White Paper
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Sports Broadcasting Under LED Lighting

Abstract:

Among other benefits, LED sports lighting presents an opportunity for increased broadcast quality in both new and existing venues. A desirable outcome requires attention to fixture selection, quantity, placement, lensing, and aiming. The broadcast relative parameters that we optimize these variables for when specifying an LED lighting system include illuminance levels and uniformity, color temperature and uniformity, flicker, and color rendering. When considering these parameters, it is important to anticipate higher frame rates and resolutions expected in future broadcast technologies.

Introduction

Since the first installation of LED sports lighting at a professional venue at the Syracuse War Memorial, many benefits have been clear: increased efficiency, low maintenance costs, bright, consistent light, and instantaneous on/off time to name a few. These benefits to the owner of the facility and to the players and in-person fans have been seen now at multiple venues. In this paper we will attempt to address the concerns of another group: the broadcast team attempting to bring the game to the home viewer.

In compiling information for this paper, we've talked to multiple members of a broadcast team (CBS Sports) and three camera manufacturers: one, commonly used for sports broadcast (Ikegami), one increasingly used for super-slow motion (Vision Research, makers of the Phantom line), and one commonly used for photo-finish (Lynx).

The topics of concern that we've discussed with these teams are:

- Illuminance levels: Overall amount of light, typically horizontal or vertical
- Illuminance uniformity
- Color Temperature (CCT)
- CCT Uniformity
- Flicker
- Color Rendering

Background

In order to understand the effect of high definition on light demands, it is helpful to understand a little about the physics of a camera making an image. In order to achieve a properly exposed image (neither too bright nor too dark) there are four basic parameters that can be adjusted: exposure time, aperture, gain and sensor size.

Exposure Time: The time that the sensor or film is exposed to the light to expose a single frame. A longer shutter time allows more light into the camera, and creates a brighter image. A shorter exposure time will show less motion blur in a freeze-frame; whether this creates a better or worse end result is subjective. Note that while each photosensor (pixel) will be exposed *for* the same amount of time, it does not necessarily follow that photosensor is exposed exactly *at* the same time: Cameras that do expose the entire frame at the exact same time are said to have a global shutter. Others, like most still cameras adapted for video, or a photo-finish camera, will scan across the image using a rolling or slit-scan shutter.

In video, the exposure time is limited on the top end by the frame rate. The relationship between the shutter time and the frame rate is indicated by the shutter angle. Video shot at 60 frames per second can have exposure time of, at most, 1/60th of a second. This corresponds to a 360 degree shutter angle. Video shot at 60 fps with exposure time of 1/120th is said to have a 180 degree shutter angle. Movies were traditionally shot at 24 frames per second with a 180 degree shutter angle (for a 1/48th second exposure time), and these settings are commonly used in digital film making to emulate the traditional look, though we are beginning to see some film shot at 48fps. Video for broadcast is typically 24 (often actually 24/1.001), 25, 30 (often 30/1.001), 50 or 60 (often 60/1.001) frames per second, with a 180 degree shutter angle common. Slow motion, with its fast frame rates and corresponding short exposure times may require close to a 360 degree shutter angle to get the light necessary. At the time of writing, a great explanation of shutter angle is available from the Red camera website here: http://www.red.com/learn/red-101/shutter-angle-tutorial

Aperture: The aperture, or iris, is made up of a ring of blades that can limit the internal diameter of the lens. A larger aperture will allow more light and create a brighter image. A larger aperture also has the effect of decreasing the depth of field of the image, meaning that less of the image will be in focus. This is generally considered a negative for applications such as sports broadcasting, where it can be difficult to maintain focus on moving targets and the viewer expects to be able to look around the image. It is often desirable in film making, where the director desires to direct the viewer's attention to particular elements on screen by blurring background (or foreground) elements.

Aperture is commonly indicated by an f-number (videography commonly uses t-stop terminology), which normalizes the aperture for the focal length of the lens. A 50mm lens with a pupil diameter of 12.5mm is at an f-stop of 50/12.5, known as f/4. A 200mm lens open to 50mm is also set to f/4 (200/50). This convention allows a photographer to easily maintain exposure settings while changing lenses or zooming a lens across its focal length range. This is because the amount of light gathered from a given scene at one focal length at f/4 should be the same as at any other focal length at f/4. Lenses with T-stop nomenclature are further corrected for the light transmission properties of the glass, making this ideal somewhat closer to reality.

Gain: Increasing the gain increases the sensitivity of the camera to light. This is the equivalent of increasing to a higher ISO setting on a consumer digital camera, or changing to a higher ISO (faster) film in a film camera. Higher gain settings are useful in low light, but come at the expense of a noisier image. Similarly, the brightness of the image can be adjusted in post processing, but generally at the cost of adding more noise than would have been present by setting the gain correctly in the camera.

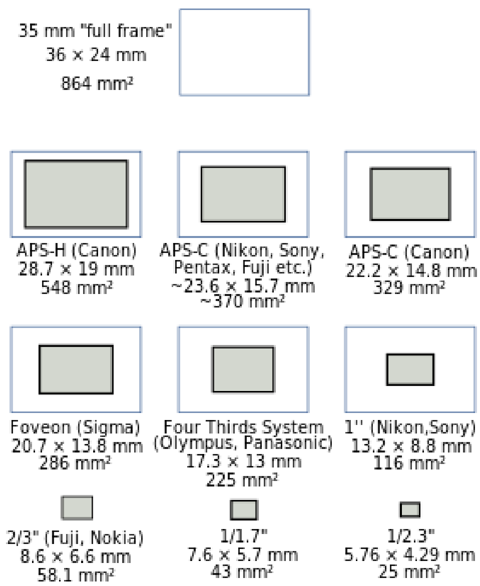
Sensor Size: The three things that must be balanced to create a properly exposed image are exposure time, aperture, and gain. So why is it that a picture taken with a small cell phone or point-and-shoot can look so different from one taken with a professional camera, even when those three settings are the same? There are a couple reasons. One big one is the quality of the lens. Modern sensors often have pixel density high enough to out-resolve most consumer quality lenses (meaning that increased pixel counts do not further increase the amount of information actually recorded in the image.) Another big difference is the size of the sensor(s) recording the image. A larger sensor has 2 primary effects on the image:

1) **Longer Focal Length**: For a given field of view, a larger sensor will require a longer focal length lens, which comes with a shorter depth of field. This can be desirable in artistic endeavors, but is generally undesirable in sports broadcasting.

2) **Lower noise:** Larger pictures receive greater photon flux over a given exposure, while noise increases by only the square root of the photon flux, resulting in a cleaner image. This becomes especially important in light-limited environments like high speed sporting events at night, where fast shutter speed and small apertures are desired.

Sensor sizes vary pretty drastically, and so, in turn, does low light performance:

Description	**Dimensions (mm)**	**Area(mm^2)**
1/3.2” (iPhone 5)	4.54 x 3.42	15.53
2/3” (many broadcast cameras)	8.8 x 6.6	58.1
Super 35 (broadcast and cinema cameras)	24.89 x 18.66	464.44
35mm Full Frame (professional DSLR)	36 x 24	864



Relating these numbers directly from one camera to the next can be complicated by the fact that broadcast cameras often use a prism to separate the red, green, and blue parts of the spectrum, and record each on a monochrome sensor, effectively tripling sensor area with the added benefit of removing the low-pass filter required by single sensor cameras (sensors with adjacent pixels filtered for red, green, and blue reception) to eliminate a rippled effect (moiré pattern).

Illuminance

Illuminance is the measure of luminous flux (light energy) reaching a unit area, and is measured in Footcandles (Fc) or Lux (1Fc = 10.752 Lux). The human eye is incredibly well adapted, functioning with varying degrees of sharpness and comfort from levels well below 1 Fc to levels greater than 1 million Fc. For reference, on a bright, clear day one can expect sunlight to provide approximately 10,000 Footcandles (Fc). On an overcast day (or “normal” as we call it in Syracuse) daylight provides between 100 and 1000 Fc. Standard indoor levels are typically 15 to 80Fc. Illuminance levels affect several factors of the broadcast of a sporting event. In each case, it is preferable to have the highest possible light levels.

1. Brighter lighting allows for lower gain levels in cameras. High gain levels can result in a noisy image- the digital equivalent to the grain seen in images taken with high-speed film. Sensor technology has improved rapidly in this area, and likely will continue to do so, but the fact remains that lower gain is better.

2. More light allows the camera operator (whether controlled remotely or not) to use a smaller aperture (iris) in the lens. A smaller aperture has the primary effect of allowing less light, but also the secondary effect of increasing the depth of field of the image (the range of the image that is in focus). While a shallow depth of field can be desirable in film making for artistic affects and leading the viewer’s eye, in sports it is generally desirable to have as much of the field in play in focus as possible. Particularly in fast-paced and unpredictable sports, it can be a difficult task for camera operators to maintain focus.

   This issue is magnified in the case of high speed cameras, like the Phantom. These cameras require more light due to their short exposure times, and therefore are likely to use a faster (wider aperture) lens. Additionally, they make use of larger sensors, which require longer focal length lenses for a given framing, which in turn further reduce depth of field.

Figure 1: Phantom cameras are capable of shooting thousands of frames per second.

3. As higher light levels allow for shorter exposure times, it also allows for faster frame rates. The majority of sports are broadcast at 60 frames per second, so the ability to record at 120 or 240FPS provides a slow motion replay at a 2x or 4x time base. Typically, speeds of 300-400FPS are adequate to capture critical action, but for highlight reels and for certain very fast events, higher speeds can be used. Video taken using the phantom cameras during the 2014 NBA playoffs is available on YouTube today. It appears to be slowed approximately 10:1, which, assuming a 60FPS playback rate, would indicate that it was shot at 600FPS.

> Less common is video taken at thousands of frames per second (used to capture the spinning of a baseball leaving a pitcher's hand, for example). With today's sensors and a fast lens, it is possible to capture high quality video at 1000FPS with light levels of about 325Fc, and when pressed, passible images can be made in light levels less than half that (down to around 100Fc, with a 360 degree shutter). In the coming years, it would not be surprising to see that capability double, as the noise characteristics of the cameras continue to improve.

It is important to note that illuminance is an inherently directional measurement. The luminous flux striking a surface is relative not only to the environment the surface is in, but also the direction the surface is facing. This is easily seen: hold your hand out on a sunny day. The top will be illuminated by the sun (to approximately 10,000Fc), the bottom will be illuminated to a much lower level by light reflected from below. This is relevant to our discussion of broadcast as, simply put, the camera cares about the footcandles it can see. In most cases, this means that broadcast is governed by vertical footcandles (those measured holding a meter 90 degrees to the ground) since cameras are generally placed at a relatively low angle relative to the surface of play. In indoor venues, this can work against us. A fixture directly overhead does not contribute to vertical illuminance (though with a wide enough beam it will contribute to vertical Fc at points diagonally below). Generally, the positions available for mounting lights are at a relatively high angle to the surface of play, and thus generate a lower level of vertical footcandles than horizontal.

Figure 2: Illuminance is dependent on direction of light

The Illuminance level specifications vary substantially based on the sport being played and the criticality of flawless broadcast. While some organizations guard their requirements as proprietary, the below table indicates some typical values for horizontal and vertical illuminance specification.

	NCAA National Broadcast Requirements					NHL Requirements	FIFA Professional Soccer Requirements	Sample Professional Televised Football	Sample Professional Televised Baseball
	Baseball Infield/Outfield	Basketball	Football	Ice Hockey	Soccer				
Horizontal Footcandles	100 / 70	100	100	100	100	200	2500 lux (232 fc)	250	250 /200
Horizontal Uniformity	1.5:1 / 2:1	1.7:1	1.7:1	1.7:1	1.7:1	1.3:1	1.6:1	1.5:1	1.2:1 / 1.7:1
Camera #1	1st & 3rd Bases	Center Main Side	50 yd line	Center Main Side	Center Main Side	Main	Fixed	Main	High
Vertical Foot Candles	70 / 40	100	100	100	100	144	2000 lux (186 fc)	200	150 / 135
Vertical Uniformity	N/A	1.7:1	1.7:1	1.7:1	1.7:1	1.3:1	2:1	1.5:1	1.2:1 / 1.7:1
Camera #2	High Home Plate	End	End Zone	End	End	Reverse	Field	End	Low
Vertical Footcandles	70 / 40	60	60	60	60	144	1400 lux (130 fc)	150	125
Vertical Uniformity	N/A	N/A	25 - 45K	N/A	N/A	1.3:1	2.9:1	2.5:1	1.7:1

Ephesus Solution: Ensuring adequate illuminance, particularly vertical footcandles, is a question of physics that must be solved through careful photometric layout through a combination of using customized lenses and aiming fixtures at one side/end of an arena across to the other. The range of lenses available on Ephesus Arena and Stadium solutions allow us great flexibility in these layouts. This ensures every venue has adequate light on the surfaces the camera is facing. For example, at the Ricoh Coliseum in Toronto, Ontario, Ephesus lighting more than tripled the overall lighting levels from 40 fc average to 157 fc providing excellent light for broadcasting.

Figure 3: Ephesus LED installation at Ricoh Coliseum in Toronto more than tripled the previous illuminance levels

Illuminance Uniformity

While modern cameras have a high degree of latitude in adjusting to light levels, it is best if that light level is even throughout the range of that camera. Cameras and televisions are far less accommodating to lighting hot and dark spots than the human eye, and it is difficult in a fast moving sport to adjust exposure while following action. Additionally, a fast moving object tracking through an unevenly lit area will appear to speed up and slow down as it goes through alternatingly brighter and darker areas.

Uniformity is generally specified either as the ratio of the minimum to the maximum values on a grid of points overlaid on the playing surface, or as a ratio of the minimum to the average, with min over max being more strict in identifying hot spots. Some venues add additional requirements for uniformity gradient and coefficient of variation, which are alternative measures of uniformity.

In addition to getting even lighting levels across the targeted surface, it is important that the photometric takes into account issues like glare and direct reflection. While a luminaire mounted low with a relatively horizontal beam angle will do a great deal to increase vertical illuminance, it will also tend to shine into the eyes of athletes and spectators. A great deal of additional information on glare is available in another Ephesus bright paper, here: http://www.ephesuslighting.com/wp-content/uploads/2014/01/Addressing-Glare.pdf

When light hits a surface, it will be reflected either as a diffuse reflection or a direct reflection. A diffuse reflection is one where light is reflected in all angles equally. A piece of felt produces primarily diffuse reflections. A direct reflection is one where the light reflects from the surface at the angle of incidence, like in a mirror. Many sporting surfaces (such as a glossy hardwood floor or a sheet of ice) produce strong direct reflections, so it is important that lights are placed so that they are not in the family of angles covered by the primary camera locations.

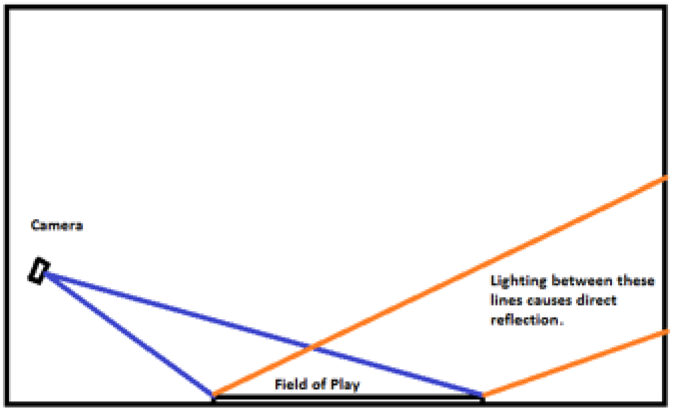


Figure 4: Light placement should consider direct reflections to the camera's point of view

Ephesus Solution: Uniformity is determined by the fixtures chosen for an installation and the position and aiming of those fixtures. Ephesus photometric engineers have fixtures of multiple power levels to choose from, with multiple lensing options for each, allowing a great deal of flexibility. This flexibility in output and lensing allows us to achieve great uniformity without adding cost due to additional fixtures. In case studies of retrofit installations, Ephesus has consistently improved or matched the existing uniformity standards using up to 50% less fixtures than the previous installation of metal-halide lighting. For example, in the Ohio University installation below, Ephesus replaced 133 metal-halide sports lights with 52 LED fixtures, and improved horizontal uniformity from 2.11 to 1.39 and vertical uniformity from 1.89 to 1.43, meeting the NCAA national broadcast requirement.

Figure 5: Ephesus Lighting reduced fixture count from 133 to 52 and improved uniformity to meet NCAA National Broadcast specifications

Color Temperature and CCT Uniformity

Correlated color temperature (CCT) describes the color of light given off by a light source (an idealized "black body", which for the purposes of this discussion can be envisioned as a bulb filament) when heated to a given temperature. A source heated to a lower temperature (2000k) gives off an orange color light (described as "warm"), while a source heated to a higher temperature

(7000K) gives off a blue light. The description of colors using "warm" and "cool" this way is somewhat subjective, but daylight on a cloudy day sunlight will be roughly 6000K, while at sunrise or sunset it may measure close to 3000K, and sunlight on a clear day is generally accepted to be 5500-5600K. The photographic industry has long considered 5600K to be the standard CCT for daytime outdoor lighting, and most flash and supplemental lights designed for film and broadcast have been designed to match 5600K lighting (and are filtered to match sunsets or especially blue light).   It is often helpful in broadcast and film to have lights that match daylight in this way so that a scene that contains light from windows, doors, or otherwise limited daylight can utilize artificial lighting to supplement or highlight without causing uneven color across the field.

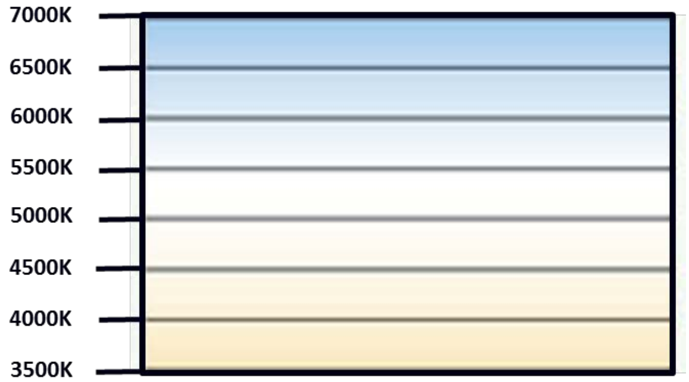


Figure 6: Color temperature of lights commonly ranges from 3500K to 7000K

While the human eye quickly adjusts to light extreme color temperatures seen in person (the brain easily recognizes a white object under yellow light), the same scene viewed without color correction will look very poorly produced on television. Live broadcast sports require the work of a colorist (often the same individual who controls camera exposure) to ensure that whatever the actual color temperature of the lighting at the venue, we perceive it at home as though the light were approximately 5600K. While this adjustment is as simple as the adjustment of a slider, it should be noted that like film cameras before, digital and broadcast cameras are designed to work optimally at 5600K, and so some additional gain is required to make this adjustment. This additional gain has the same detrimental effect as it does when used to compensate for low light level, i.e., the introduction of more noise to the image than would otherwise be present. This effect is small enough that it can be ignored in the face of a compelling argument for other temperatures where they might be subjectively preferred for the in-person experience or when matching late evening lighting is a priority, but in the absence of such concerns, we advise customers to light sporting venues at 5600K to make them look their best on the television.

Ephesus Solution: Ephesus lights are produced at a standard of 5600K for optimal broadcast without the need for filtering. LEDs also offer the flexibility for color tuning; by using a range of color temperatures paired with a control system, the same fixture can be tuned from 4000K to 6500K with no decrease in the total lumen output. This is useful for venues that have both basketball, where the preference is a warmer CCT, and hockey where a cooler CCT is preferred.   LED color temperatures are determined at the time of manufacture, and the manufacturers "bin" LEDs by color as well as by efficiency. Ephesus buys LEDs from very specific bins to be sure that we get even color across an installation and the most efficient lights possible. Unfortunately, CCT is not the end of the discussion when specifying LEDs for lighting. Unlike an incandescent bulb but like metal-halide technology, an LED can potentially produce light of a color that does not fall near the black body curve. This means that in addition to a CCT, the light could produce a green or magenta tint. Ephesus avoids LEDs in these bins to produce a natural looking light, and unlike metal-halide bulbs, which can tend to "pink-out" over time, the LED will stay consistent over its lifetime.

There are a couple of considerations in the design of the LED fixture itself that can affect color uniformity. While an LED will behave predictably over its life, its color can change slightly with the current driven through it. For this reason, Ephesus sports light always have their LEDs driven with the same current, dimming instead by decreasing duty cycle, eliminating this concern. Finally, a bare LED can show significantly different color based on the angle at which it is viewed (color-over-angle), and quality lensing like that designed into every Ephesus light is required to ensure that color is well mixed throughout the beam.

Flicker

Born from a variation in light output over time, flicker should be a consideration of anyone specifying a lighting system for use with broadcast or cinema. It is not a given that a lighting system of any type of fixture will perform well in this area; there are good and bad solutions of fluorescent, metal-halide, and LED varieties where flicker is concerned. Further, while any flicker occurring above 1500Hz will be invisible to the naked eye, cameras have the potential to be much more demanding. A metal-halide or fluorescent fixture with a magnetic ballast can show flicker at frequencies well below thresholds required for broadcast. This can drive a need for high numbers of fixtures, as a proper photometric will require coverage of a given area by lights on each of the three power phases in an attempt to smooth the light delivered to the field. Lights visible on screen can be distracting due to flicker even when the light on the field is passable in these installations.

As shutter speeds increase, as they must for high frame rates, so must the flicker performance of the lighting. Broadcasters will increasingly want to shoot at 120fps when lighting allows for smoother slow-motion, and high profile sporting events are likely to have a super-slow motion (x-mo) camera such as the Phantom V642, which are capable of high definition video at over 5,000fps for short periods. That said, speeds much in excess of 1000fps are exceedingly rare for sports even in daylight, not because of any technical limitation, but because the action of most sports is not fast enough to necessitate going beyond these rates for compelling video.

Ephesus Solution: Ephesus has tested sports lights with commonly used broadcast to prove no perceptible flicker at frame rates over 2500fps on a single fixture (as fast as is currently realistic under common indoor illuminance levels). Further, since our LED fixtures are not susceptible to any synchronization with their input power phase, there is no need to stagger lights across phases for flicker purposes.

Color Rendering

Color rendering describes the effect that lighting has on the color appearance of an object. Under daylight, we see objects under a broad, even spectrum of light, giving our eyes the greatest possible color information. While incandescent bulbs provide a similar spectrum, many other light sources do not. Fluorescent lamps, metal-halide fixtures, and LEDs all fall into this second category.

Color rendering is most often specified using CRI (Color Rendering Index). CRI quantifies inaccuracies in rendering at eight specific colors, averages these errors, and normalizes results based on a perfect score of 100. CRI has many known limitations, particularly in describing the subjective experience of viewing objects under LED lights. It can either over or under rate the subjective quality of a light source, and lacks specifically in the area of assessing the interaction between a light source and films and sensors. Many other systems have been proposed, but none are nearly as widely used. The European Broadcasting Union (EBU) has developed the Television Lighting Consistency Index (TLCI).

The TLCI measures a test luminaire against a reference emitter using an x-rite ColorChecker and a spectroradiometer. This indicator is designed to test a luminaire's performance with a camera of known responsivity. We hope to see such an indicator standardized, simplified, and automated.

Ephesus Solution: Color rendering is an area in which LED has approved in recent years, and an area where there is still room for improvement. Very high CRI LEDs are available, but at the expense of the efficiency that has made LED sports lighting a practical and affordable solution. CRIs of LEDs used for sports lighting are generally in the range of 70, which is on par or higher than the majority of the legacy lighting that they are replacing. We have tested our lights under a variety of commonly used broadcast cameras, both under laboratory conditions and in the arena, and have seen very good subjective results, ensuring that team colors "pop" and that flesh tones are rendered naturally and accurately.

Miscellaneous Considerations

- Between lighting controls, microphones, headsets, cameras with radio streams and controls, strobes with radio control, and consumer devices used by fans, a large arena or stadium on game day is a busy RF environment. It is important for facilities managers to keep track of the spectrum use in their facility and to communicate this information to the incoming broadcast team well prior to game day. The Ephesus Blackbox control system is a FCC/IC compliant solution designed to function in this environment and control its lights. It delivers optimal performance with minimal interference to other radio systems by implementing frequency, spatial, and non-deterministic time diversity, and limiting spectrum usage when the lights are kept to a static setting. Contact us for more information about our RF solution and the security it offers.

- Lens flare is due to bright light in the frame or shining into the lens from outside the frame that scatters and reflects internal to the lens, causing the formation of circles and starbursts in the image as well as an overall decrease in contrast. It can be eliminated in large part between the use of hoods to shade the lens from stray light, and the use of quality light fixture lensing coupled with light placement and aiming designed to control glare.

- Ephesus lights can be controlled in ways that legacy lighting systems cannot, allowing for dynamic use to emphasize an area, to give the appearance of motion, to emulate flash bulbs or pulses, or to add color. We are excited for the ability this gives us to add an entertainment factor to the lighting that never existed in the past, but we recognize that it poses challenges for broadcasters. It is important that the broadcast team and the facility are in communication about what lighting effects will be used, at what time, and how long they will last. This allows the broadcast team to prepare by taking cameras out of auto-iris and switching to a wide-angle view that allows the home viewer to get a better sense of the effect. Additionally, they can be prepared to show a graphic, a prepared package of highlights or interviews, or an on-air personality lit with supplemental lighting.

- Illuminance levels in crowds and along sidelines can vary considerably from venue to venue. It is our recommendation that sidelines be lit to levels similar to the field to make player and coach reaction shots easy. Crowd illumination should be considered on a case-by-case basis. Some venues prefer a photometric that puts a strong curtain/spotlight affect around the floor, either to create a theater-like dramatic effect, or to hide empty seating in the stands. Facilities with dependably strong crowd participation may want to light a few rows or seating to levels similar to the field so that camera operators can easily get crowd reaction shots or interactions between fans and players.

So, what about 4K?

There are multiple proposed formats for the next generation of super-high definition video. There seems to be some momentum now for 4K video, which is a generic term for several formats of approximately 4,000 horizontal pixels (3,840 being targeted for consumer TV) by 2,160 vertical pixels. This resolution corresponds roughly to that achieved by scanning film for use in digital cinemas. The 2K and 4K naming convention represents a departure from the historical use of vertical resolution to describe 720 and 1080 high definition.
At 3,840 x 2,160 resolution, 4K has 4 times the pixels of 1080 HD video, and approaches the limits of the human eye to resolve detail when viewed at a distance roughly equivalent to the diagonal size of the screen. In theory, this equates to having 3 sensors of 8.3 million photosites on a prism-based camera, or 25 million photosites on a Bayer pattern sensor. In reality, some camera manufacturers are using some interpolation and marketing speak to create 4K images from sensors with less resolution. Whatever the case, the upshot of 4K is higher resolution frame on sensors that are the same size as sensors used on current and previous cameras.

All else being equal, individual photosites on a 4K camera will collect a quarter of the light at given exposure settings compared to the photosites on a 1080p camera, and therefore will require more light on the target. In practice, new generations of cameras come with new generations of sensors, which generally provide better read and quantization noise characteristics, somewhat mitigating the need for increased lighting. It is this increase in noise handling capability in cameras that has kept light level specifications more or less constant through the transition from standard definition to 720p, 1080i and 1080p, and now 4K.

While 4K does not currently impose any new frame rate requirements on the lighting, there are calls for higher frame rate standards, as there is some evidence that the added resolution makes blur between frames more noticeable at 30 or 60 frames per second. Testing in this area is ongoing, so it will likely take some time before new standards result. Should frame rates rise to the neighborhood of 120 frames per second, broadcasters will likely find themselves dealing with increased problems with flicker in fluorescent and magnetic ballast equipped metal-halide lights. Properly designed LED fixtures will be flicker-free at frame rates several times higher yet. Regardless of frame rates, it may be desirable to shoot at faster shutter speeds, as increased resolution yields an increased desire to pull freeze-frames out of the video for use in other media. Shutter speeds required to freeze motion can be many times faster than those that would normally be used in video, where motion blur in an individual frame isn't noticeable.

From a lighting standpoint, broadcast of 4K video demands nothing new, but does demand more of the same; increased illuminance levels for optimal image quality and the ability to increase shutter speeds, more attention to how backgrounds and crowds are lit as background detail becomes more visible, and good illuminance and color temperature uniformity, as the clearer image provides more detail over a greater field of view.

Ephesus LED lighting meets these demands: Fixtures with output ranging from a dimmable 16,000 lumens to over 115,000 provide our photometric engineers with the options they need to get the light levels needed for any broadcast on the surface of play. Tight control over color temperature coupled with multiple lensing options give the ability to keep those light levels uniform in intensity and color across that surface. Control circuitry designed specifically for sporting events ensures flicker-free broadcast at frame rates far greater than any forthcoming 4K standards.

Conclusion

Ephesus Lighting designs sports venue lighting solutions from the ground up to create optimal conditions for broadcast, spectators, and athletes. This process starts with a deep understanding of the requirements of each party. It continues with the component selection and design of the individual fixtures. It extends to the expert photometric analysis done to select fixture power, placement, lensing, and aiming. Finally, installation concludes with laser-guided precision aiming to ensure that the photometric plan is executed perfectly.

We believe that following this engineering-centric approach throughout the process results in an outcome that is unparalleled in the industry.