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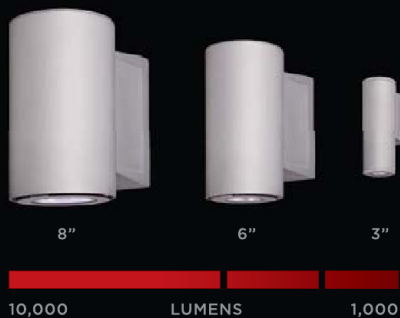
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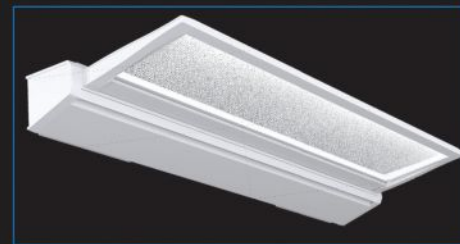
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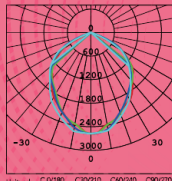


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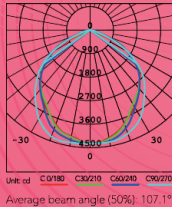
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On the Cover:

The entry plaza at the Metropolitan Museum of Art, with new lighting by L'Observatoire International. Photo by Matthew Carbone.

Left: © 2014 Kate Rothko Prizel and Christopher Rothko / Artists Rights Society (ARS), New York. Photo: Digitally restored scan of a 1964 Ektachrome transparency, Harvard Art Museums, © President and Fellows of Harvard College; Top Right: Tang Yau Hoong



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THE LIGHTING INDUSTRY: VERSION 3.0

“So what will the lighting company of the next decade look like? And can we even look that far ahead?”

Just when you think the lighting industry has settled down after a decade of mergers and acquisitions, another round of developments comes along. In the past 10 months, companies known for their lighting divisions, such as Philips and GE, have explored and—in the case of Philips—divested themselves of these businesses, similar to when Siemens spun off Osram in 2013. Coupled with this, Samsung and Toshiba—two global electronics companies, who, over the past five years, seemed poised to make a major push into lighting—have pulled out and pulled back, respectively.

What’s going on? October reports from *Thomson Reuters* suggest that while demand for LED lighting remains strong, increased competition from Chinese manufacturers has drastically reduced profit levels, making the LED sector less attractive as a long-term investment.

What does this mean for the U.S. lighting market? Thus far, the players have been slow to comment, when they have commented at all. But here’s what we do know:

Philips: A Sept. 23 story from *Fortune* indicated that Royal Philips was “spinning off its lighting unit to concentrate on its healthcare and consumer goods business. ... The healthcare and consumer goods business will become HealthTech with about \$19 billion in sales, while its lighting unit will operate as a standalone company with about \$9 billion annual revenue.” Philips, like many global conglomerates, has been the victim of its own bureaucracy, suffering from lack of information between its European home and North American division. In the U.S., there has been no press statement regarding the spin-off of the lighting business. The only news that signaled any change was the January announcement that Amy Huntington had been named president of Philips Lighting Americas.

GE Lighting: Also in September, *Bloomberg* reported that GE, which sold its home appliance division to Swedish company Electrolux for \$3.3 billion, might do the same with its lighting division. But a company spokesperson, who spoke to *Bloomberg* on the grounds of anonymity, said, “GE Lighting is not part of the sale of the GE Appliances business to Electrolux

and will continue to be a part of GE.” The same month, *Fortune* reported that Beth Comstock was assuming leadership of GE Lighting, in addition to her existing responsibilities as chief marketing officer of General Electric. This means that GE Lighting CEO Maryrose Sylvester will retain her title but report directly to Comstock rather than GE CEO Jeffrey Immelt.

Samsung: This past fall, Samsung CEO Oh-Hyun Kwon denied rumors that the company would be suspending its LED lighting business. At the same time, there were reports that the company had exited the global LED lamps business to focus on LED components. In December, electronics industry blogs reported that the company’s two main U.S. operations—Samsung Electronics America (of which Samsung LED was part) and Samsung Telecommunications America—would merge and operate under the name Samsung Electronics America. Further proof of the company’s lighting exit was a Jan. 21 release from LED lighting manufacturer MaxLite indicating that Jim Hunter, formerly with Samsung LED Lighting, had been appointed senior vice president of sales and marketing.

Toshiba: In a March 5, 2014, press release, Toshiba International Corp. (TIC) announced that its lighting business was undergoing reorganization. The LED Lighting Systems Division within TIC discontinued operations at the end of March and responsibility for Toshiba Lighting in the Americas was transferred to San Antonio, Texas-based Greenstar Lighting Products. The change represents a de-emphasis on lamps and an increased focus on street and outdoor lighting. No further information has been provided by Greenstar.

So what will the lighting company of the next decade look like? And can we even look that far ahead? Today, time frames seem to have been dramatically shortened, and it’s probably more realistic to ask what the lighting company of the next three to five years will look like. But one thing is for sure, the lighting industry version 3.0 will be unlike anything we’ve seen before. •

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Impression of the Rainbow Station art installation at the Amsterdam Central station, one of the many events taking place during IYL 2015.

2015: INTERNATIONAL YEAR OF LIGHT

text by Elizabeth Donoff

During its 68th session, which met in December 2013, the United Nations General Assembly declared 2015 as the International Year of Light and Light-based Technologies (IYL 2015). In making this proclamation, the U.N. recognized the importance of “raising global awareness of how light-based technologies promote sustainable development and provide solutions to global challenges in energy, education, agriculture, and health.”

The U.N. resolution (A/RES/68/221) designated UNESCO (the United Nations Educational, Scientific and Cultural Organization) as the lead agency overseeing the program. That organization will work in

conjunction with a consortium of hundreds of worldwide partners. Some of those partners will be international scientific unions and professional lighting associations, such as the International Association of Lighting Designers (IALD) and the UNESCO International Basic Sciences Programme (IBSP). Throughout the year, various activities, meetings, events, and lighting exhibitions and installations will occur across the globe as this cross-disciplinary education and outreach project highlights the importance of light and optical technologies. It will also be an opportunity to celebrate a number of important milestones in the history of the science of light. Some of the landmarks

occurring in 2015 include the 1,000-year anniversary since the 11th century scientist Ibn Al-Haytham wrote *Kitab al-Manazir* (The Book of Optics); the 200th anniversary of French physicist Augustin-Jean Fresnel’s first work introducing the theory of light as a wave (1815); and the 100th anniversary of Albert Einstein’s theory of General Relativity (1915).

Opening ceremonies for the program and a two-day symposium with presentations by leading policy makers, scientists, and lighting designers took place on Jan. 19–20 at UNESCO’s Paris headquarters. For an overview of IYL 2015 activities and the official schedule go to light2015.org.



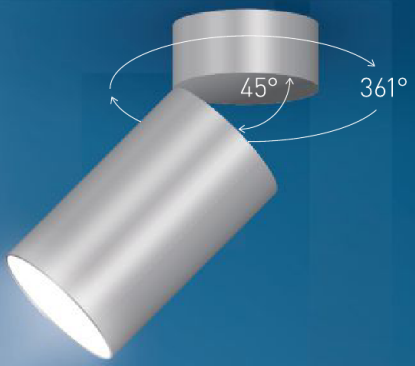
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• DESIGN



REPORT

LEDS MAKE INROADS INTO STREETLIGHTING

Along with their energy-saving advantages over high-pressure sodium, LEDs' color temperature brightens outdoor spaces in ways that can increase safety and comfort around roads and streets.

text by Bill Millard

illustration by Tang Yau Hoong

On certain streets in New York City these days, the past and the future appear in different colors. Among the many changes set in motion by former mayor Michael Bloomberg and transportation commissioner Janette Sadik-Khan, one was to swap out the city's 250,000 streetlights from the current mix of mainly high-pressure sodium (HPS) lamps, with metal halide (MH) and mercury-vapor lamps in some areas, to light-emitting-diode (LED) lamps. Night owls and motorists are getting used to a streetscape where sepia-colored blocks are in retreat and blue-white light is on the march.

The LED revolution is spreading from commercial and residential uses to the municipal realm, as New York, Los Angeles, Portland, Seattle, Boston, Detroit, and other jurisdictions have begun implementing the recommendations of numerous organizations including the U.S. Department of Energy, the Climate Group, and Rensselaer Polytechnic Institute's Lighting Research Center (LRC) in favor of LED conversion. If this technology continues to advance at its current trajectory, with costs dropping enough that long-range savings increasingly outweigh upfront investment, solid-state lighting (SSL) will logically replace HPS as the dominant form of streetlighting nationwide. Yet SSL's properties are best suited to certain settings, says John D. Bullough, senior research scientist and adjunct assistant professor at the LRC. Municipalities under budget constraints should heed what the science says about LEDs' optimal applications.

LAMP PERFORMANCE

Calculations of luminous efficacy are only the beginning of a practical analysis of how different lamp types perform. HPS lamps produce approximately 100 to 120 lumens per watt, and contemporary LEDs are now competitive with HPS in that metric. "What's more important is really getting light where it needs to go," Bullough points out—illuminating roadways, streets, and sidewalks while avoiding or minimizing upward light pollution and light trespass onto adjacent properties, particularly residential windows. Illuminance measurements are meaningful only in their purposeful context.

The Illuminating Engineering Society (IES) has recently updated its recommendations for roadway lighting. Before this, there had been no major changes in standards for light levels and uniformity since the previous recommendations in 2000, which predated the LED era. For specifiers deterred by first costs, the implication might be "don't fix what ain't broke." However, a detailed report prepared for the National Cooperative Highway Research Program's Transportation Research Board of the National Academies, authored by Bullough and his LRC colleague Leora C. Radetsky in August 2013, makes the case for a new metric, Luminaire System Application Efficacy (LSAE), to guide engineers in selecting luminaires and their spacing and mounting height in ways that not only save energy and money but target LEDs' unique properties to settings where priorities also include minimizing both light spill and distracting glare. (The LRC defines LSAE as "average luminous flux within a specific solid angle per unit of power, [including] only the light output that falls on the task plane ... and

meets the photometric requirements of the application's task.")

"We're past the tipping point where there definitely are LEDs that are as good as or better than HPS," Bullough says. "Unfortunately, what we can't quite say yet is which ones for which type of roads." LEDs may never sort out into the standardized wattage levels seen with HPS and MH lamps, making LSAE calculations complex. Still, Bullough envisions an interactive calculation tool, "under development in pieces" and probably available in the near future (perhaps integrated into lighting software), that analyzes luminaires' features, power levels, and fixture positioning to recommend designs that optimize energy efficiency and costs.

RETROFIT OR NEW?

The first point to consider about LEDs, Bullough says, is whether they would replace HPS (or other non-solid-state) lamps in an existing fixture or constitute a new installation. In either setting, they offer advantages in energy cost, light quality, and maintenance, and last 50,000 to 100,000 hours (depending on manufacturer data) if designed with proper thermal control. LEDs' energy-use reductions vary widely but boil down to at least a 15 percent advantage over HPS in the LRC's 2013 literature review.

The benefits of LEDs are greater and more diverse, however, when designed from scratch than when retrofitted. With standard cobrahead fixtures, HPS or MH fixtures take a limited number of forms. "Their performance fundamentally is pretty similar in the way they take the light from the [lamp] and distribute it through a reflector or some kind of refractor, but pretty much every LED fixture is unique in the way it's designed and how it spreads the light," Bullough says. The tightest design straitjacket, conversely, is a project using incumbent multipurpose utility poles. In these, except for average light levels, "everything else gets tossed out the window, because ... the poles are not designed at all for any kind of lighting," he says. "They're just designed for carrying utility cables." Justifying an upgrade to LEDs is generally less clear cut in retrofits, he adds, because "there's almost no way to devise a rule of thumb to say we can replace a 250W sodium cobrahead fixture with an LED that's X number of watts."

New infrastructure makes the decision easier. LEDs are more precise in their optical control, which is conducive to flexible, site-specific fixtures with full overhead cutoff and reduced glare. "That doesn't mean that every fixture out there currently does that," Bullough acknowledges. "There are some fixtures where you can see bare LEDs, and they can be pretty bright." Another advantage in a new design involves mounting hardware: When

pole spacing and height are variables rather than given conditions, system designers have more options to optimize coverage. Precision in design, of course, calls for prescience about purpose and power: In areas of the U.S. and the United Kingdom that have installed LEDs (Detroit, Baltimore, and Hastings), some citizens have complained that their operation has left crucial areas underlit. "LED lights may be okay for drivers," complained Baltimore city councilman Robert Curran in a 2012 city council budget hearing. "But where do people get mugged? Not in the middle of the street. They get mugged on sidewalks."

Such practices are correctable, not only by overcoming a default windshield perspective and making pedestrians' well-being a high priority, but by also using the technology itself. LED controls' dimming potential allows adaptation to changing conditions, such as circadian variation in pedestrian or vehicular activity, requiring different illuminance around the clock. On a longer timetable, systems can also compensate for the lumen depreciation that occurs over time, instead of overlighting at the

"We're past the tipping point where there definitely are LEDs that are as good as or better than HPS. Unfortunately, what we can't quite say yet is which ones for which types of roads."

—John D. Bullough, senior research scientist, the Lighting Research Center

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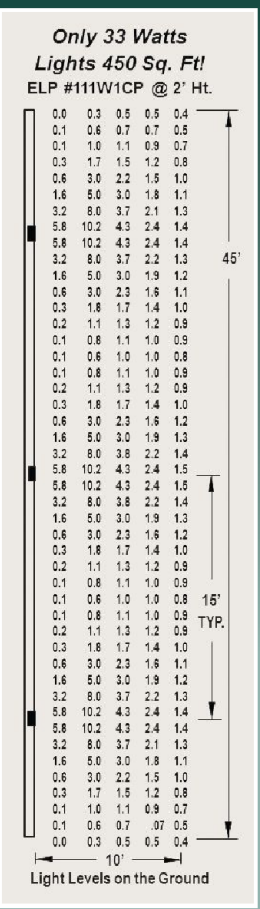
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outset. "In principle, you could have a lighting system that maintains a constant output by actually underdriving the LEDs at the beginning of their life and then, over time, slowly driving them a little bit higher," he says.

LED streetlighting upgrades represent a substantial market, bringing impressive savings. In New York City alone, the PlaNYC sustainability program will spend \$76 million between 2013 and 2017 on what will be the nation's largest LED retrofit, *Forbes* reports. The city anticipates an annual savings of \$6 million in energy and \$8 million in maintenance, which amortizes the whole capital investment in six years (the lifespan of a current standard HPS lamp) and continues to reap savings as the LEDs last up to 20 years. In 2013, Los Angeles completed the conversion of 141,000 streetlights, the nation's largest retrofit to date, aided by the Clinton Climate Initiative. The savings found in the first seven years will pay off a loan from the city's Department of Water and Power, and then the \$57 million project will save \$7 million in electricity and \$2.5 million in maintenance each year.

The gains aren't limited to major cities: San Luis Obispo, Calif., cut energy consumption by 65 percent and service expenses by 60 percent by converting more than 2,000 HPS lamps to LEDs. A Department of Energy survey of about 240 municipal, county, state, and utility organizations released in September indicated plenty of room to expand: 82 percent of the respondents identified HPS as the most prominent lighting technology, with 36 percent mentioning some ongoing use of the even less efficient mercury-vapor lights; 62 percent reported some use of LEDs, but it was the most prominent technology in only 8 percent. Accounting for some 1.1 million individual luminaires, which averaged 15.3 years in age, this sample suggests that high-performance lighting offers the nation a rich option in the effort to improve energy efficiency.

PERCEPTION AFFECTS REALITY

Compared with the correlated color temperature of HPS (around 2100K), LEDs offer a higher and broader range (3000K to 8000K), and this whiter light includes more of the blue and green short-wavelength components of the visible spectrum. Because human eyes and light meters respond differently, analyses of effective lighting include subjective components. Comparisons of illuminance per watt also need to consider impressions of overall brightness along with on-axis and peripheral vision; it is in these areas that LEDs shine.

"When people look at a lighted street, their judgment about how safe that street feels and how secure they are actually seems to be directly correlated with how bright it appears," Bullough



The image shows a white LED luminaire with a yellow LED chip inside, mounted on a white LED Power Supply. The power supply is labeled 'LED Power Supply' and 'INPUT: 120 to 277 Volts 50/60 Hz'. The luminaire is labeled 'D10CC50UNVTW-LS' and 'EVERLINE'. The power supply also lists technical specifications: 'Input Voltage: 120/277V 50/60Hz', 'Input Current: 0.57A', 'Power Factor: 0.99 ABL', 'Output Current: 1050mA', 'Diode and Driver Location: Inside', and 'RoHS: Compliant'. The EVERLINE logo is prominently displayed on the power supply.

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says. The whiter light of LEDs gives observers a perception of greater brightness even when light meters indicate they are delivering fewer lumens than their HPS predecessors. "Obviously you're going to meet the minimum requirements for the street and roadway area, but you wouldn't necessarily have to increase the light levels just to get that sense of security," he says.

A key distinction involves mesopic vision: the medium range between photopic or

daytime light levels, when the retina's cones are operating, and the darker scotopic range, when the eye's rods are activated. Vision in the mesopic range, involving both rods and cones, involves a shift toward the short wavelengths. (Though IES recommendations do not yet consider mesopic photometry, application committees are exploring the question for a future iteration.) A separate metric, Bullough notes, distinguishes peripheral detection

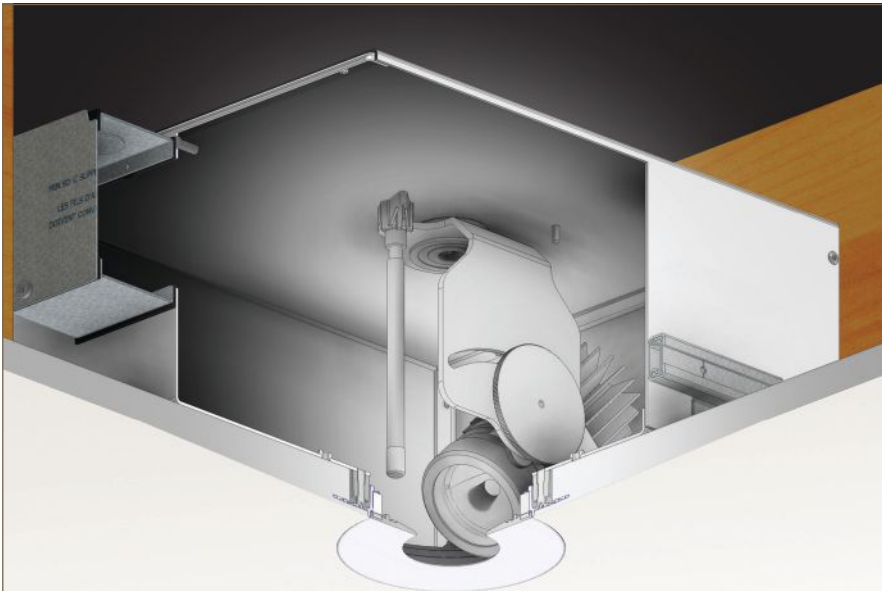
from on-axis detection: about 80 percent of the human visual cortex is devoted to the central 2 percent of the visual field, and visual consciousness focuses on details and colors in that area, while peripheral detection for most people is more a matter of general brightness recognition. From what is known about brightness perception (including the hazard of discomfort glare from overlighting) and about reactions to on-axis and off-axis visual stimuli, "for the same measured light level, a white light source like an LED will give you better peripheral detection at those mesopic light levels," Bullough says. This carries potential implications for matching road types with conversion priorities, though Bullough notes that studies linking crash safety with light levels do not yet include enough data on LEDs to show "meaningful improvement" over HPS.

In urban areas, where pedestrians often outnumber drivers, commercial activities are often nocturnal, ambient light from buildings and signage is more prevalent, and vehicular speeds are usually lower, general brightness perception is a priority for pedestrians' understanding of safety, but mesopic vision tends to fade away. The case for LEDs in cities rests more on energy and maintenance than on peripheral-detection benefits.

INTELLIGENT LIGHTING

LEDs, sensors, and other advancing technologies may change the whole paradigm, one in which streetlighting is largely provided by private utilities under public regulation, suggesting that LED conversion may represent one early phase of a broader disruption in the streetlight sector. Current "misalignment between utilities' revenue model and their customers' own financial needs and service preferences" implies that the efficiency advantage that LEDs enjoy does call for new business models, preferably ones that don't align utility incentives with high-volume sales of kilowatt-hours.

As desirable as it is to improve the performance of streetlights, Bullough cautions that what's worth doing isn't always worth overdoing. "Over the past 50 years," he says, "as lighting technologies have improved, light pollution has gotten worse. The ability to produce light more cheaply and efficiently seems like a good thing, but then we just end up putting out more outdoor and streetlighting. There's legitimate concern that LEDs are only going to accelerate that trend." A key question that Bullough believes we need to ask is: "What is the light here for?" Matching capabilities to purpose—choosing smarter lighting, not simply more lighting—will not only ease the national energy footprint, it may also let more Americans have a look at the stars. •



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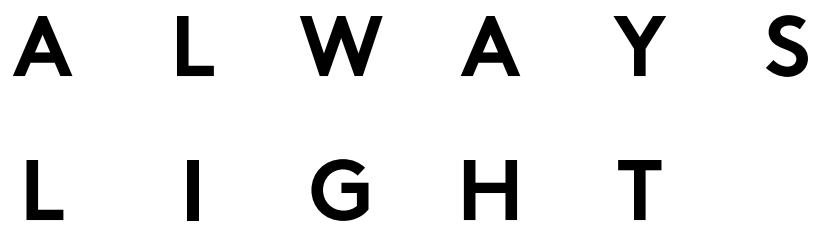


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Product submissions must include the following materials:

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TECHNOLOGY

THE TASK AT HAND

Advances in display technologies and work practices that involve more screen-based tasks require a re-examination of office lighting strategies.

text by Alice Liao

The introduction of computers in the workplace has dramatically changed not only how we work but also how we illuminate our offices. In the 1980s and 1990s, issues pertaining to reflections and reflected glare on computer monitor displays prompted the development of dedicated lighting recommendations by the Illuminating Engineering Society (IES), such as *RP-24-89: Lighting Offices Containing Computer Visual Display Terminals*. This guide remained unchanged for quite some time. (An update to *RP-24, American National Standard Practices for Office Lighting* was issued in 2004.

RP-1-04, and another was issued more recently, in 2012, RP-1-12.) But as the nature of our work has changed, to become more focused on computers and screen-based tasks coupled with newer display technologies and today's energy-efficiency criteria, what was once standard practice for office lighting has also evolved.

Though first noted in cathode ray tube (CRT) monitors, reflections on video display terminals (VDTs) can occur on any type of specular screen and are detrimental to the computer user. They impair visual acuity by competing with computer-generated text and images for the eye's attention, requiring the eye to adjust focus. Reflected glare, or veiling reflection, caused by daylight or electric sources, is particularly problematic, as it severely reduces the visibility of the screen. Left unmanaged, screen reflections can lead to eyestrain and headaches, common complaints with CRTs.

While reflections are not exclusive to CRTs, the technology is inherently reflective. Named for their bulky glass tube, CRT monitors generate images by using an electron gun to shoot streams of electrons across a glass surface coated with millions of phosphor dots. When struck, the dots emit light. In color monitors, three guns and three phosphor compositions produce red, green, and blue light, whose intensities are varied and combine to render images in a wide range of colors.

These phosphors give CRTs their inherent reflectance, says Raymond Soneira, president of DisplayMate Technologies, a test lab for display products. Although the light generated is colored, the phosphors are, in fact, white and therefore very reflective. "As a result, essentially all CRTs have some form of anti-reflection treatment," which typically involves adding a layer of dark or etched glass to the front of the monitor and applying an anti-reflection coating, notes Soneira.

Other factors compound the reflectance of CRT monitors. Early models displayed negative contrast—colored text against a black background—and were highly prone to reflections. CRTs have limited brightness—100 to 250 candelas per square meter—making them incapable of standing up to high luminance and color contrasts in their surroundings. In addition, their convex screens mirror a wider swath of their surroundings than do flat displays.

LIQUID CRYSTAL

Few CRT monitors are still in use today, having been replaced by brighter and less-reflective technologies. Of these technologies, LCD (liquid crystal display) is the most widely used in desktop monitors, laptops, tablets, and cellphones. These displays also tend to be the brightest, achieving luminances of 300 to 450

candelas per square meter, compared to 100 to 250 candelas per square meter for both CRTs and plasma screens. LCDs owe their high luminance to an independent backlight—cold cathode fluorescent or LED—"that can be more easily engineered to be brighter," says Soneira.

Apple's retina screens are also LCDs. The difference is their high pixel density, which makes individual pixels undetectable by the human eye—or retina—at a viewing distance typical for the size of the device. According to Soneira, "retina screen" is more a marketing term than a specific technology. Additionally, 1920x1080 HDTVs are technically "already retina displays," as larger LCDs require fewer pixels per inch to provide the same visual experience.

LCDs render images in a variety of ways, the most popular being twisted nematic. In this process, liquid crystal molecules, sandwiched in glass between two polarizers (set 90 degrees to each other), modulate light by twisting to allow the light to pass through and untwisting to block it. Adjusting the current varies the intensity of the light, to which color is added via

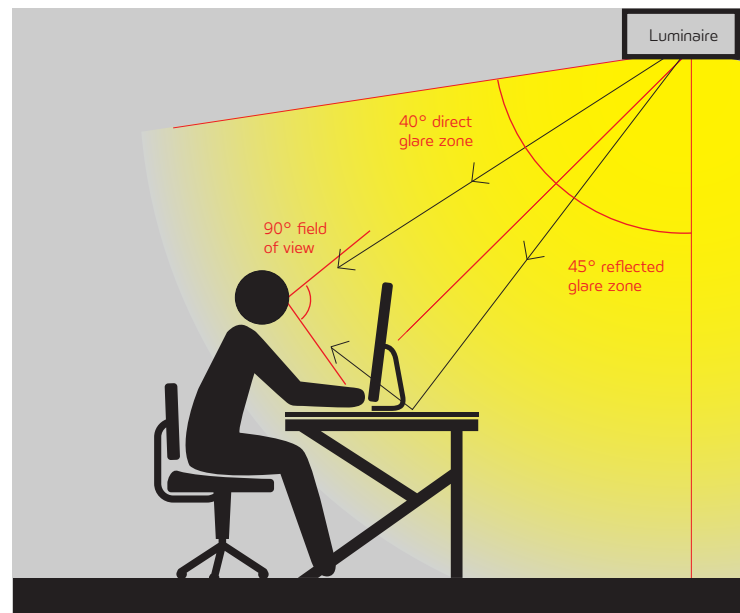
a filter of colored pixels, each comprising three subpixels in red, blue, and green.

LCDs are inherently less reflective than CRT displays, notes Soneira. The front polarizer absorbs and blocks ambient light, and "the liquid crystal itself is a clear liquid, rather than a highly reflective white phosphor," he says. While LCDs can be treated with an anti-reflectance coating, which lends a matte appearance, those touted for their clarity and vibrant colors tend to have a glossy finish—as do tablets and smartphones, to enhance their sensitivity to touch. According to Soneira, a simple way to gauge reflectance is to examine computer displays in their off state: Monitors with less reflectance will look darker.

EARLY VDT LIGHTING

Given how reflective CRT monitors are, office illumination designed in the 1980s and 1990s prioritized minimizing glare and ensuring visual performance, says Mitchell Kohn, president of Chicago-based Mitchell B. Kohn Lighting Design. Illuminance levels for screens were kept between 5 and 10 footcandles for optimal

DIRECT AND REFLECTED GLARE



When designing a lighting layout, designers need to be mindful of two types of glare emitted by a luminaire: direct glare and reflected glare. Direct glare happens when the light source emits light directly into a person's eye. Reflected glare is caused when light is reflected off a specular surface, such as a mirror or glass. Interior fixtures designed for office lighting often address these two types of glare conditions through the use of baffles and/or lenses. However, designers should still be aware of sight lines and angles, which can contribute to causing glare.



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visibility. Lamps were shielded and luminance limits were established by the IES for direct lighting at high angles between 50 and 90 degrees above nadir, typically called “the glare zone.” Compliance involved the use of low-glare lenses or louvers, which “created a cutoff at angles that commonly caused reflections,” Kohn says.

The sharp cutoff, however, resulted in a cave effect and a gloomy office environment. “Because the luminaires were so controlled, there really wasn’t any light on the walls,” says David Pfund, president of West Haven, Conn.-based Tambient, a division of lighting manufacturer The Lighting Quotient. Although light on the horizontal surface was plentiful, the upper regions of a space were darker, and scalloping was visible on the walls. To address the problem, designers supplemented with wallwashing and accent lighting on perimeter walls. In workstations, the strong directional lighting required tasklighting to eliminate shadows under shelves.

Indirect lighting offered another option for eliminating direct and reflected glare. The light reflected off the ceiling was softer, less bright and therefore more accommodating of VDTs. Fixture spacing was optimized to ensure uniform illumination and avoid high-luminance contrasts in the ceiling that could reflect on the CRT displays. The dark undersides of the fixtures, however, were sometimes visible on the screens. A screen-friendly alternative was a direct-indirect fixture, but, again, the direct component required proper shielding. Moreover, with ceilings lower than 9 feet, both fixture types became visual obstructions or required closer spacing for uniform illumination.

Fortunately, screen reflections tend to be less of a problem with modern display technologies. Anti-reflectance treatments have proven effective in eliminating reflected imaging, and higher internal brightness and increased contrast have improved screen visibility, even in elevated ambient light situations. More importantly, irrespective of finish, today’s computer screens are often adjustable and can be tilted to optimize viewing, or they’re portable, as in the case of laptops and tablets, which allows users to move away from sources of glare.

Such developments, as well as the ubiquity of workplace computers, have pushed the IES office lighting guidelines to evolve. Current recommendations, such as *American National Standard Practices for Office Lighting RP-1-12* not only specify different requirements for four levels of VDT usage but also distinguish between matte and glossy displays. Not surprisingly, luminaire and ceiling luminance limits for the former are more relaxed than for the latter. These changes point to “the

proliferation of VDTs in every type of business and acknowledge the growing prevalence of new technology, highly specular flat-screen monitors,” says Pfund.

In general, advances in computer displays have given designers a “freer hand” in devising appropriate office lighting solutions, says Dan Frering, director of education at the Lighting Research Center in Troy, N.Y. No longer confined to fixtures with low brightness or indirect lighting, the designers “are able to design different types of lighting,” he notes, and in the process, alleviate some of the earlier gloominess associated with office lighting design. The forgiving nature of modern VDTs “allows us to create brighter spaces,” says Stephen Margulies, a partner at New York-based lighting design firm One Lux Studio. “The walls can tolerate more brightness; the fixtures can tolerate more brightness.”

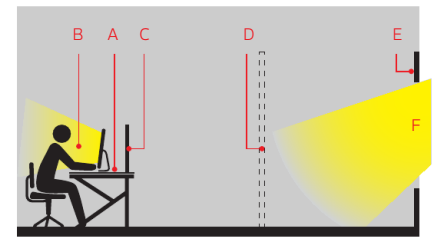
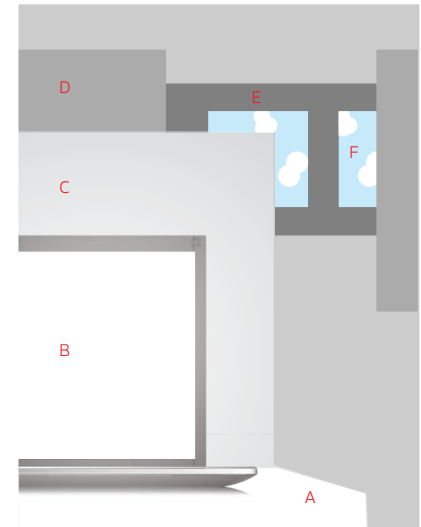
In fact, Gary Woodall, senior designer at Gary Steffy Lighting Design in Ann Arbor, Mich., and chairman of the IES Office Lighting Committee, has noticed a return to the use of white or opal lenses in direct lighting fixtures. Woodall says the trend is driven by the need “to make offices less expensive, more flexible, and easier to install.” The lenses not only diffuse the light but also “bounce” it to walls, eliminating dark shadows, adding brightness to the space and enhancing comfort. However, unlike louvers, they require no supplemental “lighting hardware,” and thus reduce cost. “So your laptop is bright enough to see,” Woodall says, “but if it’s too bright where you’re sitting, you change the angle of your screen.”

These lenses, however, have a downside. Aside from softer illumination, they’re “not really controlling the output,” Kohn says. The high-angle brightness emitted may make a space seem more inviting but, without proper management—and depending on the ceiling height and room size—it can produce direct glare and reflected glare if glossier screens are being used. Moreover, the lenses create brightness patterns on the ceiling that again can impair screen visibility and be visually distracting.

MANAGING GLARE

Addressing glare and reflected glare is particularly critical in open-plan offices and as more office work becomes computer-intensive, notes Kohn. Whereas paper tasks are done with one’s head in a downward position, computer tasks tend to be horizontally oriented, putting the ceiling and luminaires within workers’ field of view. How much glare a fixture appears to emit, however, does depend, in part, on its surroundings. The same light fixture may be more tolerable in a space with light finishes than one with dark,

LUMINANCE RATIOS



Luminance, or brightness, is one of the most important criteria to consider when designing lighting. Luminance is the amount of light energy reflected off a surface that our visual system sees. In an office environment there are three main recommended luminous ratios:

1. Between paper task and adjacent screen (3:1)
2. Between task and adjacent surroundings (3:1)
3. Between task and non-adjacent areas (10:1)

The eye adapts to different levels of brightness. The diagram above illustrates the main planar surfaces to be aware of in an office and how they relate to one another:

- A. Work Surface
- B. Screen
- C. Workstation Partition
- D. Door (Light Surface at a Distance)
- E. Wall (Dark Surface at a Distance)
- F. Window (Bright Surface at a Distance)

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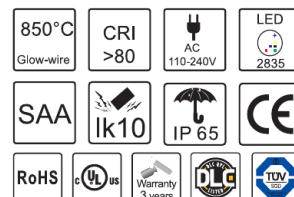
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where the contrast is more pronounced and uncomfortable.

But the largest source of reflected glare in VDTs, of course, is windows. The solution can be as simple as positioning the computer display perpendicular to the window or employing window coverings. “We are spending a lot of energy, believe it or not, on trying to convince our clients on a lot of projects to use automated shading systems,” says Margulies. With daylight increasingly seen as key to sustainable and productive office environments, such systems are indispensable. Margulies notes that they are even willing to re-examine the lighting budget so that monies originally allocated for electric lighting may be spent on motorized shade systems.

As it relates to luminaire design, however, interest in glare control has waned, according to Kohn—and not because of improvements in VDT technology. Instead, concern for visual performance in office lighting has taken a back seat to energy codes and energy performance. Fixtures that prevent glare or light indirectly are less energy-efficient and, consequently, selection is more limited now than it was before. LEDs further complicate the issue, because “when you try to crank that much light out of a small light fixture, you get lots of glare,” Margulies says.

Regardless of display technology, other aspects of office lighting remain essential to ensuring comfortable VDT tasking, such as contrast control, says Margulies. Although high contrast ratios between text and background enhance visual acuity and reading, they are less desirable for illuminating the surfaces adjacent to a

computer screen. Instead, IES guidelines restrict light and dark contrasts between those surfaces to a ratio of 3:1. Cubicle walls and the top of a desk, for example, should be no more than three times lighter or darker than the computer display.

For more remote surfaces, keeping contrast ratios below 10:1 is ideal. This applies to the luminance difference between the computer screen and, for example, a far wall, as well as that between the darkest and lightest remote surfaces within the field of view. To avoid distracting brightness patterns in the ceiling that could reflect in a glossy display, differences in ceiling luminances also should not exceed a ratio of 10:1.

Higher contrasts than those recommended require the eye to constantly adapt, potentially leading to eye fatigue. This is also why computer tasking with a window in direct view is not advisable. The contrast ratio between the screen and window can be as high as 1,000:1. Similarly, direct lighting fixtures with white lenses may produce contrast ratios in excess of 100:1 or 200:1, notes Woodall. “We’re functioning OK,” he says, but “we’re not particularly comfortable.”

Comfort may not be too far off as new products begin to address both energy usage and visual performance. Some see promise in lighting systems that offer more individualized control, be it through furniture-integrated fixtures or wireless LED technology. First and foremost, a shift in attitude is needed. As Woodall notes, “Until people decide that lighting quality is equally important to the energy used, then we’ll not see a lot of movement.” •

RESOURCES

A list of reference sources that address office lighting issues.

RP-1-12: American National Standard Practices for Office Lighting, Illuminating Engineering Society, January 2012. Available at: bit.ly/1J8szkk

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PRODUCTS

TAKING IT OUTSIDE

From heavy duty to purely decorative, these luminaires represent the latest innovations in outdoor lighting for versatile and safe spaces that mind the environment.

text by Hallie Busta



Ipnos, Flos • Milan-based Rossi Bianchi Lighting Design reduced the boxy form of a typical lantern to this slender, 2-pound decorative metal frame. Dimmable 15W LEDs in the upper edge of Ipnos' anodized aluminum profile provide 2700K at a CRI of 85. The base, which is 27.6" tall and 13.8" square, is finished in black and can become a table with the addition of a transparent, methacrylate top. • usa.flos.com



Santorini, Mørset • For Mørset, the Valencia, Spain-based Sputnik Estudio designed the Santorini series of versatile lanterns with forms reminiscent of those used to light old fishing boats. Each fixture measures 10.16" high and 8.35" wide, and is offered with gray, white, and mustard hued diffusers that can be custom-oriented for a unique installation. The fixtures can be lamped with 14W CFL or 11W LED light sources. • mørset.com/usa



EcoSpec Linear HP EXT, EcoSense • This high-output, low-profile exterior luminaire is fitted with a glass lens and vents to mitigate moisture build-up. Offered in 2700K, 3000K, 3500K, and 4000K, the fixture is fully dimmable, and it offers color consistency within two MacAdam Ellipse steps. It is IP66 and UL rated for wet locations, and its maximum run length is 55' at 120V and 125' at 277V. • ecosenselighting.com



L05175 and L05176 Drivers, Lumotech • This duo of fully programmable, outdoor-rated drivers is designed for use in high-bay and exterior applications. The 75W L05175 and 150W L05176 (shown) Class 2, IP65-rated and dimmable non-isolated drivers can support output voltages of up to 280V DC. • lumotech.com

Guide, Landscape Forms • Three twisting, multi-height, cast-aluminum panels surround a central light pillar to shape Landscape Forms' LED bollard Guide. Available in 3000K, 3500K, and 4000K at a CRI of 85, light is emitted through the bollard's slats at 120-degree angles. Created with global design studio Frog, the surface-mounted fixture measures 43 $\frac{3}{4}$ " tall by 8 $\frac{3}{4}$ " wide. • landscapeforms.com



Parco 360, HessAmerica • This pole-mounted LED luminaire gives the typical outdoor fixture a minimalist bent. At 12' tall with a cross-section of 7.5" by 3.5", the 34W Parco 360 is lamped with two modules that each include 14 LEDs and a prismatic optical acrylic lens. Offered with Type II and Type III optical distributions, the luminaire emits no uplight at 90-degrees horizontal and above. • hessamerica.com

FLL and FXL Floodlights, Hubbell Lighting • Hubbell Lighting is adding two high-output fixtures to its F Series of floodlights. The FLL (far right) uses 28 LEDs to deliver 8,054 lumens at 80.5 lumens per watt. The FXL (right) uses 56 LEDs to deliver 16,358 lumens at 82 lumens per watt. Both provide 5100K at a CRI of 67. Vented housings isolate the LED module to improve performance, the company says. • hubbelloutdoor.com





CLASSICALLY DEEP

L'Observatoire International has designed an integrated lighting scheme for the Metropolitan Museum of Art that reveals the depth of the building's Beaux-Arts façade and assists wayfinding in its new Olin-designed plaza.





text by Aaron Seward

The stately and solid Beaux-Arts façade of the Metropolitan Museum of Art has held court over Manhattan’s “Museum Mile” for more than a century. Designed by Richard Morris Hunt, with wing additions by McKim, Mead & White, the edifice is distinguished by massive Corinthian columns, heavy entablatures, intricately detailed cornices, and monumental arched openings. As impressive as the façade is, for about a generation much of its presence has been lost at night, washed out by powerful pole-mounted, glare-inducing metal halide floodlights on the opposite side of Fifth Avenue that overwhelmed the elaborate texture of the design.

That regime has now changed. A recent redesign of the Met’s plaza by Philadelphia-based landscape architecture firm Olin has transformed the museum’s Fifth Avenue–fronting public space with people-friendly amenities, including new allées of trees, modern water features that replace the old fountains, and permanent and temporary seating options. The lighting design has also been reconceived. New York lighting design firm L’Observatoire International, who also worked with Olin on the recent redesign of Columbus Circle, has introduced a new scheme that illuminates the presence of the museum’s architecture after the sun goes down while discretely providing a safe and easy-to-navigate environment in the plaza.

“The inspiration for our design was going

over there at night,” says L’Observatoire founder Hervé Descottes. “The presence of the building in the day and in the city at night were different. Lit as it was from the opposite side of street with very powerful light fixtures, the façade would lose all sense of volume. It looked almost flat. There were not too many shadows. It was a brutal way of lighting such amazing architecture.”

Descottes and his team sought to find a way to better connect the museum’s staggering holdings of classical artworks with its exterior, to bring the almost awe-inspiring experience of being inside, wandering through its treasure-bedecked halls, to the experience of passing by it on the street or relaxing in the plaza. At the same time, the team did not want the lighting to be too garish or to overly accentuate the more ornate moments of the architecture.

The strategy that the team decided on was to focus on lighting only certain relationships in the façade, such as the hierarchy between the colonnade and the entryway, or the wings and the flanking pavilions. They also decided to position the fixtures in such a way that it gives the impression that the stone of the façade itself was glowing from within.

“We have a lot of applied situations,” Descottes says. “I took care first of the pedestrian view. My concern was how would you feel when you are at street level, or in a taxi when you are coming around on 81st Street. What do you see when you

A view of the plaza during the day (above). This outdoor public space, which runs the length of four city blocks along Fifth Avenue, features new granite fountains, paving, lighting, and seating. The plaza also features allées and bosques of London Plane trees at the north and south ends that help lead visitors to the museum’s main entrance. The new LED lighting highlights the building’s Beaux-Arts style architectural details (right).

Above: Olin/Sáhar Coston-Hardy; Right: Matthew Carbone

CUBISM
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COLLECTION



LED fixtures are discreetly positioned to convey the volume and depth of the façade elements, such as the cornice, columns, and windows.



Left: Matthew Carbone; Above: L'Observatoire International

A rendering (above) of the lighting scheme by lighting consultants L'Observatoire International illustrates the hierarchy of the lighting elements:

- A. uplights behind columns
- B. uplights between columns
- C. uplights at niches between columns
- D. column downlights
- E. linear uplights at arches
- F. blade uplights at arches
- G. keystone above entry
- H. linear fixtures at ledges above columns
- I. linear fixtures at top ledges
- J. fountain lighting
- K. projector blade
- L. projector floods
- M. ledge uplights
- N. window uplights

look at the building? I didn't want you to see any fixtures. Now, with LEDs, it's easier to integrate and hide fixtures, so that's what we did."

L'Observatoire used LEDs exclusively to light the façade and the plaza. On the façade, the team placed linear LED fixtures, 7.5W per foot, strategically in reveals up the elevation, at the cornice, and at the base of the columns in order to communicate its volume and depth. The placement of the fixtures and beam distribution were carefully considered to not create hot spots, and glare shields and sandblasted diffusing lenses were used to create a diffuse quality of light. The lighting designers gave the portico extra emphasis with spotlights that flank the entryway, framing it with a precise band of light. A warm-white color temperature range was chosen for the lighting, between 2700K and 3500K depending on luminaire placement. The slight variation in temperature was used to accentuate the hierarchies of the façade. The color was also matched as closely as possible to the building itself, creating continuity in how it appears during the day and at night as well as giving the sense that the stone itself is emitting light. "It's really a feeling that the building is glowing from inside, giving a sense of, 'Wow, it's alive!'" Descottes says.

In the plaza, the lighting integrates into the ground plane and focuses light on the primary objects on the hardscape. LED accent fixtures

uplight trees and linear LED fixtures highlight benches. Zoom-focus LED projectors uplight the flagpoles and water features. Here again, slight variations in color temperature, between 2700K and 3100K, create a hierarchy across the space.

In addition to the slight variations in color temperature, L'Observatoire set the scheme on a control system that allowed the designers to change light levels in different areas, again to emphasize the hierarchy of the architecture. The system also adjusts light levels according to the time and amount of sunlight available. As day turns to night, the lighting comes on very bright to compete with the remaining ambient natural light. This prevents the building from becoming backlit, since it faces east.

As the sky gets darker, the lighting becomes softer, settling into its modulated, hierarchical display of warmer to cooler, brighter to darker. It remains on until the museum closes, and then it starts its process of shutting down: First, the flanking pavilions go dark; then, the connecting wings shut down; and finally, only the entryway is left lit. The process was designed like this as much to conserve energy (all on the plaza and façade lighting amount to 16,847W) as to cut down on spill light that may shine into the neighbors' windows. "The neighbors are very sensitive," says Descottes. "We wanted to make sure our design is elegant and doesn't offend anybody." •



Details

Project: The Metropolitan Museum of Art, Fifth Avenue façade and plaza, New York • **Client:** The Metropolitan Museum of Art, New York • **Landscape Architect:** Olin, Landscape Architecture/Urban Design/Planning, Philadelphia • **Lighting Designer:** L'Observatoire International, New York • **Water Feature Consultant:** Fluidity Design Consultants, Los Angeles • **Traffic and Transportation Engineer:** Sam Schwartz Engineering, New York • **Construction Project Manager:** Gorton & Partners, New York • **Additional Consultant:** Spatial Affairs Bureau (formerly Rick Mather USA), Richmond, Va. (site furnishings and architecture) • **Project Size:** 70,706 square feet (plaza); 1,021 square feet (façade) • **Project and Lighting Costs:** Not Available • **Code Compliance:** No energy code was required for the project due to the museum's status as a Historic Register building. (Note: The South Guard Booth [not part of the lighting scope] was a new structure and had to comply with ASHRAE 90.1-2007.) • **Watts per Square Foot:** 0.057 (plaza); 13.3 (façade); 0.47 (project total) **Manufacturers** **Altman Lighting** (Outdoor ellipsoidal gobo projector with zoom focus for façade lighting) • **Acuity Brands/Winona** (Custom glare shields for linear LED fixtures at entry) • **Acuity Brands/Winona LED** (Linear LED fixtures at façade cornice and at benches) • **B-K Lighting** (Low-voltage landscape accent light with dimmable, 3100K LEDs at planters) • **Felix (inter-lux)** (LED ingrade striplight at donor signage) • **Lumenpulse** (Yoke-mounted 3500K LED spotlight for flagpole illumination) • **Lutron** (Lighting control dimming system) • **Philips** (Yoke-mounted 2700K LED spotlights at entrance, stem-mounted version at planters and drives; linear LED fixtures at entry porch) • **Q-Tran** (Toroidal transformer for linear LED fixtures at benches) • **Sylvania** (Power supply for LED striplight at donor signage) • **Technilume** (Extruded aluminum pole to accept light fixture brackets, signage, and accessories at south and north drive planting areas and tree bosques) • **We-ef** (3500K in-ground LED uplights at tree allées and tree bosques and 2700K ingrade fixtures for façade lighting)



The plaza is transformed at night by the lighting. The allée of London Plane trees are uplit by inground 30W 3500K luminaires. Linear LED fixtures (30W per 8-foot bench) accent the bench seating areas, and 25W LED projectors illuminate the flagpole and the fountains.



REVIVING ROTHKO





A cutting-edge conservation tool uses light to erase 50 years of damage to Harvard University's famed murals by Mark Rothko.



text by Elizabeth Evitts Dickinson

Every day at 4 p.m., visitors standing in the special exhibition gallery at the Harvard Art Museums in Cambridge, Mass., can watch as a suite of Mark Rothko murals age 50 years in an instant. In that moment, a digital light projector switches off and what was a cohesive series of painted panels, known collectively as the *Harvard Murals*, suddenly looks disjointed. A beautiful, plum-colored background fades to different hues and the ravages of light and time on a delicate painted surface stand out. In an impressive trompe-l'œil, the murals painted in the 1960s by the famed abstract expressionist suddenly lose their luster.

This trick of time is the result of an innovative conservation tool created by the Harvard Art Museums and the MIT Media Lab for a special exhibition called “Mark Rothko’s Harvard Murals,” on display through July. Rothko’s paintings had originally been commissioned for a penthouse dining room at Harvard’s Holyoke Center, designed by architect José Luis Sert from 1958 to 1965 (now the Richard A. and Susan F. Smith Campus Center). The murals hung there until they began to fade. In 1979, they were rolled, put into storage, and rarely seen by the public. That is, until now.

The paintings have been restored using a novel digital camera-projector system and customized software. Developed by a team of art historians, conservation scientists, and conservators, this use of light effectively erases the damage to the work. Jens Stenger, who worked on the project at Harvard but is now the associate conservation scientist for the Institute for the Preservation of Cultural

Heritage at Yale University, says that using light as a conservation tool dates back to the 1980s. It is still considered rare, though, particularly as a color corrective technique in fine art. “This is the first project of its kind on paintings, as far as we know,” Stenger says.

When first considering how to conserve the murals, the curators and scientists had a challenge. Traditionally, paintings are restored using a painstaking reapplication of paint, among other things, but this was ruled out for the Rothko canvases. The artist blended his own paint using ingredients like animal glue, egg, and pigment in order to exact a specific impression. The different recipes created varied surface effects of matte and gloss and the artist never used a varnish, which could damage that subtlety. The beauty of a Rothko is in the painter’s mastery of surface: The delicate changes in color, texture, and paint stroke. Replicating that would be impossible. “Traditional conservation where you add paint would be irreversible,” Stenger says.

Five separate panels make up the *Harvard Murals*, and Rothko’s intent was that they work in tandem. (A sixth panel, which was never installed, resides in the Rothko family private collection.) “Rothko talked about creating an image,” Stenger explains. “The five paintings were meant to act as one unit.”

The damage to the paint over time destroyed that unifying effect, but since repainting the canvases was out of the question, the team considered a system that might recapture the original look without touching the surface. That’s what led them to using light.

The first step in conserving Rothko’s work was confirming how the paint on the original panels looked. This proved tricky. The team went to the archives at the Harvard Art Museums to examine 5-inch-by-7-inch Ektachrome images that had been taken in the early 1960s after the murals were installed. “Ironically, the images were faded as well,” Stenger says. “The reason is simply that the film at the time wasn’t stable. The cyan photographic dye degrades in the dark. You can store it really well and it still degrades.”

The team took the images to Rudolf Gschwind, a professor and head of the Digital Humanities Lab at the University of Basel in Switzerland, who is a specialist in digitally restoring slide film. “He has a custom-made LED illumination scanner to measure dye concentrations in the photo emulsion of the film,” Stenger says. “We did a scan that resulted in dye concentrations pixel by pixel.”

After months of careful restoration to the slide film, the team felt certain that they had an accurate representation of the original color. Next, they had to find a way to create a

compensation image that could be beamed onto the canvas so that the reflected light closely resembled the murals from 50 years ago. About a dozen photos were taken under different illumination conditions to generate that compensation image, according to Stenger. For each image, they analyzed, pixel by pixel, the calibration curves for each color channel—red, green, and blue. They then used a color-mixing matrix to characterize the interdependence of these channels. “We calculated the light for more than two million pixels that had to be put onto the canvas in order to create the appearance that we wanted,” Stenger says.

In addition to the digital light on the canvases, the team had to consider the ambient light in the gallery. Rothko hated the use of spotlights to illuminate his art and had very specific ideas of how he envisioned his work lit. In a letter written to a London gallery in 1961, Rothko explained his preference for gallery lighting: “The light, whether natural or artificial, should not be too strong: the pictures have their own inner light and if there is too much light, the color in the pictures washes out and a distortion of their look occurs. They should not be over-lit or romanticized by spots; this results in a distortion of their meaning. Above all, the entire picture should be evenly lighted and not too strongly.”

For the exhibition at the Harvard Art Museums, the curatorial team lit the walls and the room independently of the paintings at 50 lux. “We used light fixtures with two lenses and four shutters and a diffusing gel,” Stenger says. “We pieced together the light on the wall behind the murals and were able to illuminate rectangles that blend together,” without shining on the paintings themselves. The software that runs the digital projector takes the ambient light into consideration when calibrating how to shine light on the mural.

The decision to shut the lights off at 4 p.m. each day was one that the team debated for years, according to Stenger. “We constantly asked: How should we show the work? It was a hard decision. You want to respect the art. You don’t want this to be about a fancy conservation technique. It’s about the painting,” he says. “But on the other hand, we’re introducing this novel conservation tool. The projection and the way it’s installed now is so perfect that most people who come in the gallery can’t tell just by looking at the painting that the lights are on.”

Stenger visited the gallery recently to watch the 4 p.m. switch. “People are surprised because it’s so believable when the light is on. The change is dramatic.”

This special exhibition, with 38 works by Rothko including sketch studies of the *Harvard Murals*, remains on view through July 26. •



Mark Rothko's *Panel Four* and *Panel Five* (*Harvard Mural*), with restored colors (previous spread). *Panel One*, *Panel Two*, and *Panel Three* (*Harvard Mural Triptych*), (top). Senior conservation scientist Narayan Khandekar holds up a white card which shows the digital projection on *Panel Four* (this image). Archival photo of the installation of *Panel Five* at the Holyoke Center in January 1963 (opposite).

Details

Exhibition: Mark Rothko's *Harvard Murals*, Harvard Art Museums, Cambridge, Mass. • **Curatorial Team:** Mary Schneider Enriquez, the Houghton associate curator of modern and contemporary art, Harvard Art Museums; in collaboration with Narayan Khandekar, senior conservation scientist, Straus Center for Conservation and Technical Studies, Harvard Art Museums; Carol Mancusi-Ungaro, director, Center for the Technical Study of Modern Art, Harvard Art Museums, and associate director for conservation and research, Whitney Museum of American Art • **Research Coordinator:** Christina Rosenberger, Center for the Technical Study of Modern Art, Harvard Art Museums • **Conservation Scientist:** Jens Stenger, Institute for the Preservation of Cultural Heritage, Yale University (formerly of the Straus Center for Conservation and Technical Studies, Harvard Art Museums) • **Camera-Projector System and Software:** Developed with Ramesh Raskar, associate professor of media arts and sciences, Massachusetts Institute of Technology (MIT), and head, MIT Media Lab's Camera Culture Group • **Digital Restoration of Ektachrome Transparencies:** Rudolf Gschwind, professor and head, Digital Humanities Lab, University of Basel, Switzerland

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Denise Fong

interview by Elizabeth Donoff
photo by Olugbenro Ogunsemore

"I still get excited when I go to a project that's just finishing construction, and they turn the lights on and it looks like what I imagined it to look like. I really love seeing it. It's like, 'Wow, that's just what I thought it was going to be.'"

Trained in interior design, with a degree from Washington State University, Denise Fong found herself venturing into lighting initially from the vantage point of interiors. Participation in the International Association of Lighting Designers intern program gave her a new perspective and exposure to a cross-section of the lighting community. Those early experiences have stayed with Fong as she has mapped out her career in the areas of expertise of healthcare lighting and sustainability. And they have helped her while building the lighting practice Candela over the past 18 years, which is a division of Seattle area engineering firm Sparling.

How do you view the relationship between architecture and architectural lighting?

There's a convergence happening in many areas of design around the built environment. I think that sustainability is perhaps responsible for drawing us closer together and blurring the lines between where one discipline starts and the other one stops.

Are there designers that influenced you when you were first getting started in lighting?

Jules Horton. Jim Nuckolls. Jeff Milham. Lesley Wheel. Howard Brandston. At the time, I didn't really understand that these were the first generation of really true lighting designers. Here I was sitting in the conference room listening to them. In hindsight, I realize what a fantastic opportunity that was.

What fascinates you about light?

The intangible nature of it. I learn something almost every day about light, the way it reacts with materials, shapes, or forms. It keeps me wanting to come back to the office to see what new thing we're going to find out today.

How has the profession changed since you first started working?

The most interesting change is the fact that today people understand why they need a lighting designer. When I first started working we spent a lot more time explaining why they needed our services.

How would you describe what it is that a lighting designer does?

As a part of the overall architectural team, it's our responsibility to make sure that the vision of what the visual quality of the lighting environment is intended to be comes to fruition.

What advice would you give a young designer?

Seek out ways to learn more about lighting through travel, experimentation, and studying what others have done. •

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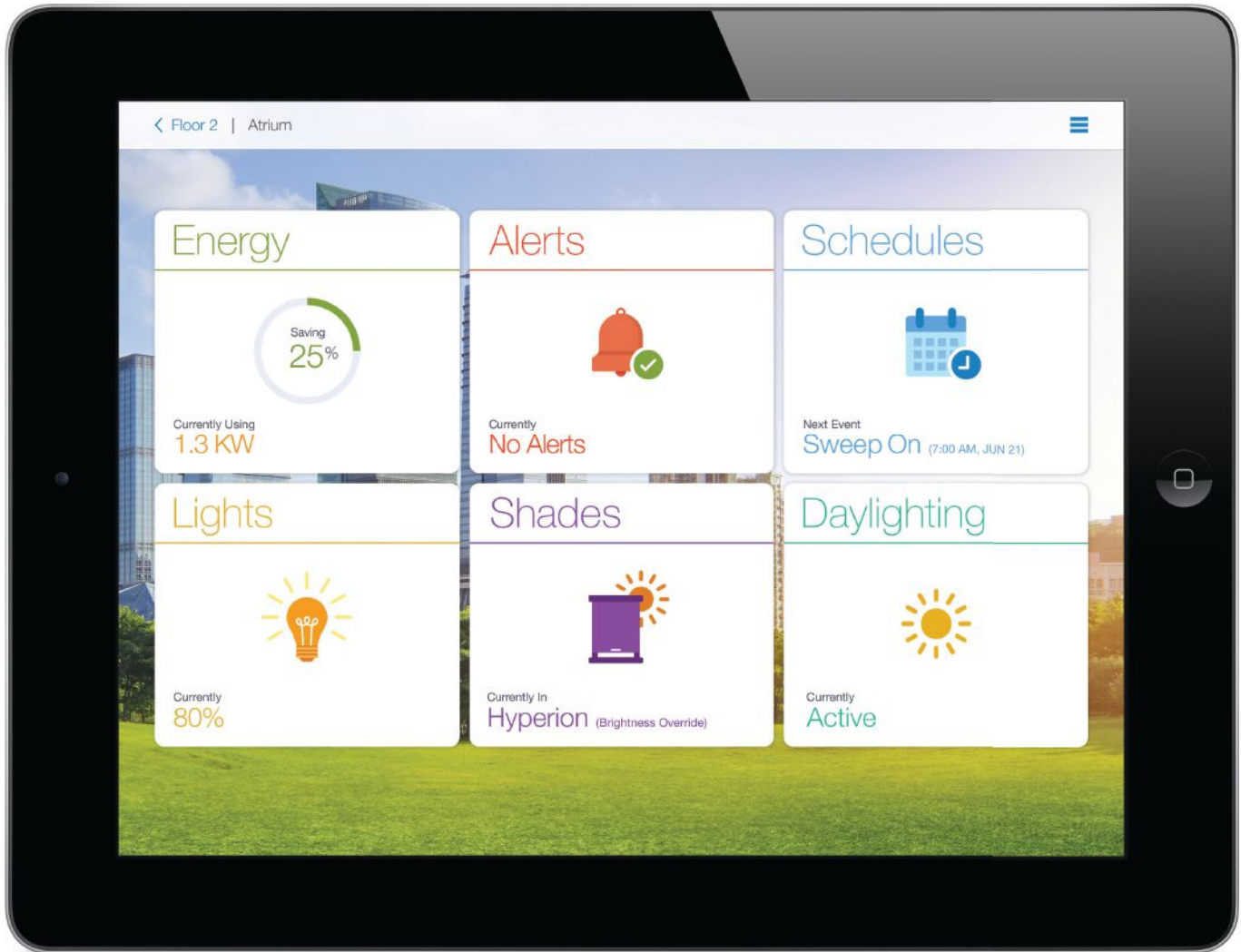
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