimized for the capabilities of their hardware. Print Solution Providers (PSPs) purchase a complete package from the vendor, who also provides full-service support for all system components.

2. **RIP solution vendors** offer powerful software products which can drive many different types of digital presses, printers and finishing equipment. PSPs and manufacturers purchase these solutions bundled with their press hardware, via the press vendor, a System Integrator (SI), or directly from the RIP solution vendor.

RIP solution vendors for industrial inkjet printing.

Adobe PDF Print Engine is built into prepress solutions offered by industry-leading solution vendors. RIP products from our partners are used to manage inkjet print workflows in a broad range of industrial applications. Hundreds of different presses and print configurations are supported, and may be highly customized or integrated with finishing equipment. Job categories include: ceramics, textiles, glass, wood, corrugated cardboard, flexible/rigid plastic, flat and direct-to-shape decoration, etc.

- EFI – Fiery XF
- Global Inkjet Systems (GIS) –Atlas
- Caldera – CalderaRIP
- Onyx Graphics – Thrive
- Ricoh Industrial Group ColorGATE Productionserver
- Esko – Imaging Engine & DFE (Digital Front End)
- GMG Color – ColorProof
- CGS – Oris (proofing)

Opportunities & Challenges

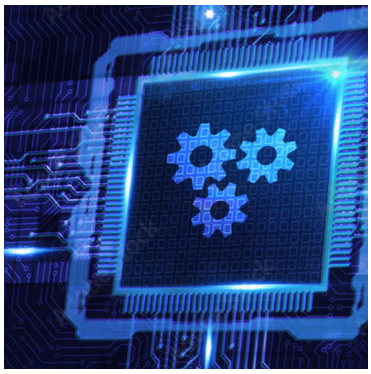
The opportunity space for industrial print is expanding rapidly. Original ideas for adding proprietary value are being tested and implemented in diverse manufacturing environments. Innovative bespoke solutions have emerged in multiple industries around the globe. To be successful, a modern industrial print application must leverage the full capabilities of the inkjet system, adapting them to the particular requirements of the product in question, while operating within the production framework. One of the key deciding factors for incorporating inkjet technology into manufacturing production is the ability to seamlessly print variable, versioned, and lot-specific content, as well as on-demand, short-run designs. But to capitalize on the new opportunities, several challenges must be addressed.

Product accountability

Batch numbers and production/expiry dates have been marked onto packages and products for decades. But today, consumers and governments are placing new demands on product manufacturers. There is a growing need to incorporate unique elements into industrial print jobs. Serial numbers or barcodes can be used to verify the authenticity of an individual product (anti-counterfeit), or to track its chain of custody at every stage, right back to point zero (loss prevention, supply chain optimization). Inkjet printing is well-suited to satisfy these requirements, since each impression can be different. Adding color to these elements, and integrating them into the design, is a big improvement over the 'add-on' approach of traditional marking and coding. However, designing, managing and efficiently producing such jobs requires new processes, software and skillsets.

On-demand personalization

There is enormous value in personalizing products, for example: photos and custom graphics imprinted on mugs, clothing, gifts, and promotional items. This manufacturing model can reduce storage, waste, and the associated logistical overhead. Digital printing is the only viable technology to make personalized products.



Automation

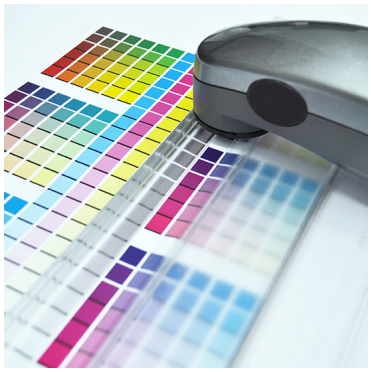
Overall productions volumes of Consumer Packaged Goods (CPGs), and all types of products, are increasing. Consumer demand for greater variety means more product versions. Greater customization and targeting (promotional, seasonal, regional, individual store) means that the average run-length for each product version is declining. To maximize the productive capacity of capital equipment, down-time must be minimized. However, the transition between jobs can be laborious, time-consuming and wasteful, e.g. equipment set-up, ink and plate changes, calibration, spin-up, etc. Digital inkjet eliminates many of these job switching tasks, one of the main reasons for its rapid growth in industrial print. The ultimate goal: seamless 'lights out' manufacturing and end-to-end process automation, from job submission to shipping – all powered by intelligent communication and decision-making.

Sustainability

Corporate responsibility can increase brand equity, so product owners seek opportunities to reduce the environmental footprint of their supply chain, manufacturing process, product packaging and the products themselves. Products, assembly lines and workflows are being redesigned to incorporate new materials, plant-based inks and waste reduction measures. Mass production is giving way to mass customization, which can reduce the environmental impact of global shipping by moving production closer to customers. This vision has been formalized by the European Union as "Industry 5.0" – a set of guiding principles for the future of manufacturing. Sustainability is the core principle, and it is supported by automation – lean and smart manufacturing is inherently green.

Customer experience

Printed graphics plays an important role in shaping the perceived value of any product, both directly and subliminally. For some types of industrial printing (e.g. textile, Direct-to-Garment), the design/print contribution may approach the value of the "blank" product. So product owners must carefully work with designers to maximize product value by tailoring the job for optimal customer experience, keeping in mind the capabilities, limitations and costs of the manufacturing process.



Managing color

Color is critical to the visual appeal of a product. But reproducing it consistently on a physical object requires careful planning and skillful execution. Trial-and-error color management is expensive, and a recipe for customer disappointment. Modern color management profiles a known printing condition (“device space”), then work backwards to convert job colors which originated in different color spaces. But jetting ink onto surfaces in industrial environments can be very dynamic, with multiple shifting factors affecting the final color. A small change in one parameter may impact other parameters.

Direct-to-shape

While printed labels can be applied to any smooth surface, printing ink directly onto a product can yield a premium appearance. Inkjet is ideal for this purpose, and can be very effective in textile, packaging and other types of product manufacturing. For curved and irregular surfaces, inkjet heads can make use of gravity to precisely target ink droplets, one of the advantages of a non-contact printing technique. But designers must account for the texture and curvature of the product surface to avoid artifacts, blurring and distortion of logos, images, text, graphics.

Registration

Until recently, monochrome printing (black ink) was sufficient for most industrial jobs. But color requirements are becoming more sophisticated, often mandating full process, or even expanded gamut inksets. During the software stage, alignment of the different color planes is perfect, by definition. But that changes once real-world physics comes into play – millions of picoliter droplets sprayed onto fast-moving surfaces. Anticipating the possibility of color plane misregistration, prepress operators may need to compensate via hardware adjustments and various software techniques.

Special effects & finishing

Manufacturing entails multiples stages leading up to product shipment and distribution. Pretreatment is sometimes needed to ensure that inks will adhere to the surface. Product decoration may take place near the end of the process. But most printing is usually followed by other steps, either inline with the press (e.g. flood varnishing, drying, rolling, stacking), nearline, or offline (different time, place). Package converting encompasses cutting, folding, gluing/sealing, shrink-wrapping and filling. Apparel printing may require cutting and sewing. Spot varnish, embossing, foils or metallic embellishments are sometimes added to preprinted graphics, usually on a different press. Foils are heat-stamped, or cold-laminated onto surfaces. A thick, shiny varnish will usually be hardened via ultra-violet light curing (UV). Metallics and some varnishes can also be applied via inkjet or electrostatic technologies, in some cases inline with graphic printing. But special effects and finishing operations must be planned together

with the text and artwork, since they are intimately related and dependent upon each other. Graphic designers and production managers need modern methods to synchronize job components in an automated manufacturing cycle.

Datastream velocity

The ongoing evolution of inkjet technology will yield even higher resolutions, greater control of droplet size, more colorants, and faster operation. Inkjet usage is already growing fast in textile and apparel printing. It will soon be integrated into new types of custom manufacturing scenarios to decorate a growing number product types. To feed the inkjet nozzles of the future, upstream data volumes will grow exponentially. This won't be a problem for simple industrial jobs, even those with complex graphics. But, for versioned jobs, jobs with variable elements or lot-specific content, every impression combines unique and common elements, and the datastream can become a firehose. Workflow components must work in tandem – rendering, compositing and transforming job elements in real-time , and caching/retrieving common (repeated) elements, in order to keep the inkjets running continuously at their full speed.

Adobe PDF Print Engine for Industrial Print

Print is part of Adobe's DNA. For over 35 years, Adobe has built software to power commercial print workflows, longer than any other vendor. Bringing the latest imaging science to the field, Adobe innovations have transformed the industry, starting with the "desktop publishing revolution" of the 1980s. In the 1990s, when the graphic arts were transitioning from analogue methods (film stripping) to digital imaging (imagesetting, platesetting), Adobe invented Portable Document Format (PDF). Its robust imaging model was ideal for prepress workflow, and PDF was rapidly adopted in the graphic arts. In 2001, the International Organization for Standards (ISO) developed PDF/X – a subset of the PDF language, optimized for the eXchange of print jobs (ISO 15930), the first of several PDF-based standards. In 2006, Adobe launched PDF Print Engine, for native rendering of PDF print jobs. Engineered on a performance foundation, PDF Print Engine uses the same Adobe technologies as Illustrator CC, Photoshop CC and Acrobat DC. Most of the leading print solution vendors employ PDF Print Engine as the core of their prepress RIPs.

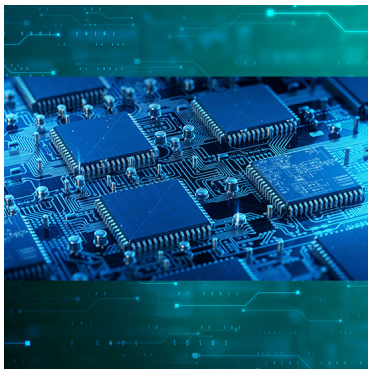
When inkjet technology hit critical mass, press manufacturers began to incorporate inkjet heads into their products. Adobe PDF Print Engine has many built-in advantages for driving inkjet presses, and today it is the dominant rendering technology for inkjet proofs, production printing and wide format printing.

As momentum behind industrial print continues to accelerate, the core strengths of the PDF Print Engine are being harnessed to increase print quality, job throughput and overall productivity in many product categories.

Variable Product Printing

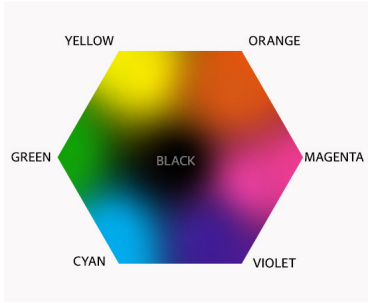
From the point of view of an industrial inkjet array, it makes no difference whether each impression in a manufacturing run is identical, or completely different, or a combination of identical + different elements. The PDF Print Engine is architected to efficiently process every category of Variable Product Printing.

- **Lot-specific manufacturing information** – batch number, date of manufacture, expiry date.
- **Targeted versions** – job subsets which contain a mix of common and versioned content targeted by region/location, language, season/holiday, time-limited promotion/event.
- **On-demand** – a single product unit, or very short run, imprinted with a high-value customized/personalized design, when printing is highly streamlined, as part of a Just in Time manufacturing process (JIT).
- **Product accountability data** – serial numbers and barcodes that are unique to an individual unit within a production run, used for authentication (anti-counterfeiting), chain-of-custody tracking, ticketing, and security printing.
- **Visual design** – random variations of graphics or images within a production run, but based on the same overall design framework.



Massive scalability

The Mercury RIP Architecture runs multiple concurrent instances of the PDF Print Engine on multi-core systems, and even across different blades and networked servers. Mercury dynamically allocates pages to dedicated instances of the Print Engine running on physical and virtual cores. Dynamic balancing of the processing load ensures that no instance is queued up with rendering tasks, while any other instance is idle. Massive scalability may be required to drive high-performance inkjet systems, especially for variable product print applications. Whatever the capacity of the inkjet arrays, or the complexity of the job, system resources can be massively scaled to the required performance level. This scalability builds on the multi-threading within each instance of PDF Print Engine, which enables parallel processing for the different phases in the rendering pipeline: interpretation, color transformation, rasterization, compression.



ECG – Expanded Color Gamut printing

Over recent decades, the print industry has experimented with various permutations of ECG. Building on the main process colors of Cyan, Magenta, Yellow and Black (CMYK), ECG adds more colorants, usually Orange, Green and/or Violet (OGV). ECG eliminates the need for dedicated spot color inks, since almost all spot colors can be accurately reproduced by a single ECG inkset. Some flexo Print Service Providers (PSPs) have adopted single-inkset printing, since it eliminates the need to change spot color inks between packaging jobs, and to run multiple jobs side-by-side, each with different spot colors. But the biggest impetus for the adoption of ECG printing is the growth of inkjet, where dedicated spot color inks are not available, or simply not practical. Adobe PDF Print Engine performs complex ECG color transforms in a single stage, resulting in fast, accurate, vivid color. Rich graphics, on-target brand colors and vibrant images can add significant value to many industrial print jobs. By pairing an ECG print system with the PDF Print Engine,

manufacturers can be assured of consistent, full gamut color reproduction across every product in the run.

Integrating graphics and manufacturing

As in other manufacturing processes, dies can be used to finish product packaging, e.g. cutting, punching holes, scoring and folding, etc. Other product types may be finished with embellishments such as metallic foil, varnish or embossing. These manufacturing elements are often specified in a CAD file, which is carried in parallel with the PDF or Illustrator file that contains the artwork. But it is imperative to synchronize the graphic and manufacturing elements across the prepress workflow. To address this requirement, print industry leaders in the Ghent PDF Workgroup defined a set of best practices which became known as PDF Processing Steps, and has been published as an international standard (ISO 19593-1:2018). Some applications emit PDF files which conform to this specification, and the PDF Print Engine fully supports PDF Processing Steps to automate the prepress workflow, and integrate printing with finishing/manufacturing. PDF Print Engine 6 also provides robust in-RIP support when spot colors are used as proxies for manufacturing elements, and can even auto-generate white underprint plates to increase color saturation when printing on fabric, metal or clear plastic.

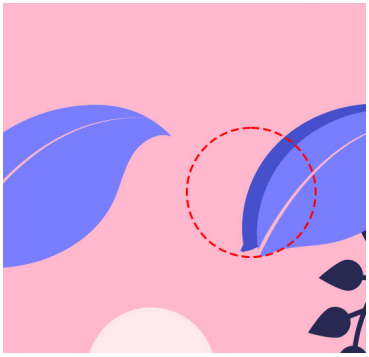
Workflow automation

Adobe is a founding member of CIP4, the print industry association which maintains the Job Definition Format (JDF). JDF and its sister format JMF (Job Messaging Format) can be used to communicate job instructions across disparate systems in a print workflow, e.g. MIS, job planning/tracking, imposition, prepress, post-press finishing. Adobe PDF Print Engine natively consumes JMF and JDF job ticket instructions, enabling real-time communication with the other system components, and seamless integration into the industrial production pipeline.

Job intelligence

PDF Print Engine supports job intelligence and real-time analytics to automate routine decision-making. These powerful features can be utilized to customize industrial applications for increased productivity and enhanced product value.

- **Transparency Decision Engine** – recommend the optimal rasterization path for pages containing transparency.
- **SmartPixels** – provide run-time information on the source of each pixel (linework, image, text).
- **Element-based actions** – enable PDF Print Engine to apply custom transforms to tagged elements.
- **Rules-based impositions** – signature and step-and-repeat impositions can be executed inline, as part of rendering, resulting in significant efficiency gains compared to preprocessing.

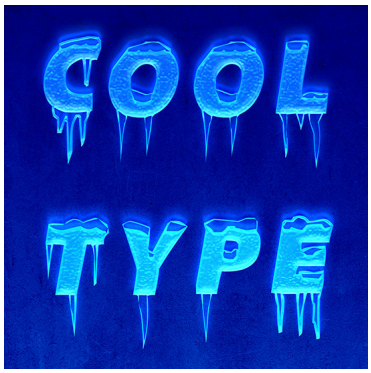


In-RIP trapping

Misalignment of color planes can be an issue in industrial inkjet applications, caused by many of the same factors found in commercial offset and flexo print shops, e.g. the side-to-side movement in any roll-fed, web press. But there are also a few inkjet-specific causes of potential misregistration, and alignment issues may be exacerbated by nozzle configuration within the inkjet array. Adobe PDF Print Engine includes an optional trapping module, which can choke or spread colors at object boundaries to prevent visible artifacts resulting from misaligned color planes. Based on rules, and executed as part of rendering, the trapping module in PDF Print Engine will work with other system components to mitigate the risk of misregistration, and contribute to visually flawless reproduction of full color graphics, text and images on manufactured products.

ACE – Adobe Color Engine

Adobe has a long history and deep expertise in color management, going back to the days of PostScript®, Adobe's founding technology. ACE is a best-of-breed CMM (Color Management Module), used for blending transparent elements, and translating colors into different color spaces, each characterized by an ICC profile (International Color Consortium). ACE is built into Illustrator CC, Photoshop CC, Acrobat DC and the PDF Print Engine. Industrial print systems that need to control color at every step can take advantage of ACE in the PDF Print Engine for precise, managed color conversions. Alternatively, solution partners also have the option of substituting a 3rd-party CMM.



CoolType

When text is printed onto a product, the characters are expressed in the chosen typeface. Font selection is an important design decision, since it adds a specific flavor to the overall job appearance, especially for large pointsize text. Fonts are seen as static job elements, but are actually computer programs that get executed when invoked by text when a job is displayed on a monitor, or rendered for printing. CoolType is the Adobe technology for rendering fonts, and is employed by all Adobe applications to display text on-screen. Print resolutions are much higher than screen resolutions. But the PDF Print Engine is able to leverage CoolType to render fonts. Typical resolutions for inkjet printing are coarser than for other print techniques. But different droplet sizes allow for different color levels at each pixel. CoolType can take advantage of this characteristic of inkjet technology to anti-alias text outlines. Anti-aliasing fills in the stairstep effect of curved/angled edges, resulting in visually smoother text appearance when viewed at normal reading distances. Anti-alias controls are especially helpful when jetting ink onto product surfaces with different textures and curvature.

Join us

For more information on how Adobe is powering industrial printing workflows,

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