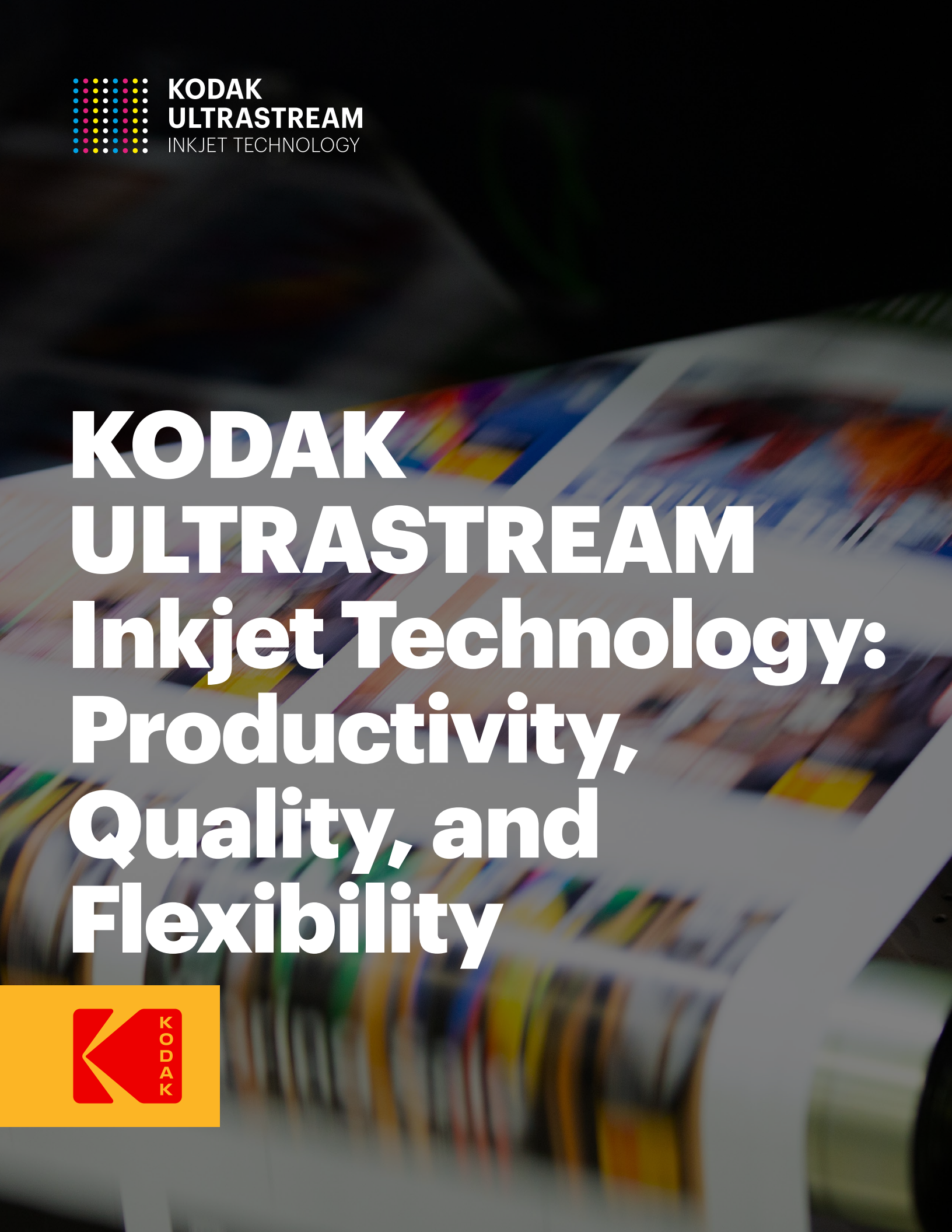
KODAK
ULTRASTREAM
INKJET TECHNOLOGY

KODAK ULTRASTREAM Inkjet Technology: Productivity, Quality, and Flexibility



ULTRASTREAM rail with jetting modules. Extensible design allows for print widths up to 249 cm (98 inches)

Introduction: Productivity, Quality, and Flexibility

Kodak's history of innovative research & development in inkjet technology has led to many new product and application opportunities in printing and packaging. The latest development in this long line of achievements is KODAK ULTRASTREAM Technology. These printheads (Figure 1) represent Kodak's fourth generation of continuous inkjet technology and are available in Kodak's own systems and those produced by its partners.

Figure 1: A KODAK ULTRASTREAM Printhead

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ULTRASTREAM Systems extend the advantages of Kodak's third-generation Stream printheads by providing higher resolution (600 by 1,800 dots per inch) and smaller drop size on top of the already extensive advantages that continuous inkjet provides. Kodak's breadth of capabilities also means that the design and manufacture of heads, inks, and customized optimizer fluids are all overseen by one source, greatly facilitating the management of ink/substrate interactions, the key to success in inkjet printing. This fact is central to the ability of ULTRASTREAM Systems to create high quality output on a wide range of papers, films, plastics, and other substrates. KODAK ULTRASTREAM Systems combine the flexibility of digital print with the productivity and quality levels of analog processes like offset lithography, gravure, and flexography.

CONTINUOUS INKJET'S ADVANTAGES FOR DIGITAL PRINT

There are two main components involved in the drop production of ULTRASTREAM Printheads: (1) a pressurized manifold with tens of thousands of nozzles capable of generating extremely small drops of ink at a rate of 400,000 drops per second; and (2) an electrode that can selectively apply a charge to these drops as they speed past at a velocity of 20 meters per second. Those drops that receive a charge are deflected and recirculated. Those drops that are not charged proceed towards the substrate and are placed with high accuracy, assuring consistent reproduction of text and image detail. (Figure 2)

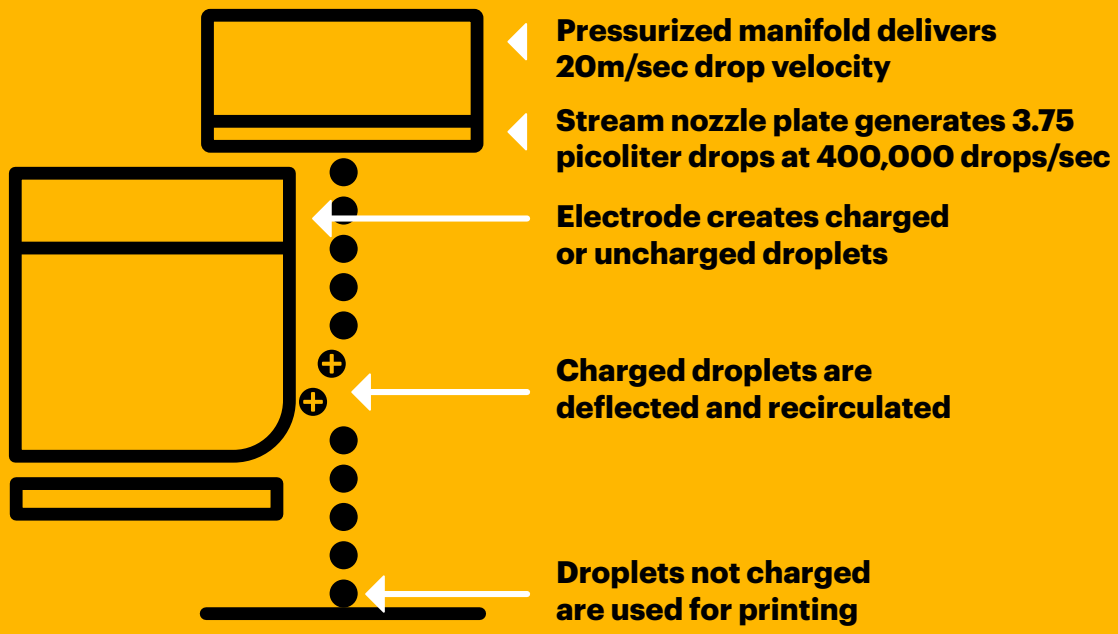

Figure 2: Electrostatic Drop Selection

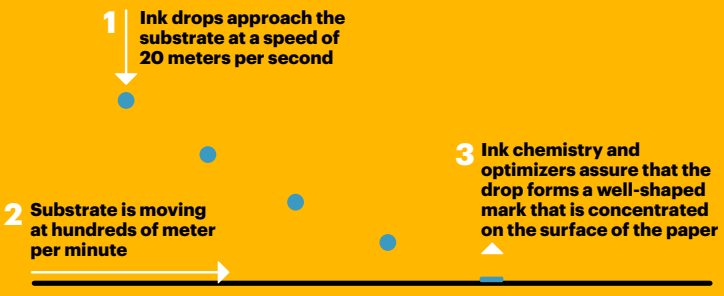

Figure 3: From airborne drop to drop on paper

The tiny 3.75 picoliter drops produced by KODAK's ULTRASTREAM Technology are one of the many factors that contribute to color quality and accurate reproduction of image detail. Other important aspects include 600 by 1,800 dot-per-inch resolution, precise and uniform dot formation, precise drop placement accuracy, ink chemistry, substrate optimizers, halftoning, and color management (Figure 3).

Managing the interaction between the ink drop and the substrate (be it paper, film, plastic, or something else) is the key to producing high-quality print and an important feature of Kodak's overall inkjet strategy. As mentioned, continuous inkjet produces very round and uniform drops, and once they hit the substrate it is important to assure that the ink's pigments do not sink or spread too broadly. Drop-on-demand inkjet, the main competitive inkjet technology for production digital printing, often produces drops that are teardrop-shaped and accompanied by satellite drops. This leads to irregular dot shape on the substrate. Poorly conceived ink chemistry and the lack of optimizers can also lead to difficulty in accurately reproducing color and detail. Kodak's years of experience in color chemistry, pigment milling, ink/paper interaction, and inkjet printhead production provide the foundation for the high levels of quality and productivity inherent in ULTRASTREAM Technology (Figure 4).

Kodak's proprietary developments in continuous inkjet provide some significant advantages over drop-on-demand competition as summarized in Table 1. Ink drop uniformity leads to better edge acuity and accurate color reproduction. High drop velocity combined with a much longer throw distance helps prevent damage to the heads caused by paper dust or paper striking the printheads. High drop velocity also allows accurate dot placement. Kodak's micromedia-milling technology produces pigment particles whose extremely small size helps to extend printhead life and to produce a wide color gamut. Kodak leverages these nanoparticulate pigments as a common toolset that simplifies their ability to serve the functional requirements of a diverse range of print applications, everything from high-quality offset printing on paper to packaging applications on film or other substrates and more. By bringing the values of digital print (plateless production, personalized print, and operational flexibility) at production speeds and quality levels typically associated with offset lithography, gravure, and flexography, Kodak is ushering in a new era of production digital printing.

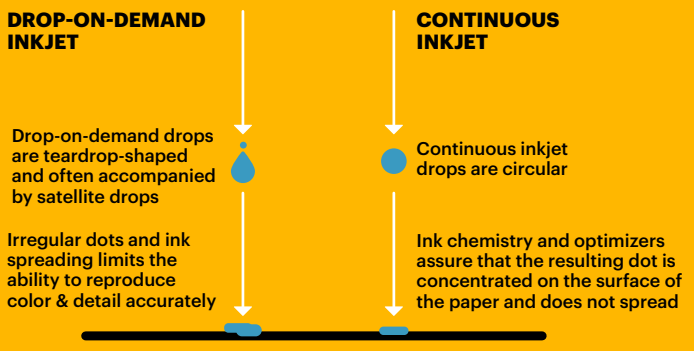

Figure 4: Comparing drop shape

Another advantage of Kodak's continuous inkjet is that because the ink flows continuously through the nozzles, it requires less of chemical substances known as humectants that keep ink from drying in the nozzles. Drop-on-demand inkjet systems need to use higher levels of humectant in their ink to prevent nozzle clogging since drop-on-demand printheads only produce drops of ink when required for printing. While humectants help keep printheads wet and unclogged, they make it harder for inks to dry when they hit the substrate. Using less humectant in an ink formulation helps for two reasons: (1) drying is simplified; and (2) the ink is less expensive. One final advantage that continuous inkjet has over drop on demand is in printhead life. Printhead nozzle life for thermal drop on demand is typically dependent on the amount of ink jetted. That means for higher coverage applications, the printheads will wear out faster. Continuous inkjet nozzle life depends on how long they are in operation. A typical continuous inkjet nozzle can jet for thousands of hours of operation, resulting in consistent productivity that is not dependent on area coverage or ink consumption.

	CONTINUOUS	DROP ON DEMAND
Drop uniformity	Spherical in shape ensuring accurate reproduction of detail	Teardrop in shape with possible satellite drops
Drop velocity	20 meters per second for accurate drop placement and high-quality reproduction	6 to 8 meters per second
Distance from nozzle to substrate	8 millimeters to reduce the chance of damage to the printhead from paper strikes and paper dust	1.25 millimeter
Pigment particle size	Kodak's micromedia milling produces nano particles that contribute to long head life and expansive color gamut	Competitors larger pigment particle size causes more light scatter and less translucency and therefore has a lower color gamut
Ink cost	Low-cost water-based formulation	Increased ink cost due to higher levels of humectants
Nozzle Life	Many thousands of hours of operation per printhead resulting in consistent production levels that are not dependent on area coverage or ink consumption	Typically much shorter and dependent on the amount of ink jetted through the printhead

Table 1: Continuous inkjet and drop-on-demand inkjet, a comparison

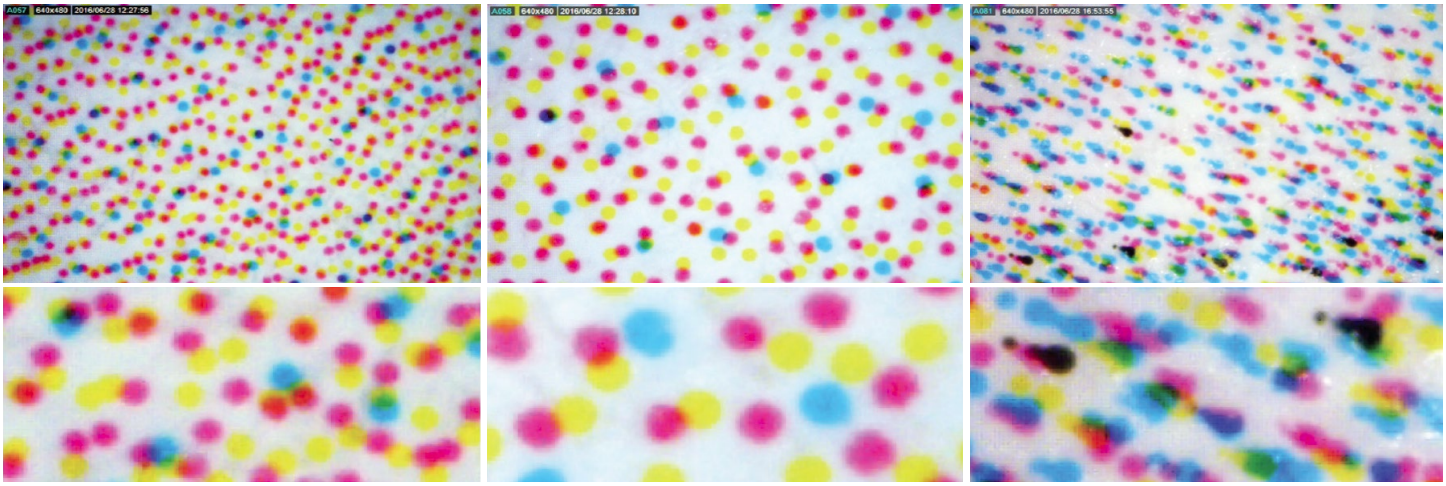

Figure 5: Microscopic view of drops placed by KODAK ULTRASTREAM Technology (left), KODAK Stream Technology (center), and a competitive drop on demand inkjet method (right)

The illustration above (Figure 5) underscores the differences in the dot formation of KODAK ULTRASTREAM Inkjet Technology, KODAK Stream Inkjet Technology, and a competitive drop-on-demand inkjet technology. On the right, note how the individual dots are irregular in their teardrop shape and sometimes accompanied by a smaller satellite drop at the tail. Dots produced by KODAK Stream Systems (in the center) are very regularly shaped and show no signs of satellite drops. On the left, dots produced by KODAK ULTRASTREAM systems are not only very regularly shaped, but they are also smaller in size than those produced by Stream. This combination of small dot size, regular shape, and accurate placement is a foundational aspect of Kodak's inkjet strategy that is furthered by competitive advantages built on the broad color gamut produced by Kodak's inkjet inks.

EXPANDING THE COLOR GAMUT FOR DIGITAL PRINT

As you combine all of these advantages, it becomes clear how nano-particle pigments, accurate dot placement, and substrate optimizers contribute to high levels of quality. To quantify that, Kodak compared the CMYK color gamut of ULTRASTREAM Technology to two industry offset lithography standards: SWOP (Specification for Web Offset Publications) and GRACoL (General Requirements for Applications in Commercial Offset Lithography). For this test, Kodak used a KODAK PROSPER ULTRA 520 Printing System on Verso TrueJet Glossy paper with KODAK PROSPER water-based pigment inks and post coating, plus a standard PROSPER ULTRA 520 System drying at 500 feet-per-minute speed.

The results show that the CMYK inks of the PROSPER ULTRA 520 produce a color gamut that is significantly larger than both of those offset lithography industry standards. In the case of SWOP, which focuses on web offset, KODAK's PROSPER ULTRA 520 system produces a color gamut that is 95% larger. For GRACol, which focuses on sheet-fed offset, the ULTRA 520 system's color gamut is 39% larger (Figure 6).

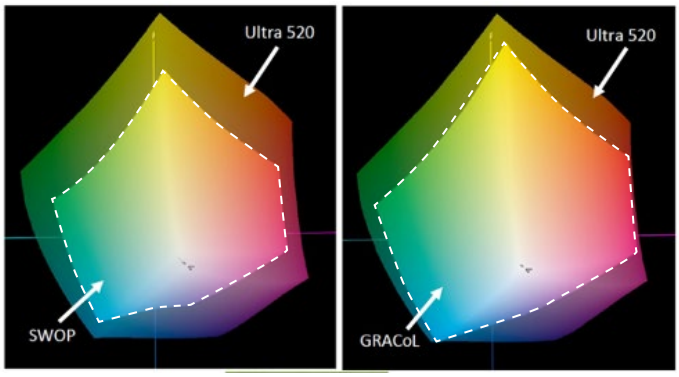

Figure 6: The CMYK color gamut of KODAK ULTRASTREAM Technology compared to SWOP (left) and GRACoL (right)

Kodak's proprietary developments in continuous inkjet provide some significant advantages over drop-on-demand competition

INKS AND OPTIMIZERS: THE KEY TO NEW APPLICATION OPPORTUNITIES

Kodak has designed the water-based (i.e. aqueous) inks for ULTRASTREAM Systems with high levels of quality and sophistication. This starts with finely milled pigments that benefit from a Kodak technology called micromedia milling that creates extremely small pigment particles (less than 50 nanometers). Smaller pigment particles help the inks dry in very thin layers with little scattering of light resulting in richer and purer colors that create a large color gamut and strong levels of image permanence. In addition, the high color strength of these micromedia-milled particles means that less pigment is required to produce high quality results. Combined with the reduced need for humectants in ULTRASTREAM Inks, this results in lower running costs than competitive systems.

But inks are only one piece of the puzzle. ULTRASTREAM Systems use water-based ink-receptive primers that are optimized for the water-based pigment inks. These printable primers enable substrate-independent print quality at high speed. Kodak has developed a range of optimizer agents for print applications on newsprint, uncoated papers, matte and glossy coated papers, and other substrates. Newly developed optimizers broaden the range of possibilities and include ones for uncoated and coated corrugated and folding carton applications as well as a film optimizer agent for impermeable substrates like plastic films, metallized surfaces, glass, and pre-printed flexographic or gravure packages. Kodak optimizers provide more than a standard primer. In addition to creating an adhesive layer so that the substrate accepts the ink, Kodak optimizers also immobilize the pigment, allowing high-speed wet-on-wet printing with no interstation drying. High quality at high speed is a hallmark of KODAK ULTRASTREAM Systems.

Kodak's strategy of water-based inks and optimizers is built on a patented strategy of prime, print, and protect to produce outstanding print quality at high speed.

- **Prime**: A thin ink-receptive optimizer is laid on the substrate to prepare its surface for effective printing
- **Print**: Continuous inkjet (CIJ) printing takes place at high speed with wide gamut inks and low levels of humectants for low-cost printing with excellent results
- **Protect**: A post-coat with either an adhesive lamination or varnish is the final step where needed to add gloss and shield from scuffing

At a system level, the combination of ULTRASTREAM Continuous Inkjet Printheads, water-based inks with low levels of humectants, nanoparticle pigments and substrate-optimized surface treatments enable low cost, high quality, and high-speed printing on a wide variety of substrates.

Figure 7: KODAK PROSPER ULTRA 520 Press and Uteco Sapphire EVO W Press

KODAK'S OWN AND THIRD-PARTY PRODUCT OFFERINGS

Kodak's own implementation of ULTRASTREAM can be found in the PROSPER ULTRA 520 press family, roll-fed production color inkjet printing systems with a maximum print width of 20.5 inches (520 millimeters), speeds of up to 500 feet per minute (150 meters per minute), and a duty cycle of up to 60 million color A4/letter-sized impressions per month. The system's 600 by 1,800 dot per inch resolution combined with Kodak nanoparticulate water-based pigment CMYK inks results in output quality equivalent to a 200 line-per-inch halftone screen (Figure 7).

In addition, Kodak has made ULTRASTREAM Printhead Technology available to key partners. When used with specially formulated optimizers, ULTRASTREAM Technology expands the application set beyond printing on paper to include printing on films for applications like flexible packaging, including personal care products, which typically must pass rigorous safety standards, and labels.

Industry recognition for KODAK Inkjet Technology includes a 2020 Intertech Technology award and a Keypoint Intelligence 2021 Outstanding Achievement award for KODAK PROSPER QD Packaging Inks and Film Optimizer Agent. Kodak's partner Uteco was also a recipient of a Keypoint Intelligence 2021 Outstanding Achievement award for its SAPPHIRE EVO W Flexible Package Printing System, which uses KODAK ULTRASTREAM Printheads along with KODAK Inks and Optimizers.

CONCLUSION: THE FLEXIBILITY OF DIGITAL PRINT WITH THE QUALITY AND PRODUCTIVITY OF ANALOG PROCESSES

KODAK ULTRASTREAM Systems enable new opportunities for production digital print through a combination of continuous inkjet printheads,

innovative ink chemistry and optimizers, and years of Kodak experience in inkjet printing. The modular and scalable design of ULTRASTREAM Printheads facilitates integration in print widths from 8 to 98 inches (104 to 2500 millimeters) for applications on paper, film, plastic, and other substrates, expanding the footprint of inkjet printing to take on the challenges of a new age of digital printing. In short, Kodak is combining the productivity and quality of analog processes like offset lithography, gravure, and flexography with the revolutionary flexibility associated with production digital print.

FEATURES	BENEFITS
3.75 picoliter round drop size	Multiple benefits: • Accurate reproduction of image detail • A tool to control ink consumption and reduce cost
600 by 1,800 dot per inch resolution	Ability to produce high-quality halftones comparable to offset printing
500 feet per minute speed at highest resolution	Productivity levels that compete with offset lithography and other conventional printing methods
Micro-media milling	Multiple benefits: • Expanded color gamut • Cost-effective use of pigment • Contributes to longer printhead life
8 mm distance from nozzle to substrate	Reduces the likelihood of damage to the head from paper strikes or paper dust
20 meters-per-second drop velocity	Provides accurate drop placement for high-quality reproduction
Thousands of hours of operation per printhead	Consistent production that is not dependent on area coverage or ink consumption
Support for print widths from 8 to 98 inches (104 to 2500 millimeters)	Modularity and flexibility for a range of print applications
Optimizer solutions	Provide flexibility to print on paper, film, plastic, and other substrates

Table 2: ULTRASTREAM System Features and Benefits

KODAK ULTRASTREAM systems combine the flexibility of digital print with the productivity and quality levels of analog processes like offset lithography, gravure, and flexography.

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KEY TERMS

Continuous inkjet (CIJ): Printhead technology used by Kodak and other manufacturers of industrial inkjet printing systems

Drop-on-Demand (DOD) inkjet: Printhead technology generally used in home and office printers and extended for use in production systems

Duty cycle: The maximum volume (generally in A4/letter-sized page equivalents) that a production printing system is capable of producing in a month

GRACoL (General Requirements for Applications in Commercial Offset Lithography): An offset lithography industry printing quality standard for sheet-fed offset

Humectants: A chemical component in inkjet inks that helps prevent ink drying and clogging of printhead nozzles

Micromedia-milling: Kodak proprietary technique of grinding pigment particles to less than 50 nanometers and very narrow particle size distributions

Optimizer: Optimizers are Kodak-developed precoat / priming solutions that are designed to facilitate the ink/paper interaction by instantly immobilizing the pigment and adhering it to the paper or other substrate at extremely high speeds

SWOP (Specification for Web Offset Publications): An offset lithography industry printing quality standard for web offset

KODAK Stream Inkjet Technology: Air-deflection CIJ printhead technology used in the KODAK PROSPER S-Series and 6000 product series and in partner products like the UTECO SAPPHIRE EVO M for flexible packaging (including personal care products), home décor (including wall paper and flooring), and product decoration

KODAK ULTRASTREAM Inkjet Technology: Electrostatic-deflection CIJ printhead technology used in the PROSPER ULTRA 520 Press and also in partner products like the UTECO SAPPHIRE EVO W for flexible packaging (including personal care products), home décor (including wall paper and flooring), and product decoration.

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Eastman Kodak Company 343 State Street Rochester, NY 14650 USA Produced using Kodak Technology.

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