

Text-Alternative Version: Better than CFL? Dimmable LED Downlights in Hospitality Facilities Webinar

Linda Sandahl: First, I'm very happy to welcome our speakers: Bob Davis of Pacific Northwest National Laboratory and Ardra Zinkon of Tec Studio.

Bob Davis joined Pacific Northwest National Lab in 2013 as a Senior Staff Lighting Engineer, where his responsibilities include directing the Gateway Demonstration Program. His three decades in lighting include experience with a large multi-national lamp manufacturer and with a small employee-owned luminaire manufacturer, where he led new product development, engineering and marketing teams. For more than 15 years, Bob has taught and conducted research in lighting as a faculty member at Rensselaer Polytechnic Institute Lighting Research Center, and then the Architectural Engineering Program at the University of Colorado at Boulder.

Ardra Zinkon is President of Tec Studio, a lighting and technology design firm located in Columbus, Ohio. Ardra has been working as a professional lighting designer since 1997 and is dedicated to the practice of professional lighting design. She is an active member of the Illuminating Engineering Society and also a professional member of the International Association of Lighting Designers. She is also certified as a LEED Green Associate by the U.S. Green Building Council. Ardra served on the IES Board of Directors and is currently serving as the chair for the 2014 IES annual conference. In addition, she contributes to several national committees to maintain her expertise in the industry.

So with that, welcome to both of the speakers. Bob, please begin.

Bob Davis: Thanks Linda, thanks for the introduction, and thank you ladies and gentleman for taking the time out of your day today to participate in the webinar. I am located in Portland, Oregon, and as you can see on your screen, Ardra is in Columbus, Ohio. I know many of you are from different time zones across the U.S., so we are glad that you could join us.

This presentation is based on a recently completed project that the Department of Energy did at the Hilton Columbus Downtown Hotel, studying their use of LED downlights in their guest rooms. We also have participating in the webinar Phil Hornstra. Phil is the director of property operations at the Hilton Columbus, and so Phil will be available during the Q&A. Any of you who have operational questions and just questions for the person who has lived in the building for these years can feel free to direct questions to Phil as well.

Before I jump into the presentation, you might be interested in seeing some results from the question we asked when you registered for the webinar. We wanted to get a little insight into the audience, so we asked if you had been involved in an LED downlight project, new or retrofit, and we gave you five choices. And we had a lot of folks who registered, and we've had 43 folks that said no and they don't have any plans, 90 who said they have not participated yet but they have a project lined up in the next year, just one person said that they had an LED downlight project that had disappointing results, 47 said they have done LED downlight projects with mixed results, and actually 190 folks responded with favorable results.

Now this is a cross-section of manufacturers and sales reps and utility people and building managers and lighting designers, so it represents all sorts of the industry, but it's good to see that a lot of folks are very active, some of you are considering new projects, some have had mixed results, and so hopefully we will be able to provide some insights that can help with your future projects through the webinar.

What I'm going to do in the webinar, I'm going to carry the bulk of things for a while and then we'll bring Ardra in. Ardra was a lighting designer for the Hilton Columbus, and we'll let Ardra share some of her specific thinking of how they approached the project and what the solutions were.

I'm going to give you some broad background about why the DOE is sort of focusing on this application, and why the hospitality segment is such an interesting and important target for implementing more efficient lighting solutions, and then I'll give you the big picture of the Hilton. We specifically focused our study on the guest rooms, but this is overall a very interesting project and I think those of you particularly that work in hospitality would like a broad view of it. Then we'll dive into the guest room lighting detail and I'll turn things over to Ardra to let her talk about the LED downlight specification selection process and also some interesting controls that were implemented and even some things that were look at and not implemented that I think we could all learn from.

The DOE did visit the site earlier in 2014 and collected some data on the LED downlights. We took light level measurements, we measured some color data of the different light sources in the guest rooms, and we also looked at different aspects of energy use. So we'll share that performance data and then we'll come back in and let Ardra talk about some of the things that she thinks are good lessons to come away with from this project and how they can be applied to today and tomorrow's projects. And then as Linda mentioned we'll open it up to questions and answers, so feel free to type questions in as we go.

The DOE has estimated that there are about 700 million downlights installed in the U.S. today, and of the current installed base, of course very few of those are LED downlights. The current technology, primarily compact fluorescent, although still a lot of incandescent and halogen, whether A lamp or PAR lamp, or reflector-type lamps, a lot of that is in the installed base. If we look at the efficacy in lumens per watt of the luminaires, not of the lamps now but of the luminaires themselves, generally those technologies we see a range of 10-40 lms/Watt of the lumens coming out of the luminaire, and the light source lifetimes with the current technology range from a low of 1000 hours or so for many incandescent products up to 10,000 hours for compact fluorescent typically. With LED the current luminaires on the market, and we've looked through the next generation luminaires submissions and other things, the general range is 50-75 lms/Watt for the luminaires, and of course that continues to be pushed upward as the technology advances. And coming up with a good life number, as all of you know who have worked with this, it is hard to say exactly what a rated life number means, but certainly the promise is 20,000, 50,000, long lifetimes from these, much more so than the current technology.

So, from, those things alone, it looks like there would be huge energy savings potential, huge maintenance cost savings potential in implementing LED. But of course we have a lot of questions about the LED technology: How much more is it going to cost? What is the investment required? What is the color quality like - is that going to be acceptable? Can I control it? Can I dim? What about the light

distribution - will it be able to match other things that I want? Will it be able to give me the kind of quality architecturally that I want?

Reliability and lifetime, we mentioned, and there are other unknowns - it is a brand new technology. So, we have this seemingly huge potential, but of course there's a lot of questions. And so the DOE has begun this series of demonstrations focusing initially on some of these downlights, and specifically some of the next generation luminaire downlights, to document sort of performance and actual few installations.

When we look at the hospitality segment, historically incandescent halogen has been a big part of it. For many decades that was the way to go. A lot of good benefits of filament sources, pretty low first cost, lots of different shapes and sizes if you're trying to do things decorative, we can get decorate shapes, lot of options. In general, the electrical control is pretty easy. In general, the optical control is good with filament sources, a small light source. And in general the color properties are very favorable on what people seem to prefer. So, a lot of benefits with incandescent halogen. But of course, the downsides have worked strongly to see some new things come into the market. Very low lm/Watt efficacy, simply meaning that to get the light levels that you need for the different types of things happening in hospitality facilities, it takes a lot of power, it takes a lot of energy. That gets combined with the fact that you're changing lamps all the time with the types of long operating hours that you typically have in hospitality facilities. And so the operating costs with the combination of energy and maintenance just are not really acceptable in today's hospitality world. And of course we have the question of how long we'll be able to get many of those products as government regulations kick in.

And so, within hospitality the compact fluorescent lamp has become a widely used technology, much higher lms/Watt, much longer life, than the incandescent halogen, so those two things combined to give us this great potential for savings in energy and maintenance costs with the compact fluorescent products. But they didn't come without their downside as well. You have to make the investment. You have to decide if economically it is worth spending more upfront. Questions about color quality, is it acceptable for guests in hospitality facilities, earlier generations did they come on right away, even today when they come on, do they come on at full output? Is there a warm-up time? I have to confess when I travel, I've sort of learned the bad behavior of turning the bathroom lights on minutes before I go in so that the lights can warm up. Not good energy efficient behavior on my part. And then electrical control is a question. Can we get the type of dimming that we really want? The functionality? And just overall, as we use these in hospitality facilities, because of some of these question marks, are guests tolerating them, do they like them, are they happy with them?

It's funny at the start of the project I was kind of curious, I should pay more attention when I travel and just see how widely implemented CFLs have been and so, this isn't a formal poll at all, but just informally, with one of my colleagues, I said: "hey your next couple trips, take some careful notes in the hotel room you're in and if you have to secretly remove some lenses and things to see what's in the fixtures, let's just do that in our next few trips."

So basically we just again, not a controlled experiment, but an informal survey we visited five different hotels that were on our list as we were traveling, in multiple states across the country. And overall in those five hotel rooms, we found 62 total lamps in use. Two LED lamps were being used, three incandescent, four linear fluorescent, and 53 of the 62 lamps in the five rooms we visited were CFL. So that sort of confirmed in my mind that the CFL technology has really been widely adopted in hospitality. I should just note that the one room that had the three incandescent was in Las Vegas, so that sort of made sense too, right? Not a lot of LED yet. So not any sort of controlled survey at all, but just our own experience and 53 of 62 CFL. Now with all the downsides, that is a big number that has gone to CFL and of course the driver there is just the money that you can save in a hospitality facility with long burn hours, lot of energy use, CFL has become quite popular.

In April of 2013, Architectural Lighting published an article called "Meet the Replacements." And in that article they talked about CFLs replacing incandescent in hospitality and they talked to Domingo Gonzalez a lighting designer in New York. And I thought what Domingo said was interesting. This quote "Though dimming is a persistent problem with CFLs, Gonzalez notes that major hospitality chains have standardized using switches instead of dimmers in their rooms." And then I italicized this next sentence: "Dimmability has been an acceptable sacrifice for energy savings." And that's sort of where we were with compact fluorescent, or where we are with compact fluorescent, right? That we need the energy savings, we need the dollar savings, we need the longer life product, but we had to make some sacrifices and one of those things has been sort of a functionality that people may expect or may want in dimmability. So we have moved from incandescent to compact fluorescent pretty strongly in hospitality and we've made some sacrifices. And now, you know the question is we have this new technology on the market now and we still call it new, it's been around for a while obviously it's still rapidly emerging, and making big headway in the market. These various types of LED products are available. And so the big question really is, can we, in implementing LED, can we get back some of the things we had to sacrifice when we moved to some fluorescent sources, and maybe there's even more things and more benefits we can realize. So I guess the question that is sort of on our mind when we look at projects like the Hilton Columbus Downtown.

Quick overview of the Hilton in Columbus, here is the architect's rendering of the facility. You can see some of the numbers on the left side of your screen there, a big facility. The architects were HOK and Moody-Nolan. The building did get lead certified at the gold level. On the right-hand side of the picture you see that sort of series of cantered roof lines across the street from the Hilton. That is the Greater Columbus Convention Center. So the hotel is directly connected to the convention center with the sky bridge that you see there, and we'll come back to that. This hotel opened late in 2012. Occupancy in October and into November of 2012. Now those of you in the audience that won't understand the construction process, so you know if it opened on 2012 that means it was being designed in 2009, 2010, these things take a long time. So, there's a lot of things that Ardra will discuss about how that process unfolds when you're working with a brand-new technology.

I should mention too, usually, if you're familiar with the Department of Energy demonstration projects, we usually focus on brand-new installations, and so in this case, we decided it was worth looking at a user, the Hilton, and with Phil Hornstra's cooperation you know really understanding, here is someone

who implemented an LED a little while back, let's take a look at this facility and see how it's doing, you know, a year-and-a-half or so after it was implemented. And so this is sort of a different sort of demonstration for us to go in and study a building that had been in use for a little while.

Some more details on the facility: 484 guest rooms, that was the focus of our study was the guest rooms, where they implemented LED downlighting, and 48 suites which have similar lighting, just more of it than the guest rooms. I also have a large event space in the facility, a decent size restaurant which is located in the atrium, and we visited this facility in March of this year to take our data and to see the facility. We're not going to talk about the whole facility, we're going to focus on the guest rooms, but again I thought those of you in the audience who work in hospitality design or in hospitality management would be interested in getting an overview of the facility. So this is the main lobby, and lots of different light sources used in this project. There's some MR16 along that back wall that you see, the accent lighting on the wall on the right-hand side of the screen is ceramic metal halide, linear fluorescent, the floor lamps would have an LED lamp in them, so, a mixture of things in the lobby.

I should mention that in Ardra's design with the design team their custom LED concept that was used throughout the facility. It wasn't used in the guest rooms but again I thought some of you might be interested in sort of seeing a little bit of this. So in the lobby see the sconces visible. Those were all designed as a custom LED sconce. So you can see the atrium opening up on the screen there. And as you move into the atrium, on the left side of your screen you can see some people sitting in the restaurant. And so the restaurant is here in the lobby area, and then the atrium opens up. Now if you look at the end wall, sort of this wall over here, you're looking directly into guest rooms in that wall. And one of the concerns that Ardra will mention was knowing that people in the atrium were going to have visibility of the downlights being used and the concern that raised in terms of color consistency and those sorts of things. So some of the guest rooms have windows into the atrium, and along the other side the doorway is off the balcony there and the windows face the exterior.

So in the restaurant there was some other things used as well. Some more MR16 and the independence were a variation of the LED sconce again with the custom LED. Down in the conference area the pre-function spaces I just showed these again because they have the custom LED sconce and it just so happens the day that I was there they had the cover removed from one of them so I thought I'd just give you a peek at what's under the cover in that custom sconce.

The glass connector bridge, another cool thing that we didn't get to study but since I'm a charter member of the lighting geek society, I loved to walk across this bridge several times. It does color changing LED system that has become quite a beacon for the city of Columbus and had quite the opening ceremony when they first opened the connector bridge.

But we want to focus on the guest rooms, I wanted you to see the whole project, but our study was really on the guest rooms, and so I'm going to give you a very quick overview of the guest room lighting and then turn things over to Ardra so she can talk specifically about their selection of the LED downlights and controls.

Here is a floor plan of a typical guest room. And those of you that are on hospitality facilities know that there is typical with many variations of typical, but this was the room that we focused our study on. The king size bedroom. There are seven downlights. You can see on the plan type GA1. There are two LED downlights over here, there's a desk in many of the rooms and a seating area over here. And this is the window that may face the lobby like I mentioned. There are two other LED downlights out here in the entry area, and notice that it's just not a passageway but there is a mirror and a closet. And then there are three LED downlights in the bathroom. There also is some Millwork fixtures that were built in behind the TV stand using linear fluorescent, and also built in behind the bed using linear fluorescent, and then some typical bed reading lights, as well as some lighting built into the mirror. A linear fluorescent lighting built into the mirror. Let's look at some of the pictures of the room itself. Here is a picture of a typical guest room. You can see the different elements we mentioned: the LED downlights, the custom Millwork uplighting to provide some nice room ambient, and then the reading light by the bed. And then the other LED downlights. And if these pictures don't look as good, that's because these are pictures I personally took on an iPhone compared to the professional photographs that I've been showing before. But these are the downlights in the entry area on the left side of the screen and then a shot of in the bathroom, some of the downlights in the mirror light. And we'll come back to that when we hear from Ardra.

At this point I'm going to invite Ardra to step in. She has a series of slides to really talk about how they came up with this design. Ardra.

Ardra Zinkon: Thanks Bob. So I think looking back the slide that you saw in the floor plan, you can see the quantity of downlight that we had in there, and there was a reason. Part of it was the geometry of the space. And part of it, the entry hallway we actually had two in that short vestibule and the reason was we had a mirror in there. And had we centered one in the center of that, you wouldn't see the mirror in the dark. So, a lot of this is based around not just the energy consumption, but making sure from the design perspective that the space was usable, and that's really what led us to an LED solution with this particular project. Knowing we were going for at least the status of at least silver, and gold was just a nice bonus at the end of the day. It was really about the guest experience. And the entire, all of the guest rooms, we did the guest quarter as well as a queen and a king guest room, was completely mocked up. We had a space blocked out inside the convention center where the owner could come in and the owner's rep and interior designers and architects were able to not just walk through and look at the lighting, but they also swapped out furniture and Millwork and finishes within that space. So, I don't know if Bob can take this back. One of the other things you might notice in that first shot (one more forward Bob), is there's artwork on the ceiling. And we also have relatively dark wall coverings within the space. So, the impact that reflectances can have on a space is pretty significant, especially when you're trying to be really conscious with the amount of energy you're putting into this space, right, so you don't necessarily want really high wattages to go into that, so this was another reason that this kind of helped solve that energy solution for us. And the uplights within the Millwork were really there to kind of compensate for some of the darkness the artwork on the ceiling actually created in there. So, Bob, if you want to skip back forward, so the slide that we were on. So, as you mentioned, we ended up with a dimmable LED fixture. And the big reason for that is it was kind of a bonus that it was dimmable.

Most LED downlights on the market come standard dimmable now. Most of them are coming standard with a 0-10 volt dimming protocol. However, at the time, this particular fixture was standard using a regular forward phase controlled dimmer. Which meant we could do this pretty easily out of the box. So it was just something that ended up being added as an easy opportunity to enhance that guest experience. And what was interesting is when we went through the mockup, the owner, the architect, nobody realized that the lights were actually LED during the first walkthrough. They assumed because they were dimming that it was incandescent, but it was clear it wasn't the thought that it might be fluorescent. The other thing that I think was important, as Bob mentioned, was the color consistency. So we actually table-topped every one of these fixtures that went into the guest room space. Not only did we do the full mockup, but I had samples in my office. Because this is owned by the Convention Center Authority, this is a public project. And it had a budget and we also wanted to provide a competitive price. So we wanted to make sure any names that were listed could provide that competitive number on the project. So we had them all in here and looked at them and went through the steps that we needed to, to make sure that this could be a competitively bid job and function with the dimmer and the controls that we had in the space for the mockup. Do you want to go to the next slide?

So, initially we could have compared these two compact fluorescent and again, I said the dimming was just a bonus for us. But the big thing that really hit me was, I travel enough that, as Bob mentioned, you go in and the lights in the bathroom are not up to full brightness oftentimes, with some of the retrofit lamps that are most typically, I think, implemented on hotels. If it's not a new construction, it's a good sign it's a retrofit lamp. You turn the light on, and it takes a few minutes to warm up all the way. And sometimes the color is not there either, and so that kind of really made me want to move forward to push for an LED solution so that you would get the instant "on." I think most people in their homes have that expectation if they haven't already made that switch to an LED or a CFL retrofit. The incandescent lamp is still our touchstone, and the thought is you turn the light on and it comes on and it is bright. We didn't want that to be a stumbling point for guests coming in and going "oh, now I have to wait for the light to come up." The other issue with compact fluorescent is that the lifetime is often based on the switching cycle. So it may say that it is rated for 12,000 hours but that is based on a 3-hour start time. And how often is the bathroom light left on for that long? Considering that we had almost 500 guest rooms, or over 500 guest rooms, we certainly wanted to make sure that this was as easy as possible for the maintenance staff in taking care of these rooms. And knowing that LED in 2009, 2010 when we designed this, was still an emerging technology, we felt that the usage of these guest rooms was not going to be a struggle in terms of replacement parts because you're sleeping for eight hours and the lights are off. And then another good portion of the time you're probably not just sitting in your guest room. And so that was another opportunity for us to really see from a longevity standpoint how long these products could go and these could last in here.

The light that you see on the image here is in the off state right now. And one of the reasons that we selected this fixture was because it had an obscuring lens. In table-topping these, I didn't want the aesthetic of a whole bunch of diodes. We were really looking for a much cleaner appearance so that somebody wouldn't necessarily, it's not that we didn't want them to know that it was LED, we didn't

want that to be what they were thinking about. We wanted it to be about the space, and how it felt to be in the space, not about a bunch of little dots coming out of the downlight. So the obscuring lens really provided us with that kind of aesthetic that would maybe feel very comfortable and easy for them to come into and not feel like there is a change, there a shift, there's something different about how the space works. The other bonus for us was at the time when this product first came out into the market and now the product has evolved over the last three or four years, it was rated for showers and we could use the same fixtures. So the bonus of that now is what location we could put that in the shower very easily and not have to go with a different type of a luminaire. So we had two coming in the entry, because we didn't want to pick up lighting on the mirror, we had three in the bathroom because we wanted to make sure that the mirror was well-lit for shaving, putting on makeup, and that we met Hilton's standards for footcandle levels in that area. And then we wanted to make sure that the bathtub was well-lit because it is never fun to go into a dark wet shower location that isn't necessarily brightly lit. So the number of luminaires in that space is really partially because of the comfort of the guest. It was making sure that it felt correct and making sure again that the color was going to be correct. We opted on this project to go with 3000K for the color temperature throughout the entire hotel. Hilton had allowed in their standards for 2700 or 3000. We chose 3000 for a couple of reasons. We knew we would have multiple source types on here. We would have fluorescent. We actually have some halogen in certain areas. And we also have some ceramic metal halide, and all of those and LED were available in 3000K, so it was important for us to be able to match the color temperature of all of the sources. And when you saw that first image of the lobby, all of those sources were available in the same color temperature, and I would think that, at least from my experience, the 3000K LED is a little bit, I don't want to say brighter, it's got a more neutral white tone to it, where as the 2700 can sometimes feel a little pink or a little bit yellow on that. So making sure that the color temp had that neutral quality to it. You can see on the slide here that fixture we ended up with on the project was from Cooper. We did table-top the Philips product as well, and we had a really good performance from both of these and both of them did have that obscuring lens on the luminaire. You can go to the next slide.

So in terms of the controls, going after additional lead points, we tried to do as much as we could to save energy within the space. So we did add vacancy controls within the bathrooms, so its manual turn-on, and then if you're gone for 15-20 minutes, it's going to turn off. And that's going to add to that. A lot of times people, you know it's not your house, you're not thinking about it, you just leave and you leave the lights on. You don't want to take one extra step back into the door and shut them down, so this worked out well within the bathroom spaces.

We looked at adding a vacancy control within the bedroom space as well, but because we had a soffit in the ceiling in the entry, we really had some difficulty getting a good angle where we were going to pick up everything within the space. We wanted to make sure there weren't false triggers, false "offs" happening when somebody was still in the space, and then what do you do if somebody falls asleep, but then they wake up, do the lights pop back on and off. So, it was really about an effort of trying to figure out what would the conditions be to turn off and turn on, and in the end we decided to keep the vacancy controls in the bathroom only.

We did end up using wireless controls on all of our occupancy sensors throughout the hotel. We've been in very good shape in terms of not having any interference with the wireless, and what that did for us was allow an easier installation, and we also didn't have to have low voltage power packs. So when you have an 8-foot ceiling slab to slab, and you don't have to put in additional conduit and wiring controls, it makes a big impact from a budget standpoint. And we'll talk about the master switch if you want to go to the next slide.

So, per 90.1, we did have to have a master switch that turned off all of the lights exiting the space or coming into the space. As I mentioned, we decided that a vacancy sensor was just not the way to go because of potential false triggers, so we located it at the front entry. It says entry lights, everything was very clearly labeled, versus the room master which turns everything on and off. And then we had the plaque above the light switch so that it would help guests understand the space. And I would say you could probably as Phil from a management standpoint, if you had any guest comments about it, but I think overall, it is relatively easy and clear and the housekeeping staff has been directed how to leave the lights on and off between cleanings so that you would turn on the room master on or off and people would be able to figure out when they come in how to maneuver around that fact. You can go to the next slide.

So as I mentioned, we did have dimming because it was an easy option, and as labeled you can see the slider dimmer over to the far right in the slide. We had talked about doing a little bit of a more, I don't want to say expensive control, but a control that would do the soft startup and fade-down time where you had the slow kind of fade up over three seconds and fade back down, and at the time we were having issues with the low-end trim. And you can have that issue still today with particular controls and the end LED product where if it's dimmed down to the 10% or 15% mark, when you turn it off there and when you go to turn it back on its not getting enough power to re-energize. So, at the time, that was an issue. Now you can easily find LED dimmers that are labeled for use with LED. That takes care of that issue that happened at the low-end trim, and we actually mocked this up with the downlights and a couple different dimmers looking at how to solve this. One option was for us to have a reset back at the high-end trim each time it turned back on. But again, I don't know that a guest wants that at 3:00 in the morning. They get up to go back into the bathroom or to leave to have it pop on at that bright level. So they are able to preset the dimming level and it will come back on and off at that desired input. Go ahead and go to the next slide.

Bob Davis: Good, thanks Ardra. And the one item I realized I forgot to put on the slide was the wattage of the downlight. It's a 15 watt downlight. One-five. It figures that the Department of Energy guy would forget to put the wattage on the slide, right?

Ardra Zinkon: And it was a thousand lumens. So if it is a thousand delivered lumens, a good comparison might be a 32 watt compact fluorescent downlight once you figure in the efficiency of the reflector and can.

Bob Davis: So even with seven downlights, you're only looking at 90 watts for the LED downlighting.

What I want to do now is just share with you some of the things we found when we visited to look at the performance of the system in application. From the light level standpoint, we also have a field color meter that we could measure the color data from the different light sources in the room. And we also looked at some of the energy used. So let me walk you through that.

In terms of the illuminance readings, I'm going to report the illuminances in lx, the international metric. Those of you that think more in foot-candles, if you remember roughly divide by ten, so when I say here the IES criteria is 200 lx, that's about 20 foot-candles. We measured illuminances across the desktop where the downlights were present. We did some different measurements. If you get the full report, you'll see that we measured with just the downlight and then what if you had the room ambient on, those sorts of things. But in general, with the downlight itself, we were getting roughly 175-275 lx across the desktop with the IES criteria for typical use of 200 lx. I do note on here that if you're familiar with the 10th edition of the IES Handbook, they give separate criteria based on age, and so the IES recommends if the bulk of the users are expected to be over 65 years old, then they bump that 200 lx up to 400 lx, and in the Hilton there is a separate task light available. So if there is someone that wants more light on the desk, they have a task light and they can get that. But in general, the LED downlight itself provides the foot-candles needed.

I should mention on the right of the screen, the upper part there is a sitting area there, and IES has different recommendations for casual reading than for desktop reading, and so I think the recommendation was 150 lx for casual reading in a chair, and of course these two downlights, as Ardra just mentioned, are connected to the dimmer switch and so can be lowered based on whatever the guest wants.

Out in the entryway, IES criteria were kind of surprising when we looked at this. And again, from my sort of entryway standpoint, all IES is doing is making sure there is adequate light that you can walk through an area and see any tripping hazards. So very low criteria from IES. But the LED downlights provide 120-200 lx and as we mentioned before, we have to deal with the mirror on the left there, the closet, and so the visual tasks are much more demanding than the usual entry area. And as Ardra mentioned, one light source in the middle of the space would not really have provided the sort of quality she was looking for because of the task and the separation of task.

In the bathroom we took some measurements at the sink, kind of the critical task area, and the capital H on my first row here means horizontal illuminances, so the IES recommendation, again based on age, generally for 200 lx up to 400 lx at a sink. With just the downlight we were over 550 lx at the sink. When you turned the mirror lighting on, that bumped up to 690, so a lot of light available at the sink.

If you look at vertical illuminances, this is now holding the meter basically at the face looking at the mirror. That is an important place to have adequate lighting. The IES has recommendations there for 200-400 lx. The LED downlight was giving about 250 lx vertically and then again with the mirror light that's built into the mirror, those really are intended to give good vertical light on to a person's face who is standing in front of the mirror. And that bumped that up over 400 lx. So overall, certainly met IES criteria and as Ardra mentioned, there is also separate Hilton criteria of very good light from the LED

downlights and then some of the other light sources involved in the room can help to fill in some of the other layers that are needed.

This is a big chart, but I wanted to show you all the details of the color measurements that we took. And so what I'm showing here, each row is a light fixture. And we were measuring the color of the light coming out of each fixture. CCT is the correlated color temperature. CRI the general color rendering index. And R9, I think most of you in the audience are familiar with R9, but if not, it's a special color rendering index that measures the rendering of a very saturated red color, and it's sort of become a criterion that many people look at with LED products to understand a little better their color performance.

So we have seven LED downlights shown there, as Ardra mentioned they are rated for 3000K and you can see they're all very close to that. I show the mean of the CCT, CRI and R9, and the range just means the difference between the smallest and the largest CCT. Because that's a big question, right - when you're putting in a lot of different LEDs, how tightly packed are they? You know, if they're rated for 3000K there's a big variation in them what comes out at 3000, then they're going to look different. And that was part of Ardra's concern of people looking up from the atrium and seeing these downlights in the windows. Would they be a lot of different colors. And you can see from the seven we measured in the guest room, the range was very small, less than 40K difference, amongst the seven.

The bed light fixtures are CFL, and you can see they are about 2800, and just between those two there's a larger range. I want to be fair, 90K is still not a big difference, right? It's not like we're seeing several 100K difference between these products. And then the Millwork fixtures are shown. They were a little bit cooler, and I think at the end Ardra will talk some about how to ensure the color consistency when there's different products coming from different areas of the job. And then the LFL mirror fixtures were also right around 3000K. You can see overall just scan down the CRI column. These are all good color rendering sources, everything above 80. R9, the LED actually had the highest R9 of the other products used in the room. If you're not familiar with CRI you might be surprised when you see a negative number, but that's actually not unusual, that's just a linear scale. Maximum of 100, but there really is no minimum. In general, the ENERGY STAR spec for LED products says that that R9 should be above zero. So it's not a number we expect to up where we see the general CRI in the 80s. And usually if the R9 is above zero in an LED product, the CRI is usually up in the upper 70s to 80s. So the R9 CRI with this particular downlight of 30s and 40s is a really excellent performance. You can see a better R9 than any of the other products that were in the guest room.

Let's talk some about the economic story. And, this project was interesting for us from the Department of Energy standpoint because when we first started talking with Ardra and with Phil at the Hilton, it was clear that they were using LED not just because of energy savings and economics. In fact that wasn't a big part of it. A big part of it for them was what sort of experience do we want our guests to have in this facility. What sort of functionality do we want them to have in the lighting. What's the aesthetic lighting quality that we're looking for. And those are what really drove the decisions. But we wanted to look at the full sort of story of where would energy and cost and everything fall out. And so, working with Cooper Lighting, they were able to provide without getting into any confidential details of the project,

but roughly we looked at a family of products that had LED options, that had CFL options, and if specifically if you wanted to get a fully dimmable CFL downlight similar to the dimming functionality of the LED downlight, that Ardra mentioned kind of came as standard. And when we looked across the price book, in some cases the LED product was actually less than the fully dimmable CFL. About 10% less. And it ranged up to in some cases the LED product was about 20% more costly than a fully dimmable CFL version.

Now, as Ardra mentioned there is a lot of different ways to dim LEDs, some more expensive than others. The same with CFL. But in general, that was when we saw that range and Ardra said when they went through the design process, they really realized that it's pretty much not an additional first cost that they would really have to factor in. It's more or less a wash if you wanted to get the same functionality from the CFL downlight.

In terms of the energy code, the guest room lighting, even including the other sources, the total lighting for the guest room came out a full 20% below the allowed power with the energy code that was in effect when the building was designed. Their final design came in 20% below. Just doing the math based on the Hilton's assumptions with their assumed operating hours, they're saving over 145,000 kilowatt hours per year in these guest rooms because of being that much below code. Of course, that is just looking at connected power. Controls involved, the dimming, the vacancy sensing, will further reduce that energy use. As we said when we looked at this room, there is linear fluorescent in there, there is compact fluorescent, there could be other opportunities to implement solid state lighting that could further reduce the energy use.

Our team decided to, even though the design team didn't really look at CFL downlights as an option because of the functionality, we thought let's do some simulations ourselves and just see, you know what would this have been like if they had used CFL downlights instead. So we picked some sort of typical 6" aperture downlights that more or less matched the LED downlight that was chosen. We chose one that had a vertical lamp and one that had a horizontal lamp. And we ran calculations in that lobby area, sort of the entry area to their room, just to try to pick fixtures that gave us about the same light levels. And so, you see the three columns here, the first column saying LED, that's the product that's installed. The other two CFL products are really from the same family of downlights as the LEDs. The first line showing the lumen output of the lamps. The second line shows the lumen output coming from the luminaire itself. And then the input power. So these were roughly 30-watt, and that includes the ballast, roughly 30-watt CFL fixtures that sort of matched up with the 15-watt LED fixture.

The luminaire efficacy as we mentioned at the outset, with CFL you're typically in the 30s and 40s. The luminaire efficacy more like 50s to 70s with LED, and we see that in these fixtures. So we sort of took the wattage of these fixtures and looked at the number of guest rooms and the number of downlights. The total number of downlights as I recall is well over 4000 in the Hilton. The annual electricity used as you can see is just over 200,000 kilowatt hours with the LED, and if we jump over to the CFL horizontal it's less than half of the energy used for the LED over that CFL.

I should mention here the CFL vertical, we did it as an exercise in the simulation just for our interest. It actually would not have worked in this building because one of the points that Ardra mentioned on her slide was that they had a 6" ceiling constraint. 6" depth constraint. And most of the vertical CFL downlights would not fit.

The next to the bottom row, average illuminance in the entry, we're showing again the lx, so you're getting in a roughly 20 foot-candles out of these. And then we've also looked at the vertical illuminance on a person looking into the mirror, so there is a little bit of a narrower distribution with the LED. It is not significant. We did some renderings, the room didn't look a lot different but you could see the vertical illuminance on the face, there's a little bit less with the LED than with the horizontal CFL. But a vertical CFL you get more light coming out at high angles from the fixture that get more vertical illuminance, but that also raises some concerns about glare from the lamps now coming down further.

I should mention we also studied a halogen PAR lamp downlight. We know in hospitality oftentimes either incandescent A-lamp or halogen PAR lamp downlights get used. And I didn't show the numbers here because I just felt sorry for the poor halogen downlight because it just can't compare in the energy store here. But I thought the rendering was interesting just to show the emphasis that when we want to talk about lighting quality, we shouldn't just talk about horizontal foot-candles or horizontal illuminance. We have to think about what the space is going to look like. So what you're seeing here is a rendering if those downlights in the lobby area were PAR lamps on the left versus the LED downlight on the right, which gives much better vertical light onto the walls.

So let's move toward wrapping up. We'll turn things back over to Ardra just to share some of the specific issues that they had to deal with during the project and some things that would help with future projects. Ardra.

Ardra Zinkon: I think that the most challenging thing as the lighting designer on a project of this type of scale or anyone working on a project of this type of scale is typically the time when you start designing and the time when it actually gets completed. So what we saw in the project today was designed four years ago. So if we were to do it today, I'm sure we would probably be looking at a few other options, other opportunities. As I mentioned, at the time the product came standard using forward phase dimming control. Today we would find that typically to be 0-10 volts. Which means additional wiring would have gone into that, some low voltage wires. And so, you know any time you look at a project like this, and you take this back-check and LED technology, I mean every six months, every 12 months, 2, 3 years, we're seeing significant advances in the technology that we have. So, you know that's definitely something to keep in mind and the concern being we specified it and mocked it up today, it's not going to be on the job site for another six months. Is that going to be the same product? Are we going to have that compatibility? So definitely the real struggle with LED I think is still confirming compatibility from a dimming standpoint. I think it's getting better. I think the move that manufacturers are making to zero to 10 volt has been incredibly helpful. As a specifier and knowing that we're going to have successful dimming at the end of the day. But making sure you do the mockups, or if you don't do a full-scale mockup, you at least have table-top products sent to you. When you're putting in 4000 downlights, it's usually pretty easy to get a sample. And looking at more than one of them, maybe ordering them at the

same time, and checking that color consistency is also very important and critical. There are so many people that have moved into the lighting industry because of the prevalence in LED technology that aren't necessary lighting people first. They might be chips people first. And understanding that wattage isn't what drives lighting design. You know, its quality. And a hotel brand is really trying to sell that experience to their guests. So making sure that it's great that we're saving energy, but we're not sacrificing that quality means really having an opportunity to look at those parts and pieces close up. So we were very lucky to have that full guest room to put everything together, but even on a small scale project, doing that legwork on the back end was incredibly important for us to make sure at the end of the day everything was going to work very well within that timeframe when we were finally able to open up the doors.

And I think the other thing and I didn't touch on this when we talked about the guest rooms, was when you were looking at a hospitality project, a lot of times the plug-in lighting fixtures are specified by the interior designer and they're part of that portion. So how do you ensure that what the interior designer's specs say are going to match what the lighting designer or the engineer's specifications say in terms of color temperature, and control, and who's checking submittals. So there was a large coordination effort that went into making sure that all of the parts and pieces would line up at the end of the day. That we could maintain a consistent color temperature throughout all of the products and the lamp that you saw on the either side of the bed – those are actually built into the headboard furniture and they're plug-in. So those came as part of the furniture package. So we did write a specification for all of the lamps upon replacement that they would be retrofitted with an LED retrofit lamp that is dimmable and does have that 3000K color temperature and does have a omni-directional field to it, and that's the tricky part with LED retrofit lamps is making sure that you actually have that same matching beam pattern on there. So we had a large conversation, multiple conversations, as the project was opening with the staff and the facility people on making sure that we were able to match all of the color temperatures of the floor lamps with what was happening throughout the rest of the project. And, yeah, we had a lot of team members. That was the other issue is just again making sure we are all on the same page with this and in the end I think the Hilton has been pretty happy with the final outcome. But making sure that you are able to put together something that is clear to the rest of the team in terms of the importance of the technical specifications, and making sure that that guest experience gets translated was part of our big challenge going forward.

And I would say that the other thing is you know we ended up with LED downlights within all of the guest rooms, and a large part of that being able to happen on this job which did have a budget like every job does, was the quantity. Being able to know that they were getting a quantity of 4000 of these going into a new construction project, I think at the time helped us manage that cost. And I think today the LED downlights themselves, I think we see those coming down in cost and being very competitive. So it's a great opportunity to start implementing downlight technology. Linear is still out there somewhat, but I think that definitely in the downlight scheme, we're seeing that as a really good first choice in a lot of project types. I think that's it for me.

Bob Davis: Great, thanks Ardra. Just as we move into questions I thought you might be interested to see some comments from reviewers. We explored the idea of trying to survey some guests at the hotel.

That ended up being a little bit outside of our scope. But we did go online, and here are some things we found when we searched online for the Hilton Columbus. I'll give you a minute to read those, then we'll move to question and answer.

You know oftentimes in lighting we say if people don't notice it, it's good, but I think if people notice it and comment online about it, it must be very good if they're giving positive comments. So with that, I want to thank Phil Hornstra and he'll be available to help with some questions here in a minute. Phil was a great support for the project. Cheryl Fabian at Cooper provided lots of helpful info. And then the beautiful pictures that you saw Scott Pease gave us permission to use those.

With that I'll turn it back to Linda and we'll take some questions.

Linda Sandahl: Well thanks so much Bob and Ardra for a really informative presentation. We did have a lot of questions, many of which I think were answered as the two of you went through the presentation near the end. We have just a few minutes left, so I'll go ahead and pose the question and then let you know who I think is probably the most likely to answer it.

Question: First of all, are differing correlated color temperatures of say 4000K and 4100K acceptable for different fixtures in the same space? For example, 4000K sconces and a 4100K downlight?

Answer (Ardra): I think that may depend on how the product is being used. A lot of times, especially if you were to look back at the image that showed the lights on the headboard, versus the Millwork lighting coming up the wall. Because the headboard was a warm wood tone, it had an amber appearance. So you have to take into consideration if you're putting something in a decorative fixture, what is the, does it have a shade, does that have a color to it as well? The other thing that you could also consider, a hundred on a color temperature scale is not that significant. I think those are fairly close and would be acceptable, but knowing its coming from two different sources that might have different reflector finishes, or a diffuser or maybe one doesn't have a diffuser at all, it is important to take that into consideration. How is it being applied and where. Spaces feel very different if you walk in and all of a sudden that wall is painted bright red versus everything in the room being the exact same color, the exact same finish. So I think it can be completely appropriate if it works within that installation, and it's really probably application based. If you have a downlight next to a fluorescent slot or a linear slot or a troffer of some type, it might be more noticeable. The other thing to keep in mind is that color temperature is not exact. You may have someone say this is 4000K, but it might be 4000K and have a little bit more of a pinker hue to it, whereas this other 4000K might have a little bit more of a yellow hue to it. But all of them would quality within that particular reference point of being within that same color realm. Even just from manufacturer to manufacturer, I mean we have that within linear fluorescent lamps, our specifications call out that all linear fluorescent lamps are to come from the same manufacturer or same supplier, because their recipe for 4000 might be a little bit different than somebody else's recipe for 4000. So I think it's ok if it's in a different source. That was a very lengthy response – sorry.

Question: Phil this is probably for you – have you had any LED downlight failures?

Answer (Phil): You know within the whole project, of the 4000 in the guest rooms and the other spaces in the building, we've only replaced a couple dryers, maybe five total, on the whole project. So of all the materials, all this is definitely, the least issues we've had is with lighting of all the products installed, so they've held up great for us.

Question: Ok Ardra this one is probably for you - is the room master a preferred solution to the European room key in the slot variation?

Answer (Ardra): Yeah, we had that discussion as part of our mockup and we had encouraged the owner and the team to consider the little card slot, and the feeling was at the time that people wouldn't know what to do. It's not seen over here as often as you might see overseas, and that it might be confusing. And that's the big thing – you have guests coming from such a different background, younger guests, older guests, people who have never been exposed to that particular type of technology. So for, I guess for anybody who is not familiar with that, instead of having a switch you have to put your room key in a slot at the door to be able to turn your lights on or off. And so we did talk about it, but it was determined that that might be baffling. The other thing is, those are easily defeated by someone who doesn't want to deal with losing their room key, so they put a business card in there and then the lights are left on all of the time as well. But I think the ownership felt that it just wasn't around enough here in the U.S. to try it, and they weren't ready to jump into that experiment at the time.

Question: OK, and did you check for light flicker at dim levels, also color shift, either of those?

Answer (Ardra): I don't know if Bob had that included within his study. We haven't had, as far as I know. When we did this in a mockup you know we turned everything down relatively low and did not have any issues of flicker. I don't know if Phil has had any complaints about that or Bob noticed that. I did bring in like a flicker tester that you can see if it has an impact.

Answer (Bob): We didn't take any direct measurements. I certainly didn't notice anything when I was in the room and using the lights I guess. Have you heard any flicker concerns Phil, from guests?

Answer (Phil): So sometimes if a guest doesn't know there's a dimmer switch and it gets hit accidentally at a certain point, it does flicker, but it's very few and far between that we get that complaint. That's really the only complaint we get.

Answer (Ardra): And these particular downlights I think only dim down 15%, so that's the other thing to keep in mind you weren't going down to a 1% level.

Question: And Phil, any issues with glare? Has anyone complained about that, especially in the bathroom with so much horizontal illumination?

Answer (Phil): No, we haven't had any complaints about glare.

Answer (Ardra): The requirement in the bathroom by Hilton was actually, I think, 50 foot-candles on the face, which is about where we were with all the lights on, so while the levels did exceed IES's recommendation, we were in line with the owner's requirement in terms of light level.

Question: OK, and we are over time, so I'm just going to pose one more question and any of the panelists can answer it. Would you recommend LED in a retrofit given that a permanent LED fixture is more guaranteed, warranted and efficient than a retrofit unit, while the retrofit project may not have the benefit of changing out the housing, etc?

Answer (Ardra): I would say at this point, we've actually started to see some really good LED retrofit kits on the market that are not using a retrofit lamp. There are a couple manufacturers out there who are doing standard 4", 6", 8" cans that actually are not a retrofit screw-in type product, but a decent size luminaire, so I think it depends on the scenario. If you can do new construction, I think that's usually the better route to take. But, you know we've had other projects where we've certainly looked at retrofit housings that would go up inside an existing housing. We have used retrofit LED lamps in some occasions when we know we can control the specification, especially if you're dimming LED using a retrofit. That again is very complex and you want to make sure you do your homework up front and that it's all going to work together at the end of the day. If you have to list three names for the control in the lamp you're going to potentially have a struggle making sure that dims smoothly.

Answer (Bob): Phil, have you had any experience, you manage other properties as well, have you had any experience with some LED retrofits?

Answer (Phil): I have not; I am dealing with screw-in light bulbs now.

Answer (Bob): Got ya. That might be a good segue Linda, because I'm putting the cursor over by the NGL link. The Next Generation Luminaires Competition, this year for the first time, added a retrofit category. And I know there were some downlight retrofits that are being recognized. The winners haven't been announced yet so that will be coming soon. But if you keep track of the Next Generation Luminaires Competition, the downlight that was used in this Hilton project was an NGL winner a few years back, and I know there are some retrofit products that were submitted this year that we'll soon find out how they did.

The other links on this page show you how you can access the information about the Hilton, the Better Buildings Program, and just some of the general Solid State Lighting Programs.

Linda Sandahl: Ok great. Well we are out of time. I want to thank our presenters for a very informative presentation and for answering all the great questions that came through during the presentation. Again, you can download the report, a PDF of the presentation, as well as a video will be posted on the Better Buildings site in the next couple of weeks. So thanks everybody for participating in today's webcast, which was brought to you by the U.S. Department of Energy.