10
Colour management across the supply chain

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10.1 Introduction

This chapter explains the structure of a typical colour critical supply chain in the apparel industry. This industry is chosen as an example because colour is so important there and garment supply chains are unusually complex, but the general points apply to plastic components supply chains for the automotive or electronic industries, for example, and to many other supply chains. Changes to the apparel supply change in recent years (essentially more complexity, faster) are covered, leading on to the colour processes involved and their information requirements.

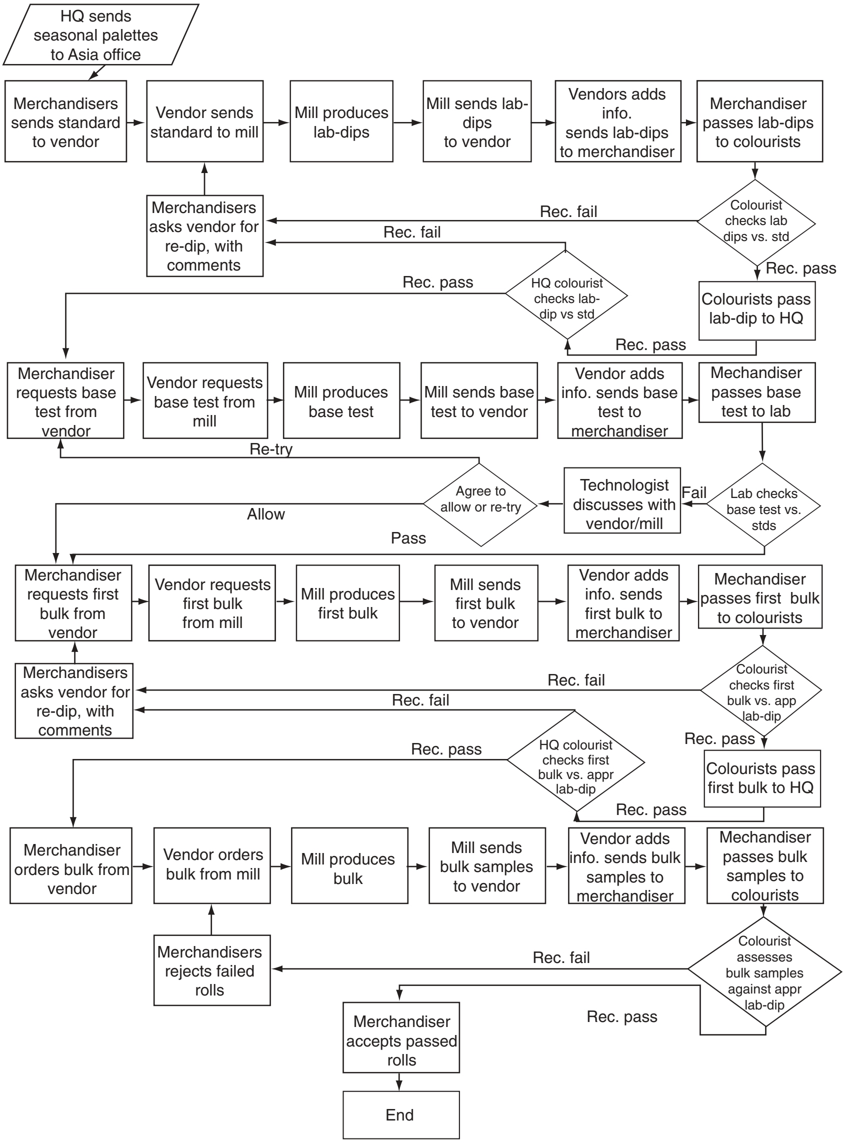
Three methods of dealing with colour information are then discussed: physical/visual, digital standalone and digital centralised, with a sub-discussion on the option of digital centralised being provided on an application service provider (ASP) model or not. The balance of pros and cons is clearly in favour of the digital centralised model, although elements of the other colour information methods will always be required alongside this.

Finally, in future trends the eventual subsuming of colour software into more normal supply chain management solutions is proposed as the logical outcome of the application of web service technology approaches. Future trends also covers increased use of multi-spectral images.

10.2 Colour supply chains

10.2.1 Supply chain explanation

The supply chain referred to here is a group of commercial operations involved in producing and selling a coloured product. In this chapter the comments focus on the apparel colour supply chain as an example, but the same trends highlighted below (more fashion, wider ranges, longer supply chains but shorter lead time targets) can also be seen in almost every industry where product colour is important (Fig. 10.1).



10.1 The workflow for a typical apparel colour supply chain (for a large UK retailer).

The colour supply chain of the apparel industry would, as a minimum, include the mill colouring the fabric, the factory cutting and sewing that fabric into a garment, and the retailer buying the garment for resale to a consumer. In practice, supply chains are usually much more complicated.

The retailer may buy from a brand owner, who may subcontract to a licensee, who may handle regional sourcing via a local office or sub-contract to a buying office, who may buy from a major vendor who subcontracts to several factories who buy fabric from a fabric agent who deals with the mill. Then there are all the companies supplying secondary components of the garment – thread, zips, buttons, straps, other trim, and so on. In all, up to 100 or so locations may be involved in getting the coloured parts of a garment produced, assembled and shipped to the buyer.

Shipping the finished garment to the retailer's warehouse is not the end of the colour supply chain, however. Colour management can extend to ensuring that garments of different sizes that hang on the same rack in the same store are the same colour, or that Internet-ordered matching top and bottom are indeed identical in colour, even if one was made several months before the other.

10.2.2 Recent changes to colour supply chains

Most areas of the supply chain for apparel have changed enormously in the past decade or two. Twenty years ago, it was not unusual for a branded apparel supplier to be selling four seasons per year of styles planned long in advance, with a fairly small colour range. Production would almost all be in the same country as the brand owner, from factories and mills that were either part of the same company or at least closely linked commercially and geographically. Retailers were mainly department stores, which typically stocked branded goods sold by the brand owners. The key changes in this situation include:

- 70%–80% or more of apparel sourcing has now switched to overseas, leading to the multi-player, multi-country supply chains described above.
- Typically, the colour specifier knows little about the supply chain, and may not know even the name or location of the final mill. When supply was from one local vertical manufacturer, most brand owners trusted that manufacturer with colour development, feasibility checks (can we make this colour on this fabric?) and production colour quality (batch-to-batch or roll-to-roll variation) control. When the mill is unknown, such trust tends to break down, and final buyers add processes such as the lab-dip approval cycle just to check that the mill can supply the required colour/fabric combination.
- 'Colour specifier' is itself a new term, as many garments are now designed and sourced by major retailers directly ('own label') rather than from brand owners. Companies like the biggest of these, Walmart, have built

their fortunes on supply chain management and want to control much of it themselves.

- Partly because of Walmart and others, the real prices of apparel have been dropping for most of those two decades. The search for ever cheaper production locations means ever longer supply chains.
- Most of the personnel in these supply chains are involved in colour decisions in so far as they decide whether to pass on, or not, colour submissions from below them in the chain. But only at the mill end and at the main colour specifier are there likely to be trained colourists, or probably any colour measurement equipment. The other personnel have principally clerical roles, but they are part of the commercial relationships and can not be left out.
- In parallel with the increasing complexity of such supply chains, the colour demands placed on them have also multiplied. Not only are there more colours in each season, there are more seasons, with the majority of companies aiming for 'fast fashion' – the ability to bring out a new line in time to catch a trend at its start. Many companies now aim for monthly product line adjustments, and some such as Zara restock their lines every 2 weeks.

10.3 Supply chain colour process requirements

10.3.1 Colour processes involved in the supply chain

Overall, then, the colour supply chain is being asked to handle more colours, faster, through a more complex web of companies. The supply chain retains the same basic colour processes as before the changes, but the added complexity has meant the pressure to modernise those processes has increased. These processes (1–8) are discussed below.

1 Choosing colours

Usually done by designers, and the range of their inspiration is already too well covered to go into again here. It is a fact that, although superb supply chain management can keep an apparel brand in profit, only improved designs can double sales overnight, so getting precisely the right colour is very important. Designers tend to need to choose from real physical examples; the challenge is to create a useful example of the required colour – a physical sample that is close enough to the desired colour to be approved by the designer. At the same time it must also be feasible to produce with minimal metamerism on all the materials it will be required on in ways that conform to other requirements for the garment (washfastness, ecologically sound colourants, and similar).

2 Checking that suppliers can produce the desired colours

As mentioned, supply chains are hugely complex nowadays and the fabric dyeing or printing facility may be on a different continent and separated by many commercial 'layers'. It is therefore usual for a colour specifier to require proof, before ordering from a particular colouring unit, that the unit can create a colour close to that required. This proof is usually a 'lab-dip' – a small piece of the required fabric coloured to the right shade. Actually, usually several 'rounds' of lab-dips are required, as the colour specifier and colour producer 'negotiate' with the initial lab-dip being rejected as too far from requirement, and successive ones getting closer until the specifier is happy or until time pressures force an agreed 'concession colour' on the specifier. During this process, the specifier and supplier also discover any issues of impracticality with the colour if not spotted before (e.g. achieving exactly the colour target with particular fastness requirements may mean use of a high cost dye).

3 Checking that bulk production matches approved lab-dip

Fabric dyeing or printing machines of production size rarely produce exactly the same colour if fed with the same recipe and fabric as the laboratory machine that produced the lab-dip. Specifiers often therefore request to see the first actual production colour as well.

4 Secondary component matching

Most garments have at least five or six components, even if that only means main fabric, second fabric (for example for a collar), lining, thread, zip and buttons. Complex lingerie items may have 20 or more components, produced from a wide range of materials, using a similarly wide range of colourants. In every case the secondary components need to be matched to the standard, but often they are also checked or re-matched later to the accepted lab-dip or even to the first production colour for the main fabric. In some cases this matching process is a colour search of a provided shade range, in others, colours are produced to match and therefore a lab-dip loop or loops are usually involved. These processes are usually managed by the main vendor or the specifier's office local to the main vendor – the degree of specifier involvement usually increases with increasing garment complexity.

5 Production checking

Long production runs invariably produce colours that vary through the run, from roll-to-roll on continuous machines or from batch-to-batch on batch machines. The requirement is to ensure that the variations are within a tight enough tolerance for all the batches or rolls to still be close to the required colour. Some specifiers leave this to the suppliers whilst some have the suppliers send examples of selected rolls or batches.

6 Colour sorting

Once the rolls arrive at a garment maker for cutting and assembly, they will need to be sorted into groups or sequences that can be cut and then assembled. The acceptable colour tolerances between two sewn pieces (for example, between the main fabric and waistband and patch pockets on khaki pants) are generally tighter than the overall tolerances that have to be accepted across any total production run. So it is necessary to group the rolls of fabric into clusters of close colours, and to adjust the laying and cutting order accordingly so that all the components cut from one fabric for any given garment are from rolls with very closely matching colours. Usually this process is left to the garment maker.

7 Distribution choices

The processes just mentioned for roll grouping mean that, whilst particular garments will be highly colour consistent, the colour variation between garments will be perceptible if they are hung together or worn together (if a suit jacket made from one fabric group is worn with trousers from another group, for example). So, in a high colour quality process it is also necessary to ensure that the grouping choices made as described create a whole group – a complete size group, for example, or even a complete group of all sizes for a particular retail channel or retail region. To do this in all cases is an ideal (or perhaps the ideal is zero roll-to-roll variation, but that is rarely achieved), so most apparel supply chains do not achieve this currently, and just have to cope with returns due to non-matches, or in-store problems with obvious variations on hanging garment racks.

A further example of the need for the colour grouping process is the increasing volume of apparel purchased on the Internet. A typical purchaser can tolerate a certain variation between the colour displayed on a web page and the colour that arrives by mail, but not any variation between two purchased items that are supposed to form a set.

8 After purchase

Finally, apparel buyers carry out several colour processes themselves, finding accessories or other apparel that match their garment as closely as possible. This is currently left almost entirely to the apparel purchaser.

10.3.2 Requirements of these colour processes

The colour information requirements of these processes are fairly simple.

- All parties involved in the colour supply chain should be trying to match exactly the same initial standard.
- They should be aware of the tolerances allowed from that standard.
- They should be able to easily access an objective measure of how far any lab-dip or production fabric deviates from the required standard.
- They should have an objective framework of description for differences between colours.
- Colour information should be able to quickly move up and down the supply chain (e.g. lab-dip submits returning to the specifier, or roll-to-roll data going to the cutter).
- Any party involved should be able to access all the data necessary for their colour role, for example a garment maker should be able to search for trim to colour match an approved lab-dip.
- Changes to colour information should be easily shared with all parties (for example, if the approved first production becomes a secondary standard, then everyone needs easy access to that new standard).
- Colour information must not degrade over time, during travel from one party to another, or be substantially affected by the environment in which it is accessed.

Finally, the non-colour information requirements must also be covered. Colour processes only work if all the people involved also have access to a great deal of additional information, on fabric types, design style references, even things as simple as lab-dip number, and this information must be reliably connected to the relevant pieces of colour information. Non-colour information also includes records of colour transactions – for example, a record of whether a particular party decided two colours were acceptably matched. Colour decisions can be very valuable or very expensive depending on the context, so keeping accurate records of them is also a requirement of all the colour processes listed above.

10.3.3 Method choices available for colour communication

The available methods for storing and communicating colour information are physical and digital, and for communication and management purposes digital colour information can be further split into standalone or centralised. To explain these in more detail.

Physical/visual

The physical/visual method is still the one used for perhaps 99% of all colour transactions. This means that colours are stored and communicated as physical examples – fabric swatches, for example. So, a specifier will send out physical examples of their standard colour, and mills in the supply chain will send back physical samples of their lab-dips or production. Non-colour information is handled in the physical method by typing it on to pieces of paper attached to the physical swatches.

Digital standalone

'Digital standalone' means that colour information is stored digitally but at many standalone locations, typically on PCs. From an IT perspective, the most important feature of digital colour measurements is that they are meaningless on their own – any digital colour transaction requires a 'colour engine' to handle the data (for example, to calculate whether the objects described by two measurements are close enough in colour terms in a particular light). This aspect of digital colour data is covered in more detail in Future Trends below, but the relevance here is that, although in a standalone digital model, the data can be transferred from one party to another, usually by point-to-point email, any party that works with it must also have access to a colour engine, normally standalone PC based colour software.

Note that physical colour information can be evaluated visually or by using a spectrophotometer, which converts the physical information into digital, so the two methods above can mix (lab-dips are sent physically, but they are checked against the standard visually and instrumentally, for example).

Digital centralised

With the digital centralised method, colour information is again stored as digital colour measurements, but in this case on one central database which can be accessed, in different ways by different parties, over the Internet (usually via a simple web browser). The server hosting the centralised database also hosts a full feature colour engine, which means parties in the supply chain can access *and* work with the data without any extra software.

Table 10.1 shows how these three options perform against the requirements listed above. The comparison applies to their use in processes a) to f) and mainly to processes a) to e). Only the digital centralised method can really be applied to processes g) and h), and then only after the developments described in Future Trends.

10.3.4 ASP or not

The combination of digital colour measurement and centralised data storage is now seen as the way forward by most technology leaders in the apparel

Table 10.1 Colour methods choices vs. supply chain requirements

Requirement	Physical	Digital standalone	Digital centralised
(a) All parties involved in the colour supply chain should be trying to match exactly the same initial standard.	Engineered physical standards are available with guaranteed variation $< \pm 0.5$ DE (CMC 2:1). Many other physical standards vary by much more than this.	Properly calibrated, profiled and maintained spectrophotometers can have inter-instrument variation $< \pm 0.3$ DE (CMC 2:1). Checking this across many instruments using email can be complex.	Properly calibrated, profiled and maintained spectrophotometers can have inter-instrument variation $< \pm 0.3$ DE (CMC 2:1). Centralised data storage of all measurements allows variations to be easily tracked.
(b) They should be aware of the tolerances allowed from that standard.	Very hard to describe tolerances allowed given only physical standards and text.	Tolerances can be simply described in numerical terms. Updating them or using different tolerances for different situations can be complex via email with many parties involved. All parties must have access to colour software.	Tolerances can be simply described in numerical terms. Updating them globally is instant, and a choice of tolerances can be easily offered. Calculations can be provided on a web browser.
(c) They should be able to easily access an objective measure of how far any lab-dips production deviates from the required standard.	Visual assessment is inherently subjective, no standardised output.	Colour variations are numerically described. All parties must have access to colour software.	Colour variations are numerically described and easily understood by all. Calculations can be provided on a web browser.
(d) They should have an objective framework of description for differences between colours.	Colour variations are very hard to describe in text-only terms in a consistent and meaningful manner.	Numerical differences are consistent and have same meaning for everyone. All parties must have access to colour software.	Numerical differences are consistent and have same meaning for everyone. Calculations can be provided on a web browser.

Table 10.1 (Cont.)

Requirement	Physical	Digital standalone	Digital centralised
(e) Colour information should be able to quickly move up and down the supply chain.	Physical swatches must be sent by mail or courier.	Digital measurements can be sent by email.	Digital measurements once saved can be accessed by anyone with permission.
(f) Any party involved should be able to access all the data necessary for their colour role.	Anyone requiring to carry out a colour transaction must collect all the physical data (such as lab-dip plus shade cards for trim),impractical for all players to do this.	Digital measurements can all be shared amongst everybody in theory. In practice many measurements and many parties to be constantly updated means this is very complex, and again all parties must have access to colour software to carry out trim search or similar.	Anyone can access all the measurements they need, for example for online search of a live trim colour database without any local software.
(g) Changes to colour information should be easily shared to all parties.	Issuing any new data means sending new physical examples to everyone involved and ensuring changeover happens everywhere.	New colour measurements can be easily circulated, though ensuring everyone has changed over can be complex.	New colour measurements can be made instantly available and any replacement of standards is centrally controlled.
(h) Colour information must not degrade over time, during travel from one party to another, or be substantially affected by environment in which it is accessed.	Physical standards fade, can be damaged or spoilt, and are affected by temperature and humidity.	Digital measurements are constant, though email communication can be corrupted.	Master of each digital measurement is stored on server, cannot be corrupted or edited.
Non-colour information must be accurately recorded and reliably linked to relevant colour information.	Only method is attaching paper details to physical swatch, can become disconnected easily.	Non-colour information can be stored with digital measurement in same file or record, though multiple storage locations and frequent passing on and editing can allow mistakes to enter.	Non-colour information can be stored with master record, always linked and available. Editing possible but centrally controlled.

sector, and the growth of this method is rapid considering that only a few years ago the concept of broadband Internet connections to a dye mill in China would have seemed a long way off. One follow-on choice to be made once a digital centralised model is chosen is whether the centralised database and colour engine should be hosted by the specifier itself (internal) or by the software solution provider (the application service provider or ASP model). The pros and cons depend mostly on the size and complexity of the supply chain involved and the IT support skills of the specifier, but the ASP model has many advantages for the apparel industry.

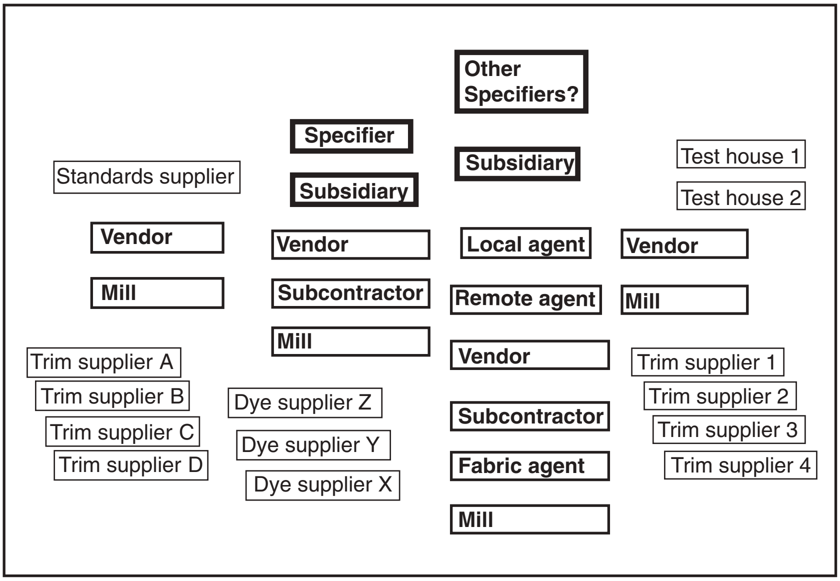
This is because an apparel supply chain may have more than 1000 parties involved, in many countries and time zones, and the actual parties may 'churn' (i.e. some are dropped, some added) continually. If the specifier IT team is responsible for managing this churn and supporting each party, the work load can be huge. Also, such support generally includes colour science education as well as software help, and is typically in a language different from that of the specifier's home country. There are also serious IT security concerns if all parties are to be brought inside a specifier network. A useful analogy is with the generally existing physical colour communication systems, which are always handled by external parties – courier companies such as UPS, Fedex, and DHL. An apparel supply chain should have its digital colour communication supported on a third-party platform for the same reasons as apparel specifiers use Fedex rather than starting their own courier company (Fig. 10.2).

In other industries this reasoning may be less valid: FMCG companies, for example, tend to run sophisticated global IT networks, and their supply chains have fewer players and fewer layers, so internal hosting may be appropriate.

10.3.5 Best practices

Most apparel supply chains will use some combination of all three methods with the centralised digital method gradually becoming the default – almost all designers and many mills will not drop their preference for physical examples of standards, and there are some benefits to offline software (for example, for recipe prediction where Internet connections are difficult or expensive). Generally accepted best practice in this area includes:

- use of a single digital measurement as the master standard for each colour, with this measurement being shared with all parties from a centralised database and colour engine, via the Internet;
- use of engineered physical standards as visual representations of the digital standard, with online ordering and recording of their use;
- optionally, the ability to switch from the original standard to a 'production standard' after first bulk production has been approved on the main



10.2 An example of the many parties involved in typical colour supply chain for the apparel industry.

fabric. This can be useful where the main fabric colour must be adjusted to take account of significant production issues (such as colourant costs and ecological effects) and where many other components must then be matched to the main fabric, especially if the garment will be viewed under many lighting conditions. If the original standard is maintained in this situation, problems of metamerism between main fabric and secondary components may arise;

- use of measurement variation tracking modules within the centralised database. As it remains normal for the specifier to still ask for a final physical example of what they have approved digitally, even if only for archiving purposes, a centralised system allows a digital re-measurement of, say, a lab-dip, to be compared automatically to the supplying mill's original measurement of it. The centralised nature of the database means any authorised user can then see live reports on the differences between the readings that refer to real textile measurements, and to act accordingly;
- continuous checking of the reasons for any measurement variations seen and addressing of them, which will typically includes training and certification in sample preparation and measurement procedures;

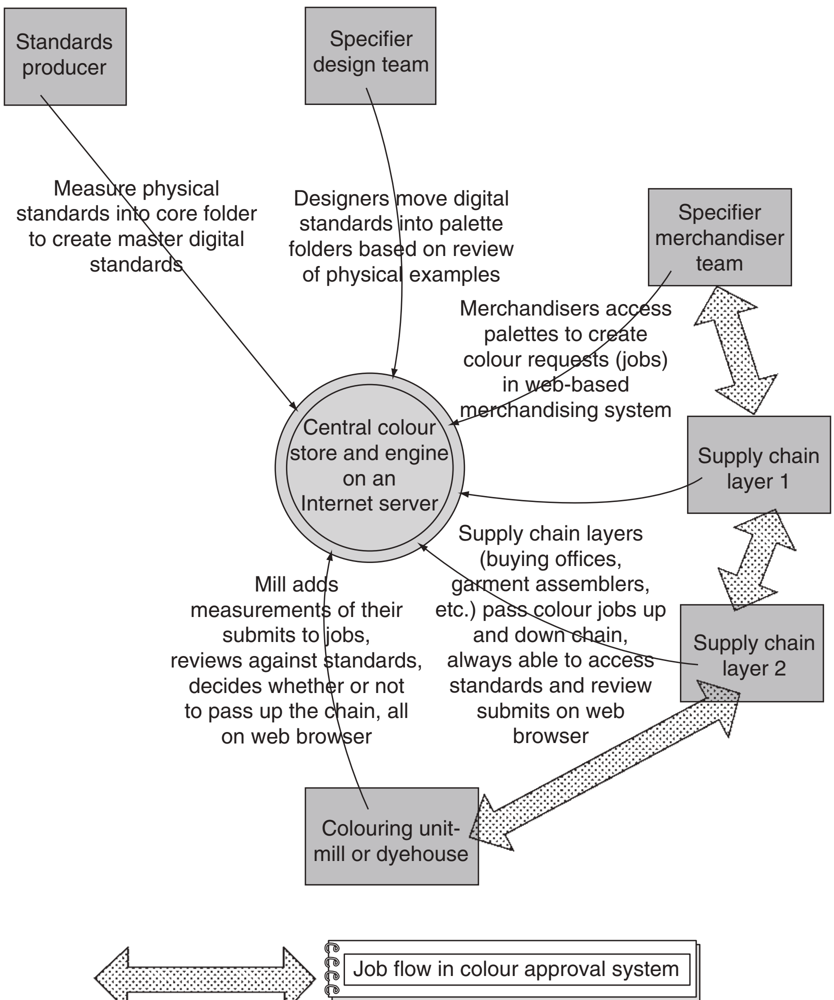
- additionally, the use of instrument profiling modules that use software to reduce measurement differences between spectrophotometers in the network. If a centralised digital solution is being used overall, the use of a centralised (for example Internet-based) profiling module is appropriate;
- constant monitoring and mining of the data stored on the database to spot bottlenecks and track improvements in colour quality, process lead times, workloads and similar.

Overall, perhaps the most important best practice in improving colour supply chains is to see colour management as yet another business process which can be improved, by measurement, by shared information and requirements, and by continuous effort. Although digital colour measurement and calculations are not perfect, for the reasons given elsewhere in this book, they are certainly good enough to give immediate improvements to most colour processes (Fig. 10.3).

10.3.6 Demonstrated benefits

The most commonly demonstrated benefit of the best practices just listed is a reduction of several weeks in colour approval lead times compared to the physical process. This typically happens because the physical process may have included between three and ten 'loops' of lab-dip submission where a specifier rejects a lab-dip, another is produced and sent, and so on (Colour Process 2 above), whereas in a centralised digital submission the supplying mill will ensure that the submit is within tolerance digitally before sending a physical sample – the specifier approves remotely and digitally and uses the physical sample only for confirmation. After a few months of using a digital colour centralised architecture, specifiers typically are approving more than 90% of the first physical submit they see, for example. Other benefits seen in most cases include:

- lead time reductions where roll measurements are shared instantly with garment assemblers to allow pre-planning of cutting and pre-selection of rolls;
- faster trim selection via online colour search, which also saves trim suppliers the cost of maintaining updated physical shade cards;
- reduced mill production costs from lower re-dips;
- lower courier and postage charges arising from all the other benefits;
- lower return costs in the retail stores;
- minimised need for spectrophotometers – standards, submits, bulk samples and rolls, etc, need only be measured once at point of production, with everyone else simply using that data – nothing should ever be re-measured except to check measurement variations.



10.3 The workflow of a typical colour supply chain on a digital centralised model.

Over time, the continued use of shared systems and agreed data means the specifier may pass authority for colour approval further down the chain, eventually perhaps using the roll-to-roll variation data just as a continuous monitor of the ongoing colour quality performance of the dye mill. If this method is reached, the supply chain will have returned close to the 'old' route of trusting a local supplier, but with the cost benefits of long-distance sourcing.

10.4 Future trends

10.4.1 Links to other software

As mentioned above, non-colour information is a major part of what needs to be communicated down a colour supply chain. Yet almost all of that information is already available inside other software solutions used in the supply chain, and typically gets re-typed into the digital colour software solutions. So the more advanced digital colour solutions are already using the latest software communication protocols (such as XML file transfer or application protocol interfaces) to take this data seamlessly and invisibly from the CAD or product lifecycle management solutions and to return status data (on where in the colour cycle a particular set of jobs has reached) back to those solutions.

10.4.2 Standardised data

Links will be made easier if all parties can agree on what the various data field headings mean in this area – there are almost as many definitions of what the difference is between 'material' and 'fabric construction' as there are specifiers involved. The American Association of Textile Colorists and Chemists, AATCC, has been working on standardising these definitions whilst their UK counterpart, the Society of Dyers and Colourists, SDC, has been addressing the standardisation of instrument measurement settings and their descriptions. This work will definitely lead to easier communication through the colour supply chain.

10.4.3 Increased use of multi-spectral imaging

The discussion above centres around the use of spectrophotometers to create digital colour information. Such instruments can measure only one colour at a time, yet many garments include textile prints with many colours on them. The mismatch is not as bad as that statement implies – almost all multicoloured textiles have their colours added one colour at a time (one yarn, one ink, etc.) and these can be individually monitored (and there are usually not many basic colours involved). The problem arises more from the enormous complexity of calculations needed to model the human response to variations in one colour in a multi-colour object. Whilst the maths needed to model human response to variations in one colour is now good enough to be used for objective colour management processes (in other words, better than any individual human checker), that is not true for the maths for multi-coloured objects. World-class research is going on in this area, however, and will definitely form part of future colour supply chain technology.

That in turn will lead to a greater need for multi-spectral imaging devices – whose output is a picture in which the spectrum of each pixel is measured or derived. These are not so far removed from current spectrophotometers – which can be described as a long thin CCD camera with a diffraction grating instead of a lens, but commercial units are only just becoming available. It is possible that such devices will replace spectrophotometers in the longer term, however.

10.4.4 The end of colour software?

To look further ahead, though, it is necessary to ask why there should be digital colour software at all. After all, there are digital measuring instruments for length, weight, yarn strength, fault levels and many other types of data that are communicated around the apparel supply chain, and around many other supply chains. So why does no one sell 'digital length software', or indeed write book chapters on 'weight in the supply chain'?

There are many differences between colour and weight as product attributes, but these differences relate principally to human perception. There are some similarities too, because weight depends on the environmental gravity just as colour depends on environmental illumination, but that is beyond the scope of this chapter. When we deal with what we call colour measurements (actually measurements of the reflectance properties of a coloured object: colour is a sensation in the brain of the observer and almost impossible to measure, as covered elsewhere in this book) we are referring typically to a set of 31 numbers output from a spectrophotometer, digitally not very different from the numbers output from a digital weighing machine. So the question remains – why do we need specialist software for dealing with colour measurements but not with weight measurements?

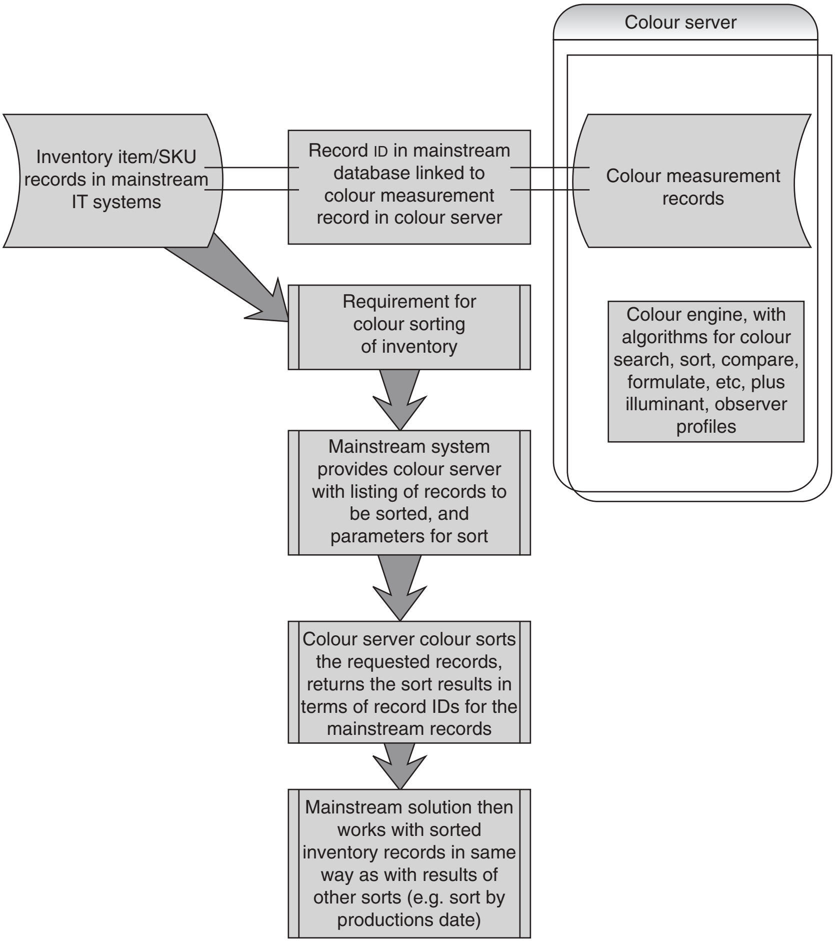
Because not only are there globally accepted systems for weight measurements (kilograms, for example) but the maths of dealing with them is available everywhere. An object weighing 1.21 kg meets the standard 1.2 kg ± 0.02 kg. In a database sorting, the 2 kg object will always show between the 1 kg and the 3 kg one. The same database can be searched for the record of the object closest in weight to my target, and if I have 10 kg of a dyestuff I can always manage a recipe requiring 3.35 kg of that dye. In other words, standard mathematical functions, of the type built in to every spreadsheet, database, CAD solution, ERP program or any other software solution, can work with weight data. There is no need to build special systems to check whether or not the supplier's fabric weight is within 2% of the specifiers standard – any purchasing system can confirm this if fed the weight data.

None of this is true for colour measurements. There are no spreadsheets sold that, given two sets of data from a spectrophotometer, can calculate how close they are in colour terms, and even the most powerful databases from Oracle or IBM or Microsoft cannot search a set of colour measurements and output the closest one to my required target (the equivalent of searching a trim shade card for a match to a lab-dip swatch). This is because, to carry out these operations, the software needs to include a colour engine that not only has all the integral maths functionality needed for working with reflectance data, but also stores all the other data (such as illuminant profiles) that is required alongside reflectance readings. And, until recently, colour engines were only available in standalone PC-based colour software. Although, in theory, Oracle could include them in a database solution, or Microsoft in a spreadsheet program, they have not chosen to do so.

Colour engines can now also be Internet based, interfacing directly with spectrophotometers (and with standalone colour software) and delivering colour measurements *plus* the required colour functionalities (colour compare, colour search, formulate, etc.) to 'clients' such as web browsers, with no additional software needed by the user. That is a major step forward for colour in the supply chain, but logically it will not stop there.

Most of the 'big' systems that run the world's supply chains (enterprise resource planning – ERP systems, inventory systems, supply chain management – SCM systems, and similar) can also act as clients for mini-applications delivered over the Internet, provided the interfaces are configured correctly. The term for the correctly configured services is Web Service Components. Almost all these big systems are built on a centralised database architecture (no one would run a global purchasing system by email), so it is simple to tag a record relating to a garment order in a big purchasing or planning system (which will have a colour name in it but no colour measurement) to a record on the centralised colour system that stores the colour measurement for that named colour. Whenever the big system wants to carry out a colour calculation on two or more items, it 'asks' the colour system for the answer, as shown in Fig. 10.4, and then carries on. For example, a supplier mill might still enter their lab-dip colour measurement into a web page to see if they met specification, but that web page might be the web-based part of a specifier's purchasing system. The colour server can also provide the data needed to show the colours on screen correctly within the purchasing system if required.

Such an approach will also address colour processes 7 and 8 above – distribution and retail logistics are already almost always controlled by big centralised database systems, so an inventory management system could 'decide' which sets of apparel to move to which shop by asking the colour server for a colour grouping – Process 7. And, the retail inventory system can ask the colour server to search all the colour measurements relating to all the items in stock to find a match for a customers target colour – Process 8.



10.4 The workflow for a combined big system and colour server colour transaction.

The leading colour software vendors are already working on achieving this vision. When they do, users will no longer use ‘colour software’, they will just work with colour inside there normal supply chain solutions in the way they work with weight now, and many colour decisions will be made automatically by those big systems. But there will be many more digital colour measurements and digital colour transactions taking place than there are now and the requirements of colour in the supply chain will finally be being met in full, or close to it.

10.5 Conclusions

Apparel is used here as an example but all colour supply chains have, in recent years, seen greatly increasing complexity, coupled with requirements for much faster throughput. These challenges can only be met by the fuller use of digital colour measurement and communication, and the current best practice is for a combination of centralised digital colour solution (with database and colour engine available via the Internet) and engineered physical standards. But the full needs of colour in the supply chain will only be close to being met when colour software as a specialist solution has faded from sight and colour functions are built into generic supply chain management and distribution software via the technology of Web Service Components. At that point, in addition, whole new business opportunities will open up for colour processes.

10.6 Further reading

Description of the apparel supply chain, see *Birnbaum's Global Guide To Winning the Great Garment War* by David Birnbaum.

Methods and best practices to be used in digital colour communication. The AATCC website at http://www.aatcc.org has a wide library on recommended practices, including *Color Management Principles*. This site also covers the work on standardised descriptions for non-colour data.

Explanation of spectrophotometer profiling technology. A market leader in this area explains their approach at http://www.gretagmacbeth.com/index/products/products_color-communication/products_color-compliance/products_netprofiler.htm

Explanation of other supply chain management solution areas. There are numerous books and papers on this area. TC2 has a wide library of those relating to apparel and textiles at http://www.techexchange.com/apparel-supply-chain.html

Explanations of ASP and web service technology models. *Out of the Box: Strategies for Achieving Profits Today and Growth Tomorrow Through Web Services* by John Hagel III. John Hagel has written widely on this field, and many more papers can be found at www.johnhagel.com.