BY **MIKE WOOD**

Potpourri

OVER THE YEARS of writing these articles I often receive comments from readers (which I am very appreciative of, thank you) that spur further thoughts. Additionally, technology moves inexorably onwards and some the things I've written about now have new information. I have a little list of these items, but none of them are enough to fill an entire column. Accordingly, this issue, I'm doing what TV companies do at the end of a season and presenting a set of snippets culled from the cutting-room floor!

> **"If anyone tells you they really understand color theory and how it works, they are lying to you."**

Switches and multicast traffic – *Protocol* Fall 2017

I'd like to start with the article I presented in the previous issue of *Protocol* concerning problems I had with switches in a streaming ACN (*ANSI E1.31*) network. That elicited as many responses as I can remember about any of my articles (excepting perhaps the ones on animal eyes and color names). It seems many folks have had the same or similar problems when it comes to dealing with large lighting networks; not just with streaming ACN but with other protocols as well. I should re-iterate that the problems I had were nothing to do with streaming ACN itself, which performed perfectly, but with the off-the-shelf switches we purchased to handle the network traffic. Commercial switches and routers may or may not handle our kind of traffic, but it's just about impossible to tell without testing it on-site. In many cases of course, this is too late.

I've received some interesting information from two different manufacturers of networking equipment in response to the article. They both confirmed that my guess as to how the number of multicast groups available in a switch was driven by memory availability was likely correct. Apparently, a manufacturer will typically have an internal engineering specification for multicast groups, but in a SOHO/low end commercial switch, that spec may only require 16 groups, or so. That's all the multicast groups you need for video streams in a typical home or office, after all. At compile time, multicast will get this number of groups plus whatever else can be provided after everything else has had memory allocated. Multicast apparently chews up high speed memory rapidly, so often gets pushed to the bottom of the queue. This is why one revision of a switch may give you 60 groups while another rev of the apparently identical switch only gives you 40. As long as there are 16, it meets the engineering spec, and all is good as far as the manufacturer is concerned. The rub from our point of view is that the engineering spec isn't available. Unfortunately, the only way to be sure is to test.

There may be more on this topic at a later date as one of the manufacturers (a very large multi-national) was interested in the problem, and is currently testing some of the switches we had tried to find out exactly what was happening and why and how they failed. Apparently, one possible failure scenario adopted by some switch hardware vendors is that, once the switch has exhausted its allocation of multicast groups, it will convert any further multicast packets into broadcast packets which, in our case, could easily have swamped our receivers. More information to come….

Quantum dots – *Protocol* Winter 2017

I discovered something from Samsung in their literature about quantum dot video displays which I had no idea about when I wrote this article. Apparently, humans have been using quantum dots to make color since perhaps the first century AD, in stained glass!

To quote from Samsung, "Stained glass has been around for well over 1,000 years—much longer than your SUHD TV. Most notably, stained glass was used as a medium of artistic expression commonly found in European churches during the medieval period. Medieval artists who dabbled in alchemy blended gold and silver chloride with molten glass to create red and yellow tints that sparkled spectacularly in the sunlight. When light struck the stained glass, the chloride nanoparticles were acting as quantum dots, reflecting a range of

PHOTOGRAPH COURTESY OF SAMSUNG

Figure 1 – Nanoparticles in stained glass

magnificent red and yellow light in that area of the color spectrum."

Apparently, the metal oxides and chlorides found in stained glass react with light in a way similar to that of quantum dots. The size of those particles is on a par with current quantum dot technology. Recently scientists analyzed stained glass from this era and discovered that the technique, possibly dating back to the 10th century or earlier, worked because of nanotechnology; analysis of the stained glass revealed that gold and silver nanoparticles, acting as quantum dots, reflected red and yellow light, respectively.

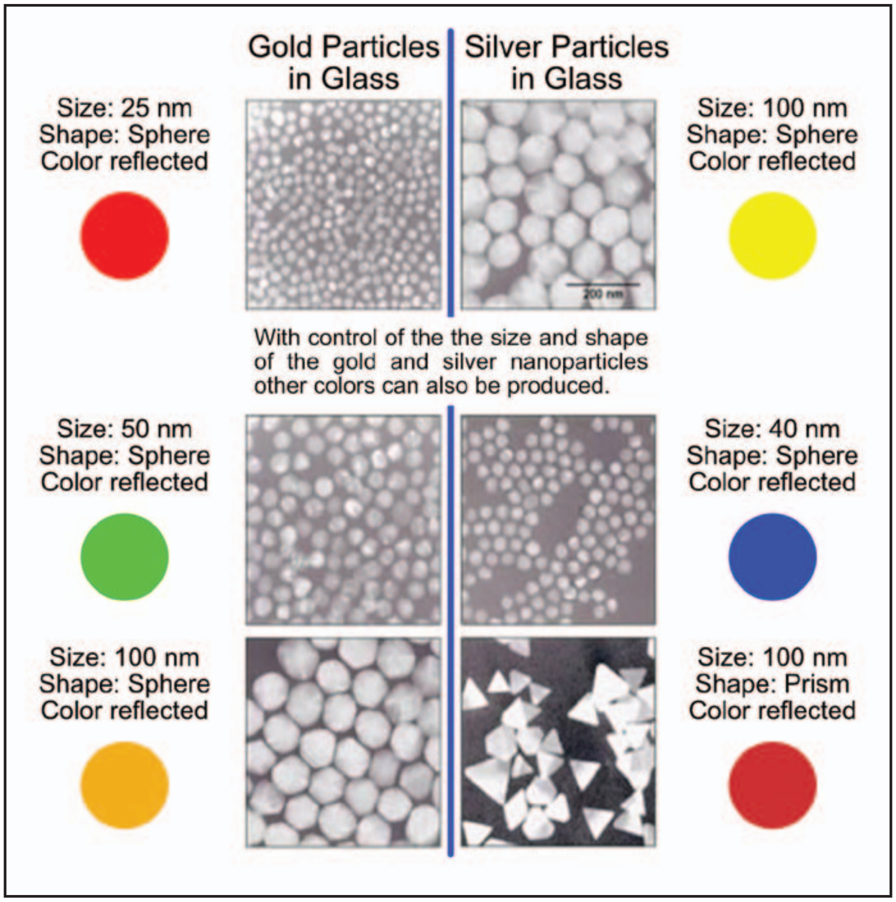

Figure 2 – Stained glass colors from nanoparticles

In fact, by varying the size and shape of those same gold and silver nanoparticles you can get a whole range of colors in stained glass as shown in **Figure 2**.

Narrow red phosphors – *Protocol* Winter 2010

You've heard me talk about the use of phosphors in LED light sources more than once. The article I cite above was an early one on white LEDs. I've also mentioned that RGB-based LEDs have the potential to be more efficient than a white LED using a blue pump and a yellow phosphor, the primary technique in use at the moment. This is because a three band RGB light source can be tuned to the response curves of the eye so as to exceed the maximum possible efficacy of a broad band continuous source. Using a conventional white LED maximum efficacy tops out at around 350 lm/W, but theoretically using RGB we could exceed 400 lm/W at some color temperatures.

A barrier to real products has been the poor performance of current red and green LEDs, neither of which is anywhere near as efficient as blue. Additionally, red LEDs suffer badly from thermal droop in which the light output reduces with increased temperature.

> "Nobody can spell 'fuchsia.'"

One possible solution to this, and one that is being explored by GE, Lumileds, Osram, and others, is to use all blue LEDs, but with phosphors to convert the blue light to green and red. Because there is no benefit from light spilling into the invisible infrared, currently available broad red phosphors don't really help. What is needed

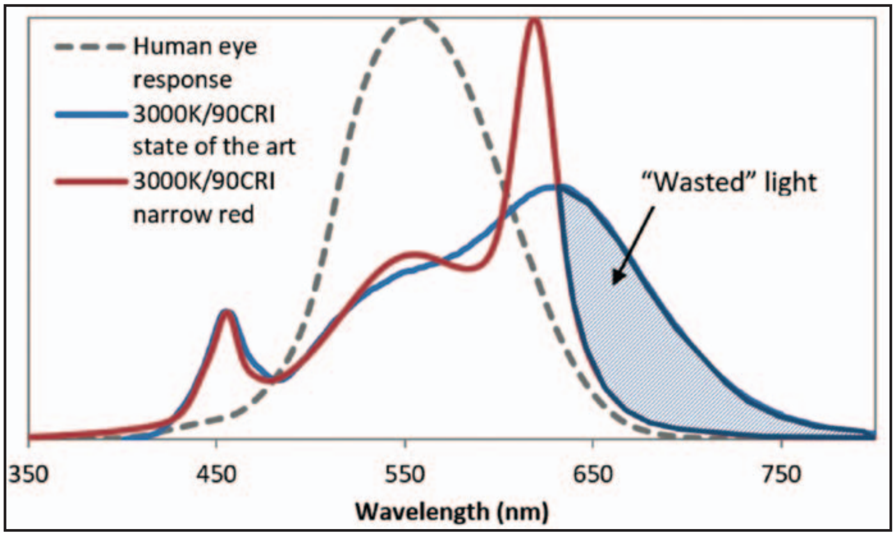

Figure 3 – Typical spectrum of a state-of-the-art 90 CRI LED, showing tail of emission into the infrared, and modeled spectrum of a 90 CRI phosphor converted LED with narrow-band red phosphor.

are narrow-band red phosphors that more closely follow the response curve of the eye as shown in **Figure 3**.

Narrow band red phosphors with steep cut-off like this are extremely difficult to make and there has long been a search for suitable chemistry to manufacture them. Prior solutions have worked well at producing broader band red, but exhibited large Stokes losses that eliminated any overall efficacy benefit. With support from the DOE, GE has commercialized a new narrow band red phosphor, based on potassium fluorosilicate, (PFS) while Lumileds have their own solution based on strontium aluminate (SLA).

This research has a potential spin-off benefit for entertainment use as well. We want good narrow-band color phosphors for color mixing, not just white light. The broad reds available at the moment are not as saturated as our users would like and appear very orange, but these new products may be perfect.

Global Shutter CMOS Sensors – *Protocol* Summer 2011

The subject of rolling shutters hasn't gone away. Even though LED PWM rates have got higher, which eliminates most regular shutter strobing problems, you can still suffer from rolling shutter artefacts when using LED luminaires on camera no matter how fast your PWM rate. Video cameras are increasing in resolution, with 4K fast becoming the standard. At the same time, the technology in digital movie cameras has improved but, simultaneously, become even more difficult to characterize as it is now a trade secret how the sensors in an ARRI Alexa, or a RED camera behave.

All this has made working with LEDs from different manufacturers in TV studios and film sets problematic to say the least. (And I'm ignoring all the color matching issues….)

However, the film and TV industries dislike rolling shutter cameras for all kinds of reasons, not just because of the way they interact with LEDs, in particular the artefacts they introduce to moving or rotating objects. This has put a lot of pressure on sensor and camera manufacturers to develop global frame CMOS sensors. They've been available for a while in machine vision cameras, and I've seen their use in some specialist videos. However, this last year, they've started to appear in standard broadcast cameras as well. One of the first non-specialist broadcast uses I became aware of was on the Grammy's this year where Sony global shutter CMOS cameras were used. Sony aren't the only ones, Blackmagic and URSA are now also making global shutter CMOS cameras. I suspect it won't be too long before global shutter CMOS cameras become much more common. They won't solve all our problems with LEDs, but it should make life a little easier.

Color Names – *Protocol* Winter 2015

The subject of color names is very topical. My article talked about the origins of the fundamental names such as red and green, however the use of LEDs and color mixing has reinvigorated the topic. As we move more and more towards color mixing luminaires, what do we use for a universal language of color? Do we stick with using the gel color names that we know and love, or do we need to invent something new? How will a lighting designer in 2025, who has grown up with LEDs and RGB rather than gels, communicate the color they want to see on stage to the board operator? I suspect that this may be a problem that resists any kind of forced solution, one that is resolved by evolving language rather than a standard, however it is still interesting to speculate.

I was reminded that a large social study had already been done on this topic by, of all people, Randall Munroe, author of the popular *XKCD* comic strip. Although *XKCD* is primarily humorous, Randall Munroe is a highly intelligent scientist and engineer and his comic strips often present complex scientific issues in a straightforward way. Back in 2010 he ran a web-based survey asking his readers to give English names to RGB colors. Over 200,000 people responded making this one of the largest, if not *the* largest, surveys of its kind ever created. The end result was a list of 954 consensus names for the most common RGB colors used on monitors. Now, I know there are all kinds of questions about this; this isn't lighting, RGB isn't an absolute color space, this was only done for English, and the demographic was likely skewed. However, it is without doubt both significant and interesting. Here are the first 48 colors out of the 954 total colors:

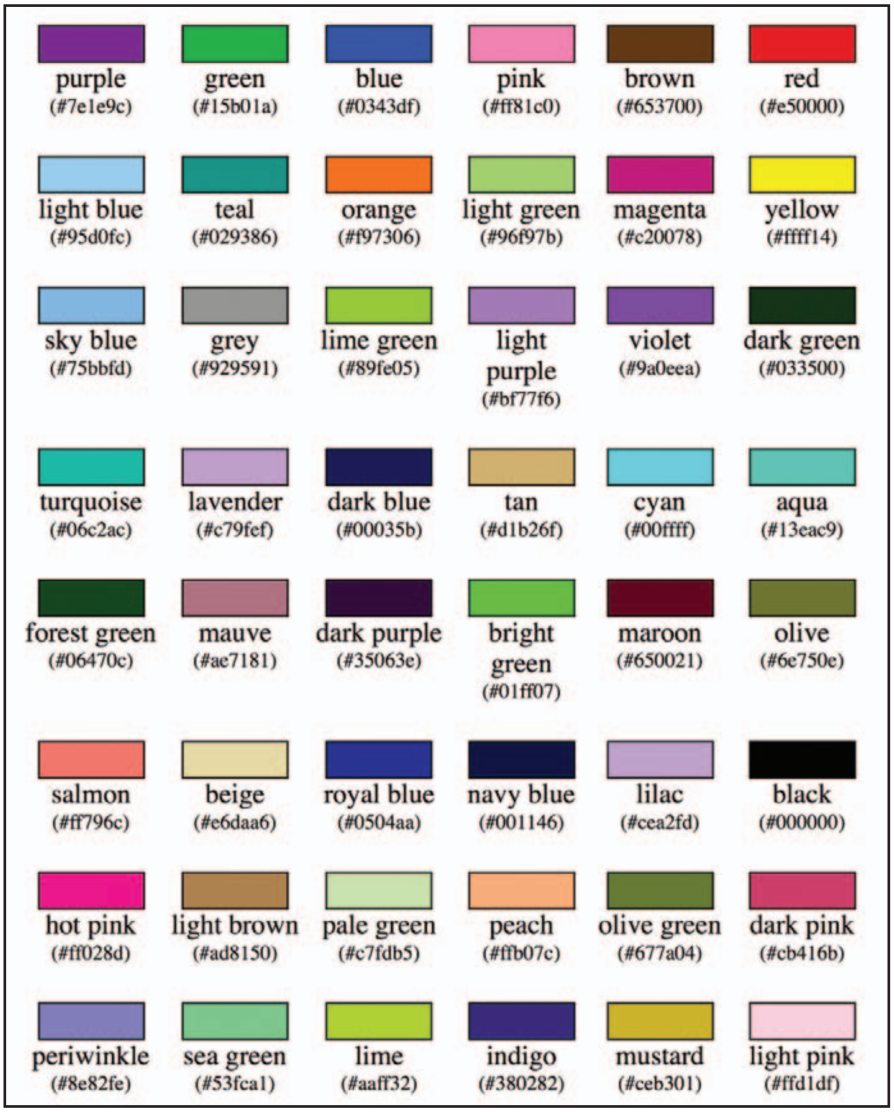

Figure 4 – Color names from *XKCD* survey

Randall has put the data into the public domain, and they are free for anyone to use. I encourage you to take a look at the full results which are available at https://blog.xkcd.com/2010/05/03/color-survey-results/ or http://estalink.us/2bslw.

Randall had a few preliminary observations about his survey:

- If you ask people to name colors long enough, they go totally crazy.
- "Puke" and "vomit" are totally real colors.
- Colorblind people are more likely than non-colorblind people to type "fuck this" (or some variant) and quit in frustration.
- Indigo was totally just added to the rainbow so it would have seven colors and make that "ROY G. BIV" acronym work, just like you always suspected. It should really be ROY GBP, with maybe a C or T thrown in there between G and B depending on how the spectrum was converted to RGB.
- Nobody can spell "fuchsia."

As we are on an *XKCD*, I'll finish this issue with one of the strips which I think summarizes extremely well what many of us feel about color theory:

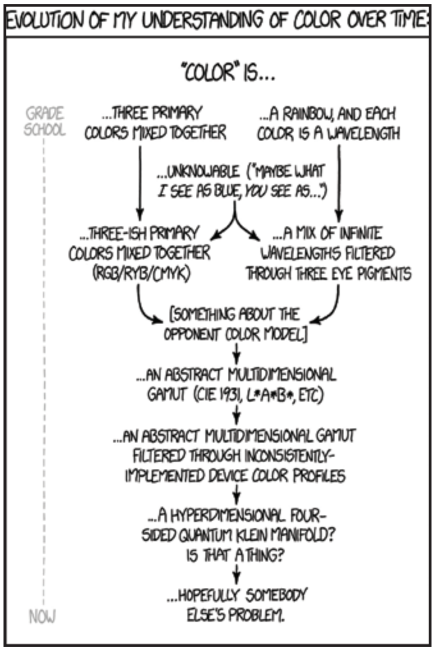

Figure 5 – Color models

If anyone tells you they really understand color theory and how it works, they are lying to you. It's fake news…. ■

Mike Wood runs Mike Wood Consulting LLC, which provides consulting support to companies within the entertainment industry on product design, technology strategy, R&D, standards, and Intellectual Property. A 40-year veteran of the entertainment technology industry, Mike is a past President of ESTA and Co-Chair of the Technical Standards Council. Mike can be reached at mike@mikewoodconsulting.com.