ECM Tech Brief

The Reliable Digital Workflow

Enterprise Color Management (ECM) – a concept that provides the right tools and technologies to simplify color control on a global scale and ensure color consistency among suppliers.

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The Reliable Digital Workflow

How it will change the way you match and communicate color.

Digital technology and the internet have literally transformed the way business is conducted. From everyday communication to global manufacturing, such technologies have enabled completely digital workflows and enhanced the speed and frequency of business transactions, thereby increasing productivity and reducing costs.

Yet when it comes to color, the efficiency of a digital workflow has fallen short. Cost, complexity and technological limitations of color matching and communication have undermined the reliability of a digital color workflow.

This paper discusses several new technological innovations in color matching that are enabling a reliable digital workflow and bringing about hastened speed to market, simplified workflow and as a result, have made the implementation of color a more profitable venture for driving business.

Throughout the paper, the term color matching will refer to the full process of creating, developing, producing and communicating color.

How does a reliable digital workflow differ from the way color matching is done today?

Today's workflows are mostly digital, however, they are not reliable. Those specifying color are finding that the process does not meet their expectations relative to accurate color and the speed at which accurate color is achieved. Early findings indicate that the root cause is the reliability of the data input at various stages throughout the product development and manufacturing process.

Disparate color matching systems with proprietary software protocols distributed throughout complex, geographically dispersed supply chains compounds data reliability issues. The result is a product that must be scrapped, reworked, or sold at a reduced cost. Therefore, the speed, efficiency and profitability of a digital workflow are lost on poor color quality. Manufacturers are still producing inaccurate color, only faster.

However, that is about to change as new technologies close the gap between disparate color matching systems and globally dispersed enterprises and their supply chains.

Key technologies that are enabling the reliable digital workflow.

This section explores new technologies that are paving the way for a reliable digital workflow. The technologies described use an open development platform making them compatible with most existing color and manufacturing systems. Additionally, these technologies exploit the benefits of a more robust internet. In many cases, a simple software upgrade or add-on are all that is required to make an existing digital workflow more reliable.

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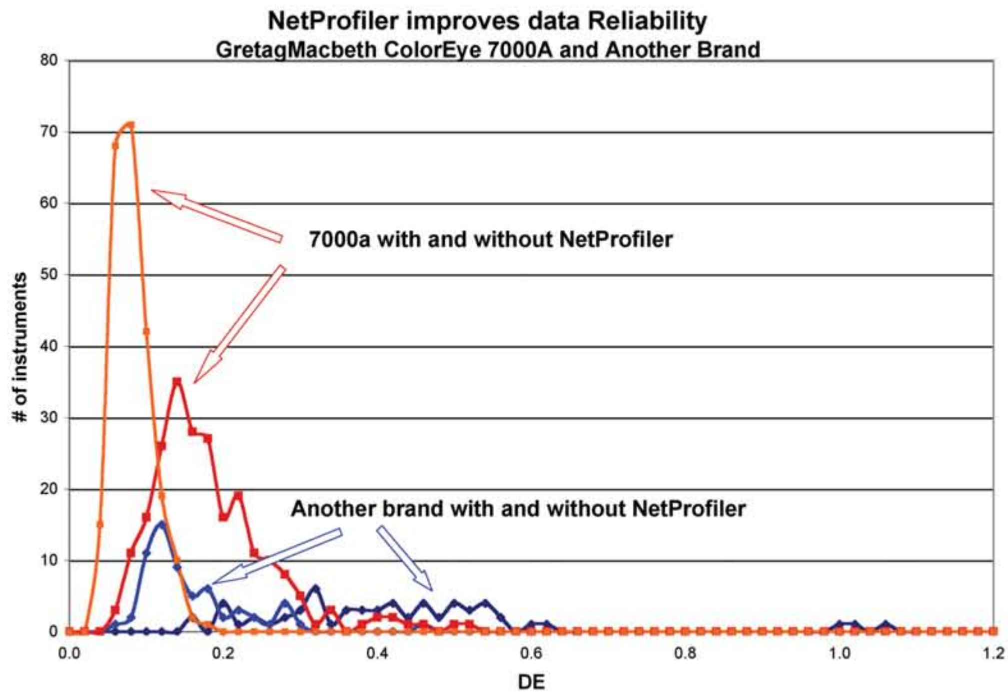
Profiling

Profiling is one of the most influential technologies driving the reliable digital workflow. It addresses the root cause of unreliable data – inconsistency. Research indicates that profiling can reduce the risk of compromised color data from entering the supply chain by approximately 68%[1]. The following chart displays the effect of profiling. It indicates a reduction in delta E (CIE L*a*b*) within a population of 228 GretagMacbeth spectrophotometers and within a population of 63 spectrophotometers of another brand. It also indicates that both populations, when profiled, output similar color data.

Figure 1.



Disparate color matching systems exposed to differing environmental conditions throughout the supply chain can introduce inconsistent or erroneous color data. Unlike physical measurements, where 10 mm measure the same on any ruler (barring operator error) regardless of environmental conditions or the age of the ruler, color measurements are much more vulnerable. Heat, humidity, temperature, dust and other environmental conditions affect the reliability of color measurements. And numerous options for configuring the instrument also impact data reliability, often in the form of operator error.

[1] *GretagMacbeth study of 250 customer-owned-and-operated spectrophotometers of several makes and models including the GretagMacbeth ColorEye®7000A.*

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Such conditions erode confidence in the accuracy of the data. Even what appears to be a small color difference compounds as a product makes its way through the supply chain resulting in scrap or rework, in addition to lower profit margins.

Profiling instruments on a regular basis insures that the instruments are operating to the manufacturers specification. In addition, instruments of different manufacturers can be brought closer together in performance so that data can be reliably shared.

Since profiling is internet based, it is now possible to monitor the performance of an entire world-wide network.

Profiling involves reading a set of tiles and transmitting data electronically back to a central laboratory. The data is then processed and a profile generated – the process taking approximately 15 minutes.

There are added service benefits that profiling brings in addition to service-related cost reductions. Until profiling, the only way to certify a spectrophotometer's performance to original factory specification was to return it to the factory or have a service technician visit. This was typically done once or twice a year. Profiling eliminates most calibration and certification-related service calls and lets the operator certify any number of spectrophotometers remotely at any time.

New advances in profiling

Recent advances in profiling include embedding the capability within the spectrophotometer. Embedded instrument profiles enable greater interoperability between the instrument and the software to reduce the potential for operator error and simplify color control. Instruments with embedded profiles come equipped with indicator lights that visibly display the instrument's calibration and certification status along with the system's configuration. The full functionality of embedded profiles is exploited when used with the e-Job concept in the Color i™QC and Color i™Match software. The e-Job concept is described in the following section.

e-Job

While the "job" concept has been used for some time, the e-Job concept adds even greater automation and collaborative color matching capability, particularly when used in conjunction with embedded profiling.

The e-Job is part of the color matching software. It "containerizes" all aspects of a job including customer color acceptance tolerances, process steps, work instructions, user interface choices and spectrophotometer configuration. When used with contemporary spectrophotometers, like the Color i7, the e-Job includes the instrument settings required for a specific job and automatically configures the instrument. Such settings include measurement mode (reflection or transmission), lens position and aperture size among others. Embedded profiles and e-Jobs can greatly reduce operator error.

Another aspect of e-Jobs is its portability. This is a key attribute in optimizing the speed and accuracy at which color matching occurs throughout the enterprise and supply chain. For example, a manufacturer with a large diverse supply chain can ensure color accuracy anywhere products are manufactured, including subcomponents coming from different suppliers. An e-Job file can be shared with other facilities and supply chain partners ensuring that color matching procedures and tolerances are adhered to by any supplier. Because all of the job requirements are containerized with an e-Job, no additional setup is required further simplifying the color matching process for recipients of e-Jobs.

Although e-Jobs alone can speed the color development process on a global scale, open architecture and common data formats found in GretagMacbeth's latest color matching

The open software platform and data format enable simple, seamless connectivity of color data to systems such as CAD/CAM, mixers, dispensers, product life cycle management (PLM) systems and others.

software programs, offer greater flexibility to optimize existing systems and protect against equipment obsolescence.

Open software platforms and data formats

Another technological breakthrough is the ability to seamlessly connect color data to other systems in the workflow. The open software platform and data format enable simple, seamless connectivity of color data to systems such as CAD/CAM, mixers, dispensers, product life cycle management (PLM) systems and others. Open platforms and data formats are currently available in the GretagMacbeth Color iMatch and Color iQC color formulation and quality control software systems.

The open software platform can literally model a color-related process flow. The connectivity resulting from open development platforms in many cases streamlines the workflow. It does this by amortizing color data over numerous processes steps that require color input, but as a result of seamless connectivity, no longer require additional color measurement.

Practical application of a reliable digital workflow

A reliable digital workflow involves the application of previously mentioned technologies to maintain accurate color inputs and consistent color reproduction throughout the workflow, including supply chain. The result is a more efficient means of manufacturing products that meet the specified color faster and at a lower cost than conventional digital color matching methods.

The next section examines the practical application of new technologies throughout the process steps in a sample production workflow consisting of: concept and design, sourcing and sampling, production, quality assurance, allocation and fabrication/assembly.

[2] *Based on data from actual GretagMacbeth customers.*

Concept and Design

In this phase, the use of profiling and open data formats can help reduce costs and improve reliability through data sharing. Profiling enables more accurate on screen color rendering among computer monitors and ensures that color is rendered consistently from monitor to printer.

Additionally, the open data format of certain spectrophotometric color measurements can also be used by CAD/CAM design systems. Uploading spectrophotometric data can improve accuracy and streamline the time it takes to conceptualize how the color will appear on a rendering of the end product.

Sourcing and Sampling

Some of the most dramatic reductions in time and cost have been realized in this phase of product development. Using conventional methods, the process can take as much as three to eight weeks. With the technologies used in a reliable digital workflow, the process is reduced to two or three weeks and even less in some cases[2].

Conventional methods involve measuring a sample using a specific spectrophotometer to ensure accurate color data input. In a reliable digital workflow, samples are measured using profiled spectrophotometers. The profiled measurement enables the distribution of digital samples that are more reliable than digital samples coming from an unprofiled instrument and much faster to distribute than physical samples.

In addition, open development platforms and data formats enable the ready use of color data from a profiled spectrophotometer to a laboratory or production color matching system where the actual color is formulated and an electronic sample is submitted for approval. It is important to note that some industries, such as apparel, are moving towards the exclusive use of digital sample approvals. This can only be achieved effectively with a

Adaptive technologies open new opportunities for on-demand color services.

reliable digital workflow in place.

While other industries continue to rely on physical samples for final approval, the reliable digital workflow can significantly reduce costs by enabling the use of reliable digital samples during the iterative process of fine tuning the color. The result is a lower cost of color development and a higher rate of approval on physical samples, which are only produced from an approved digital sample.

Production

The production phase derives additional cost benefits from profiling technology in the form of spectrophotometer management and maintenance as described previously in the "Profiling" section. However, embedded instrument profiles in conjunction with the e-Job concept play an important role in managing the complexities of today's production requirements including: managing multiple job requirements from the same or different customers, managing jobs throughout multiple production facilities and mitigating potential operator error and time delays.

Job requirements are becoming increasingly more complex and sophisticated. An e-Job allows an operator to set up these requirements within the color matching software. For example, a plastics application requires the use of small area view aperture size and an average of three measurements using D65 illuminant and the CMC color difference equation with a 2:1 l to c ratio and an overall Delta E of less than 1.5. The aforementioned parameters can be set within an e-Job and stored as a template. The e-Job will then prompt the operator to follow the procedure and automatically configure the instrument to the appropriate settings.

An e-Job can be digitally transferred to other color matching systems within the workflow, simplifying the distribution of complex requirements throughout the enterprise and supply chain. This in turn reduces errors and enables production to respond more rapidly to customer requirements from any manufacturing location.

Quality Control

Similar to the production phase, the quality control phase also involves the management of multiple customer requirements, multiple jobs and the potential for operator error. As with the production phase, the ability to model a quality assurance process using an e-Job greatly reduces setup time while preventing operator error. In addition, the quality assurance function is performed at various locations throughout the supply chain adding another level of complexity and potential for error.

The combination of profiling plus open software platforms and data formats enables the use of "digital signatures" on all color data. The digital signature automatically accompanies any profiled color data. It indicates, among other items, the date, time, and instru-ment calibration and certification status, which can be used to prevent compromised or erroneous data from entering the supply chain.

Allocation, Fabrication and Assembly

During the allocation, fabrication and assembly phases, the ability to assemble approved parts coming from multiple vendors or facilities into a cohesive and uniform final product can present a challenge. Although color matching is still not a perfect science and quite subjective, new technologies can now fine tune the process so that lot-to-lot color variations, whether within tolerance or not, can yield more acceptable final products. The result is a reduction in scrap and associated costs.

A technology known as "Clustering and Tapering" uses reliable digital color data to electronically combine parts from differing production lots into a uniform final product – it is the electronic equivalent of physically sorting bins of parts by shade so that the most closely matched shades are assembled into a single product. The cost and time savings alone can be significant.

Another issue in this phase of product development is matching standard and legacy colors despite changes in raw materials or formulas. The use of "adaptive color technology" ensures that a color is reproduced to match the exact lot from which the original color came. For example, a ceramic bathroom tile breaks. The original tile lot has since been depleted. Until "adaptive technology," there was no way to be certain that the replacement tile would match the existing tiles. Therefore, the only options were to accept an off-color tile or retile the area. Adaptive technology digitally encodes the color of the original lot so that subsequent lots can be matched to the original lot.

Combining adaptive technologies with open software platforms and data formats enable the use of color data in other systems within the workflow. Product life cycle management (PLM) systems can import color data to speed the allocation of end products.

Adaptive technologies open new opportunities for on-demand color services. Manufacturers can now offer more cost-effective short run, small lot production on-demand. This in turn enables retailers the capability of offering large scale customization on-demand.

Summary

New technologies are reducing the cost, complexity and technological limitations of conventional digital color workflows. Many of these technologies, such as profiling, can be employed within existing digital workflows to improve reliability without completely replacing existing equipment.

While some industries are just beginning to embark on the reliable digital workflow concept, several industries have already begun to specify a reliable digital workflow as a prerequisite to gaining their business.

As digital color workflows become more reliable, the entire product development workflow becomes more efficient. This not only saves hundreds of thousands in overall operating costs, but also enables additional revenue streams through value-added customization and on-demand services.

About the author:

Roland Connelly is the GretagMacbeth director of enterprise color management solutions. The immediate past president of the American Association of Textile Chemists and Colorists (AATCC), Mr. Connelly has spent over 30 years helping retailers, brands and their global supply chains use technology to improve color development. Mr. Connelly holds four U.S. patents and has published numerous papers in the field of textile color development and control. He is a frequent guest lecturer at and an active member in several international organizations including the International Committee on Illumination (CIE), American Society of Testing and Materials (ASTM) and Inter Society Color Council (ISCC) of which he is a past president and board member.