

# THE SECOND C: The Ninth Sphere of Paradise— Primum Mobile, Part 2

By Keith Hoover

*“No other heaven measures this sphere’s motion,  
but it serves as the measure for the rest.”*

—Dante Alighieri, *Divine Comedy, Paradiso, Canto XXVII*

In “Primum Mobile, Part 1,” we explored the CAP (Color Accreditation Program)—a better model for fulfilling the Color Team’s purpose. [1] Conventional lab dipping reacts to whatever arrives in the brand Color Office inbox without connecting to the dyeing process. By contrast, the CAP’s C2M2 (Color Capability Maturity Model) provides the means to assure color quality as an outcome of the dyeing process. Whereas the C2M2 provides the ability to predict a mill’s performance quality, the substance and power behind the CAP emanate from real-time access to the mills’ colorimetric data for every production lot to be shipped. In this installment, we will look at the CAP data collection process and how it provides valuable insight and feedback.

## REMEMBER, TIME IS NOT YOUR FRIEND

Conventional wisdom holds that the lab dipping process takes a long time. It does—mainly because more lab dips are requested and processed than needed. A practice seen all too often is “dipping the palette.” The brand tells mills to dip all palette colors in all fabrics just in case these colors are needed. Such practices overload the process, adding unnecessary work and cost since the majority of those lab dip requests are never converted into production orders. A well-known Chinese mill proudly told me that they create 3,000 lab dips a day—*every day*—to support their brand customers that “dip the palette.” [2]

The CAP eliminates the excess time and wasted effort of lab dipping, focusing instead on the actual colors

died on specific fabrics for which mills receive purchase orders. The model changes from “just in case” to “just in time.” [3]

## RECAPPING THE CAP

Conventional lab dipping delivers 1) an approved lab dip for color development and 2) an approved bulk sample for production. The CAP process eliminates the lab dip/color development step and focuses on the color quality of all production (brands don’t sell lab dips). The brand lab dipping process is thus *eliminated*. Period. The notion of discarding “the way we’ve always done color” can be rather unsettling. What takes its place? Actually, the new process is simple.

## CAP Color Development

The brand creates color match requests by associating a **color** with a **fabric** at a **mill** (the “Tri Key” concept)—usually when the Bill of Materials (BOM) is built. [4] These requests are sent to the mills. That does not change.

Upon receipt of these color match requests, each mill initiates work in the dye lab. If the requests are received well ahead of the projected production date, then a mill might identify a starting dye recipe using formulation software (to assure that the color is matchable) and delay the actual lab dyeing until later. Or, it might start the lab match process immediately. This flexibility allows the dye lab to spend enough time on dye recipe and procedure selection.



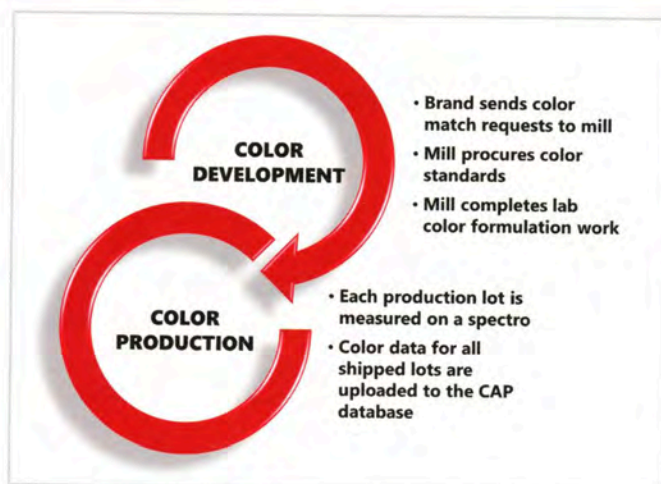


Figure 1: Steps in the CAP process.

## CAP Production

Once a mill receives an order for dyed fabric, the real work is triggered. Additional lab work may be required. A scale-up process might be in place to assure that the lab recipe is accurate in production loads. All of this takes place in the old-fashioned lab dipping process, too—it's just not seen by the brand. It has been—and will continue to be—each mill's responsibility to assure that the required lab color development is completed and ready for production.

After each production lot is dyed, it goes through an internal QC process in which various specifications such as shrinkage, WPI/CPI count, fastness, and color are checked in the testing lab. [5] For color, a fabric swatch is measured on a spectrophotometer and reviewed in the lightbox for acceptability. Again, these same steps are already in place for all production lots, whether the brand uses the lab dipping process or the CAP.

The CAP adds a simple new step. After the mill lab technician has measured a production lot and determined that the color difference is  $<1.00DE_{CMC}$ , then that record is stored in

a specific folder on the computer. [6] That's it. By doing this, that record is automatically uploaded to the CAP database establishing its color quality. [7] Measurements for all subsequent lots determined to be acceptable are stored in that folder and uploaded, as well.

## DATA AND METADATA

One key to a successful process is identifying and communicating the right stuff. When discussing digitization (the process of converting a thing into numbers) and digitalization (monetizing that data through process optimization or elimination), we must first look at what is being captured—is it data or metadata? Data describe the thing being digitized, in this case, color. Metadata are data about the data.

### Color Data

The primary source for defining absolute color is spectral data—the digital output from a spectrophotometer.

Required spectral data include:

- **Master color standard:** Master spectral data are supplied by a color standards provider or the brand
- **Batch color measurement:** Each production lot is measured to generate the data

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## Essential Metadata

In the CAP, each mill adds metadata relevant to their operation. Each batch color measurement must be associated with a brand-specified master color standard and include the following:

- **Date/Time stamp:** Included in the digital file
- **Batch ID:** The mill's internal production dye lot ID
- **Fabric ID:** The mill's fabric article ID is the preferred label, however some brands specify fabric master part IDs

## Anachronistic Metadata

Conventional lab dipping processes include metadata relevant to the brand's merchandising structure such as Division, Category, Product Type, Season, and Delivery. Color approval status is an important Key Performance Indicator (KPI) in lab dip-driven systems because it is tied to a key milestone in the product development calendar. However, CAP changes all that because color match requests sent to CAP mills leapfrog the old-fashioned color approval requirements.

This is an important point. CAP is *not* about mills self-approving lab dips. CAP mills can go straight to production (after POs are issued and delivery dates are defined) with no brand-driven approval obstacles. After all, color measurements of every production lot are posted in the CAP database that the brand can monitor for color quality verification. So, once a color match request is issued to a mill, the color status can be set to "approved" (or "BR—buy ready" or "OTB—okay to buy" or whatever acronym is specified).

## BETTER LIVING THROUGH EXCEPTION MANAGEMENT

The CAP process eliminates the problem of managing lab dip approvals for many colors on many fabrics at many mills. But is the solution worse than the problem? After all, there are multiple lots of production for each color/fabric combination across the mill matrix. Showing data for all of that stuff is going to be massive. How does the system manage such a proliferation of data? And how does a Color Team deal with all of that data without tears?

CAP is built around exception management. Production lots measuring within tolerance ( $<1.00 DE_{CMC}$ ) need no attention. Only those out of tolerance require action. That is where the CAP Maturity Levels (1 – 5) come in.

## The Brand Dashboard

The dashboard shown in Figure 2 provides a roll-up of the work in progress at each CAP mill in a given period

of time. This view shows the key information about each mill's performance:

- **From Date/To Date:** A filter to focus on specific activity
- **Mill Name:** ID of the CAP Mill
- **Type:** Dyeing process (Exhaust, Yarn, Continuous)
- **Samples:** Number of production lots in the date range (all colors combined)
- **Average  $DE_{CMC}$ :** How closely the production lots match their respective color standard
- **Precision  $DE_{CMC}$ :** How closely the production lots of each respective color match each other
- **% in Level 4 Tolerance:** The percentage of all production lots measuring  $\leq 1.00 DE_{CMC}$
- **% in Level 5 Tolerance:** The percentage of all production lots measuring  $\leq 0.60 DE_{CMC}$
- **Outliers—Level 4:** The number of production lots measuring  $>1.00 DE_{CMC}$
- **Outliers—Level 5:** The number of production lots measuring  $>0.60 DE_{CMC}$
- **CAP Level:** Calculated in real-time based on the  $DE_{CMC}$  numbers of all production lots across all colors (Figure 3)
- **Data Hygiene:** The percentage of all records containing all required data and metadata
- **Color Consistency:** A histogram plot showing the distribution of  $DE_{CMC}$  values for all production lots (Figure 4)

But wait, there's more....

Clicking on the Mill Name in the brand dashboard generates a detailed view of each mill's work in progress. As shown in Figure 5, this view is similar to the brand dashboard except that the Average  $DE_{CMC}$  and Precision  $DE_{CMC}$  values are shown for each color. Two columns—Plot and Trend—are added.

## Plot View

Clicking on "Plot" in the Mill view shows the Average Color Difference in a plot comparing all lots in the specified date range to the color standard along with the corresponding color difference metrics (see Figure 6). Illuminants can be changed to show the correct colorimetric data and the batches can be filtered based on fabric ID. Additionally, all production lots (regardless of date) can be added.

The color analyst can also see the Precision Color Difference in a separate plot that moves the color standard to the center of the cluster. Evaluating the average color difference and precision color difference (Figure 7) along with the standard deviation values for each provides an excellent way to assess the stability of production quality.



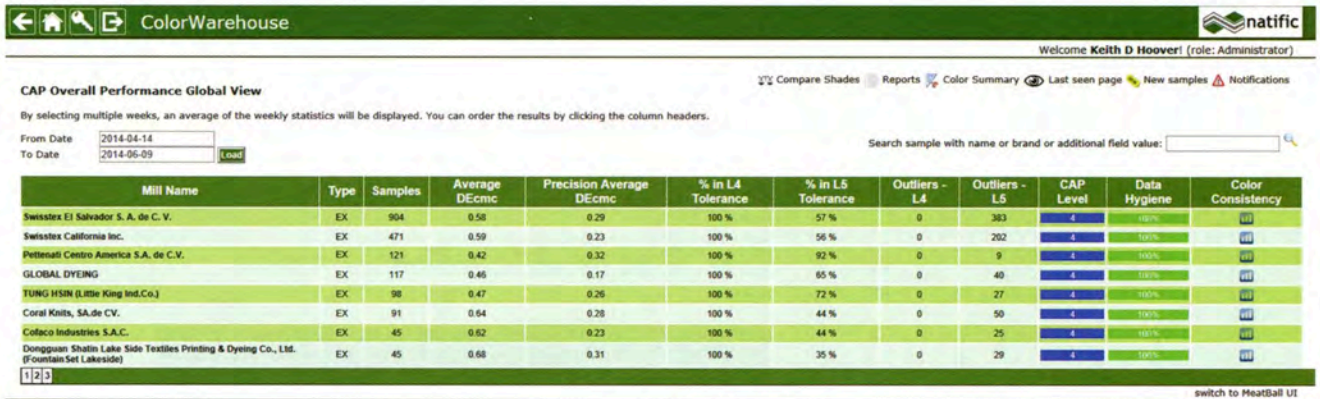


Figure 2: The brand dashboard shows a roll-up of all CAP mill production.

<b>Level 1</b>	No CAP privileges
<b>Level 2</b>	Includes lots > 1.75 DE <sub>CMC</sub>
<b>Level 3</b>	All lots ≤ 1.75 DE <sub>CMC</sub>
<b>Level 4</b>	All lots ≤ 1.00 DE <sub>CMC</sub>
<b>Level 5</b>	All lots ≤ 0.60 DE <sub>CMC</sub>

Figure 3: CAP Level specifications



Figure 4: A histogram showing Swisstex's color consistency over 1126 lots.

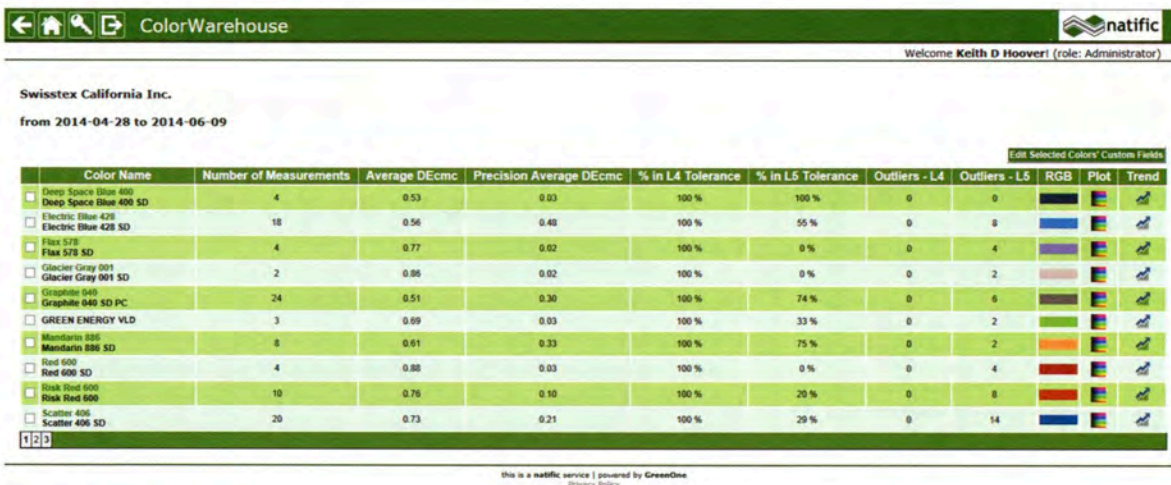
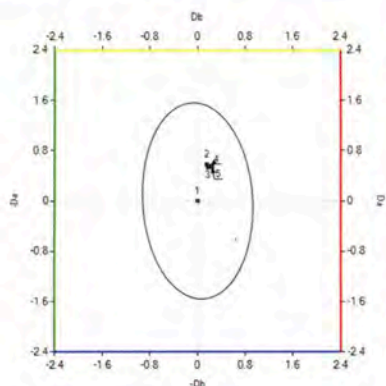


Figure 5: The mill view shows each mill's production.



from 2014-04-08 to 2014-04-09

Average DEcmc: 0.53  
Standard Deviation: 0.02



Plot all samples for this color (removes time constraint)

Color name : Deep Space Blue 400 SD

Swisstex California Inc.

Illuminant :  D65  UL3500  A

Export to QTX All fabrics

Add as MeatBall

Standard:

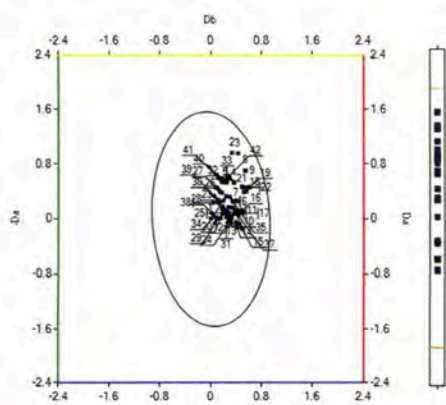
Nr.	L	a	b	C	h	Taken
1	20.66	1.25	-17.85	17.89	274.02	8/9/2013 8:12:34 AM

Samples:

Nr.	AF	Sample name	DLcmc	Da	Db	DCcmc	DHcmc	DEcmc	Taken	Delete
2		692862,63	-0.31	0.15	0.56	-0.36	0.21	0.52	9/24/13 AM	
3		692862,63	-0.31	0.17	0.53	-0.33	0.23	0.51	9/25/10 AM	
4		692864,65	-0.31	0.22	0.55	-0.34	0.28	0.54	9/25/25 AM	
5		692864,65	-0.31	0.24	0.54	-0.33	0.31	0.55	9/25/39 AM	

Figure 6: A plot of all production lots for a specific color. By the way, look closely at the third tab in the browser. Information about a mill in Los Angeles was accessed while on a flight to Shanghai.

Average DEcmc: 0.63  
Standard Deviation: 0.13



Precision plot : Average standard for color : Deep Space Blue

Export Average standard as QTX

Precision Average DEcmc: 0.37  
Standard Deviation for mean: 0.18

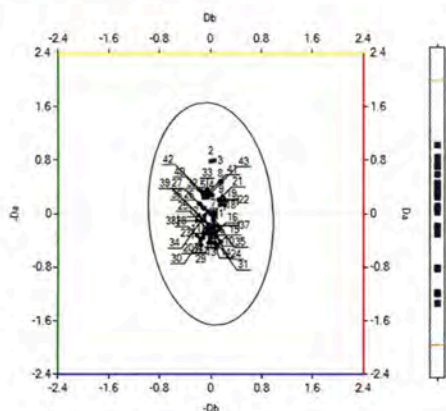


Figure 7: Accuracy vs Precision.

## Trend View

Clicking on “Trend” in the Mill view shows a trend chart that plots various colorimetric data from multiple lots of production. Viewing data like this allows the user to spot shifts in performance over time. In Figure 8, DE<sub>CMC</sub> is consistent at about 0.75 over the first 10 lots. A slight correction in depth is then made, cutting the color difference in half.

## A SIMPLE VIEW OF COMPLIANCE

In a previous installment, I stated that “simplicity is managed complexity.” For example, the face and hands of a watch manage the complexity of the gears inside in order to indicate the time. Since this is an article about digitalization, we’ll update the analogy and state that the CAP Level score serves as the watch’s digital display. It shows each mill’s quality compliance at a glance without having to drill down and look at the color differences of all the production lots. The CAP Level score is the true Key Performance Indicator because any mill scoring at Level 4 or Level 5 needs no attention—all lots (every single one of them) is within the DE<sub>CMC</sub> tolerance in each illuminant.

Therefore, the brand dashboard is the main tool used by the color office team to process all of the production color data without tears. A brand Color Analyst (formerly the “lab dip processor”) sets the “From Date/To Date” filter to a specific range (daily, weekly, etc.) and checks the CAP Level grade of all mills. If the value is 4 or above, then everything is in order.

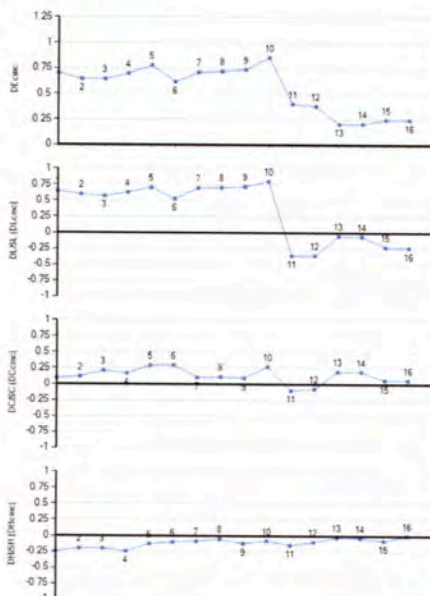
If a mill has a rating below 4, then the value in the “Outliers—Level 4” column shows how many production lots are out of tolerance. The Color Analyst can click into the mill’s detailed view to find the culprit(s). Alternatively, the Color Analyst can forego the brand dashboard and select the Meatball UI (a task view with pre-defined queries for individual mills). One of the Meatballs shown in Figure 9 is “Out of Tolerance.” In this example, all Swisstex production lots for the two-week range are in tolerance.



Illuminant : F2  
from 2023-03-06 to 2023-03-19

Swistex California Inc. - Piece Exhaust  
bella / canvas new navy 2015 standard  
3228J2

Tolerance:  Normal  Extended



Nr.	Sample name	Fabric	DLcmc	Da	Db	DCcmc	DHcmc	DEcmc	Taken	Delete
1	1408584.85	3228J2	0.65	-0.20	-0.14	0.10	-0.24	0.70	3/10/2023 7:07:36 AM	✖
2	1408584.85	3228J2	0.60	-0.18	-0.17	0.12	-0.20	0.64	3/19/2023 7:07:58 AM	✖
3	1408582.83	3228J2	0.57	-0.15	-0.30	0.21	-0.20	0.64	3/10/2023 7:06:35 AM	✖
4	1408582.83	3228J2	0.63	-0.20	-0.24	0.17	-0.24	0.70	3/10/2023 7:06:48 AM	✖
5	1408586.87	3228J2	0.71	-0.10	-0.41	0.30	-0.13	0.78	3/10/2023 8:47:36 AM	✖
6	1408586.87	3228J2	0.53	-0.08	-0.42	0.30	-0.10	0.62	3/10/2023 8:47:47 AM	✖
7	1407097.98	3228J2	0.70	-0.07	-0.15	0.11	-0.08	0.71	3/13/2023 7:03:11 PM	✖
8	1407097.98	3228J2	0.71	-0.04	-0.16	0.11	-0.05	0.72	3/13/2023 7:03:16 PM	✖
9	1408588.89	3228J2	0.72	-0.10	-0.14	0.10	-0.12	0.74	3/13/2023 7:03:52 PM	✖
10	1408588.89	3228J2	0.81	-0.06	-0.38	0.27	-0.08	0.86	3/13/2023 7:04:45 PM	✖
11	1408592.83	3228J2	-0.36	-0.13	0.14	-0.10	-0.15	0.40	3/14/2023 5:57:16 AM	✖
12	1408592.83	3228J2	-0.38	-0.08	0.10	-0.08	-0.10	0.36	3/14/2023 5:57:21 AM	✖
13	1408590.91	3228J2	-0.05	-0.02	-0.27	0.20	-0.03	0.20	3/14/2023 5:57:41 AM	✖
14	1408590.91	3228J2	-0.06	-0.02	-0.27	0.19	-0.04	0.21	3/14/2023 5:57:46 AM	✖
15	1408594.95	3228J2	-0.23	-0.06	-0.08	0.06	-0.08	0.23	3/14/2023 2:55:30 PM	✖
16	1408594.95	3228J2	-0.24	0.00	-0.08	0.06	0.00	0.24	3/14/2023 2:55:37 PM	✖

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Figure 8: A trend plot for 16 production lots.

## What about the Outliers?

In my experience, working in the CAP process since 2007, I have rarely seen mills rated below CAP Level 4. Showing up at Level 3 is a temporary anomaly (based on the date range) when one or two lots measuring slightly above 1.00 are included. These lots usually cluster closely with lots measuring less than 1.00. Using the Precision Color Difference view of all of these lots shows that the color difference risk is low because the lots match each other.

## Less is More

With all of the data, plots, and graphs in the CAP database, there is a temptation to do unnecessary work. Remember, in the old lab dipping process, a brand only saw a single lot of production (was it really production or just a "Golden Sample" sent to trick the colorist?). Other than checking for CAP Level 4 compliance and investigating an occasional exception, little else is required to assure color quality in this new process. The garment vendor receiving the fabric order is responsible for reviewing the lot-to-lot color quality (and always has been). Access to the CAP database allows garment vendors to oversee color quality much more simply. For a Color Analyst at the brand to do much more than check CAP Level 4 compliance would be like proof-reading a printed Word document against the onscreen version.

## STRATEGIC ANALYTICS

Access to CAP mill production data provides strategic benefits unavailable to lab dippers. For instance, the risk of shading when multi-sourcing fabric can be reduced or eliminated. One CAP brand was able to source the same fabric in identical colors from five

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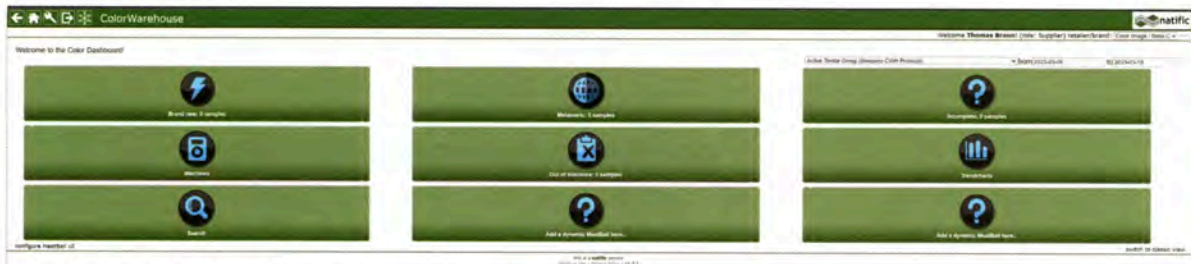


Figure 9: Pre-defined reports make spotting exceptions easy.

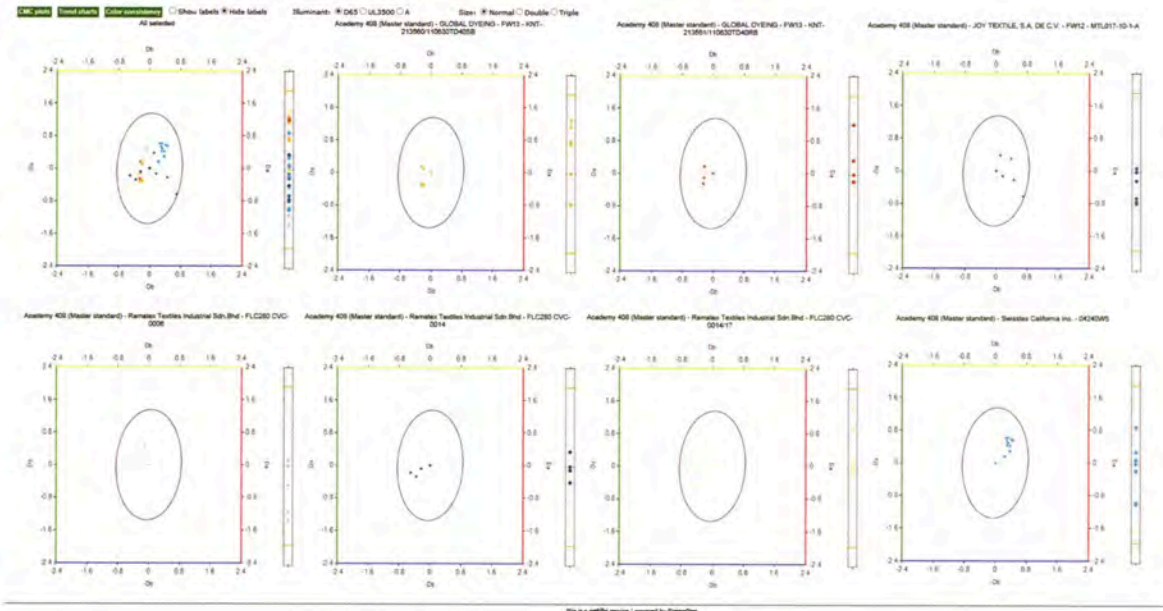


Figure 10: The same color at multiple mills can be plotted and analyzed for consistency.

different mills for use in one style produced at a single garment factory without segregating by color. Figure 10 shows a color difference plot for the same color fabric produced at eight different mills.

## THE MEASURE FOR THE REST

A case for proper metrics, tolerances, and absolute standards was presented in previous installments. Now you know why. Quadrant approval, matching approved labdips in production, and unnecessary metrics are not only silly, but they preclude the application of data analytics to tackle color quality at a global level. In the next installment, we will look at the cost of color management and determine where value is truly added.

### Notes

- [1] Natic supports the CAP industry-wide. <https://natic.com/>
- [2] Such behavior generates about 17 acres of lab dips each year and adds at least \$0.05/yard in overhead cost.
- [3] Credit goes to the clever Carol Revels, Senior Manager, Color and Fabric Operations at Lands' End.
- [4] Or, they create a spreadsheet with a bunch of colors and fabrics listed. Or, they write an email with a bunch of colors and fabrics listed. Whatever the documentation, the substance remains the same. Three things are specified: 1) color ID, 2) fabric ID, 3) mill ID. In cases where a vendor selects the mill, then the brand sends the color information and the vendor adds the mill and fabric ID. In any case, when the mill begins production dyeing, they will have been directed to dye a specific fabric in a specific color.



- [5] Some brands require third party testing on the first of production. This is a separate topic. All mills have some internal QC process to check production prior to shipping as a means of establishing quality.
- [6] A mill may choose to ship fabric that measures out of tolerance (that has always been the case before CAP). However, they are obligated to upload that measurement to the CAP database (which impacts their CAP level). If the garment factory determines a shipment to be offshade, then the CAP database is reviewed. If that lot measured in tolerance at the mill, then it must be accepted. If it measured out of tolerance, then a discussion takes place. If there is no corresponding measurement in the CAP database, then the mill is in BIG trouble.
- [7] Natic's product name for the CAP database is "ColorWarehouse" (CWH). A version called "ColorWarehouse Network" (CWN) is available to garment vendors to review the colorimetric data for all production lots on order.

Keith Hoover, President of Black Swan Textiles, implements manufacturing-centric digital processes for color and fabric development. He has implemented digital color management programs for Ralph Lauren, Target, Lands' End, JCPenney, and Under Armour, ultimately leading to a process that eliminated lab dips altogether. At Under Armour, Hoover championed the UA Lighthouse, driving digitalization and advanced manufacturing processes to explore local-for-local sourcing. He has worked hands-on in mills worldwide and is a frequent AATCC presenter.

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