TEXT-ALTERNATIVE VERSION: CONTROL SYSTEM INTEROPERABILITY

**Michael Poplawski:** Three terms I just want to talk about. And these are the words I use to describe those concepts. So first of all, there's the concept of compatibility. And this really means the ability of devices in a system to co-exist, to not interfere with each other. Now that's a little distinct from interoperability, where two devices in a system need to do more than co-exist. They need to work together.

And then that still is distinct from interchangeability, where I'm talking about two devices in a system that can be exchanged for each other. I take one out, put the other one in, and within some parameters, it does the same job. So three concepts, three words.

And then I thought, OK, how can I make this message yet another way? And so here is the visual for those visual learners out there. This is compatibility. Two people not interfering with what each other are doing. They are co-existing and doing their own thing. Interchangeability. We're going back in the generations. I should ask who recognizes this. One of my heroes, Dr. Seuss.

And then now here's interoperability, right? Working together to achieve common goals. So how does this play in lighting? I'd argue that there's an evolution with any new technology that requires work in all three areas. And so again, compatibility, if I introduce a new technology into the existing environment, I have things in the existing environment. I need to make sure that new technology doesn't interfere with those things.

For the introduction of LEDs, we saw a lot of compatibility issues between LED sources and phase-cut dimmers. If you worry about disrupting the performance of some other system, some other communication network, et cetera.

On the other end of the spectrum, interchangeability. When a market starts to mature, and you start to see many products offered by different vendors that look kind of the same, that do kind of the same thing, but they're a little bit different. Well, that's a call to standardize. They're almost the same. Let's do them exactly the same.

So, some easy examples in lighting are the ANSI bases. For people who were here yesterday, you saw a nice slide of all the incandescent lamp styles in the early days of incandescent. They kind of looked the same, performed the same. They had screw bases that were slightly different. Well, then the base got standardized. Then we standardized on lumen outputs or wattages.

But really at the focus of this panel is on the thing in the middle. Interoperability, I would argue that that's where we're at with this technology, and in this changing building, and even in the outdoor lighting field, where we're developing and improving upon and creating new interoperability standards. So why focus on interoperability? It facilitates the ability to integrate best of breed components. And in lighting systems those are controllers, sensors, software, et cetera, into a system.

It facilitates the ability to modify and improve an existing system as you learn what you really want. How many people in this field with this technology think they know what they want, go install something, and they're, “Oh, I learned something along the way.” Or a new product or feature came out, I wish I could put that into my lighting system. Do I have to tear everything out and start from scratch? Or can I plug and play some devices?

Well, interoperability facilitates that kind of learning curve. It helps manage the risk of component and manufacture obsolescence. Certainly, lots of new players in this field. I think we all know they're not all going to be here in five, 10 years, so this is a risk that needs to be mitigated. But at the end of the day, as again, lighting infrastructure becomes more about systems, interoperability facilitates the sharing of data.

That's really the key point. Where interoperable devices can share data that they generate, they can use data generated elsewhere. This sharing of data can help lighting systems perform better through implementation of adaptive lighting, et cetera. It can help facilitate non-energy benefits for the lighting system or for other systems. As lighting systems can generate and can share data that may be of use to other systems, that increases the value of those lighting systems.

Now, this sharing of data, though, requires a common application definition sometimes referred to as a functional profile, or an up-to-date translator. And hopefully explain a little bit more about that in the next few slides. So, what are some interoperability specs and standards? Well, you've heard about a few of them already.

0-10V, DALI. There are actually a fair number of other specifications or standards focused on interoperability. Then I want to review real quickly a couple of them. For those folks who are familiar with 0-10, or especially those who aren't, this is an analog, one-way communication standard. But actually it's two standards. That reminds everyone of the popular comic strip, right, about there's too many competing standards. What's the solution? Generate another standard.

So this is a challenge already for the standard, if you will. There's actually two versions of it. Here's a listing, a brief listing, of features and challenges, but the one I've highlighted is, this standard defines a limited amount of application requirements. It defines off, but it doesn't define the dimming curve. It doesn't define low output level.

So sometimes when a specification or standard doesn't deliver what you think you want or need, it's not because there's a problem. It's because it didn't set out to do that. So an important need when wanting to write specifications, and understand what existing specs and standards will get you, is to know what their scope was. What were they trying to achieve?

And as I pointed out earlier, and I'll keep saying it again and again, these different efforts set out to achieve different things, and they go about them in different ways. So they're different. And some examples of how you see this in the field, here are a number of dimming curves measured from 0-10V luminaires controlled by a 0-10V dimmer. And you see this fact that you don't get the same output necessarily from a luminaire for the same input. This varies.

This is not because people are not following the specification or the standard. It's because the standard doesn't require it. And different products then perform differently.

DALI. Another longstanding communication protocol. Standard digital, two-way communication. Much more capable. It has some interesting issues or challenges.

Its data speed is in some ways limited, especially going forward for new applications. And the people who developed this standard were a little slow, if you will, to develop a compliance testing procedure, and/or to evolve the standard. And both of those forces have, let's call it encouraged manufacturers to go do that on their own.

We need new features. The standard hasn't evolved. I'm going to go add them on my own and call my product DALI light.

So that has led to some confusion in terms of products that seemingly say they follow DALI, or people refer to them as DALI. Well, they're not all the same, and they're not all interoperable necessarily. DALI does specify a dimming curve, right? So when you see a certain DALI control signal, you're supposed to put out a certain amount of light.

But then there's still a potential issue here. The standard doesn't require you to dim to a particular light level. Right? So you may look at the performance of a particular DALI luminaire, and you give it the digital number 60 here control signal, where it's supposed to go down to almost 1%, but it doesn't. It goes to 10%.

Does that mean it's not complying with the standard? Well, no. The standard tells you if you can go to 1% you should. But it doesn't require you to. So some luminaires can't go that low, therefore they don't. So hopefully you get a feel for that there are different levels of interoperability. People that develop interoperable specifications for a living have actually developed a model to communicate with each other about what their goals are and how they're going about this.

I like to try to bridge the gap to something maybe people are more familiar with. And just think about how you communicate with your friends and family and whatnot. If you were to specify how are we going to communicate, you'd have to figure out a number of things.

Are we going to get on the phone, or I'm going to write you a letter. Is that letter going to be written in email, or is it going to go via snail mail. Are we going to communicate in French? Are we going to communicate in English? What topic are we talking about? Are we talking about cooking or quantum mechanics? Do we have the same background and know the same lingo and jargon about cooking techniques or spin up, spin down particles, et cetera.

If any of those things are not aligned, you're going to have some diminished ability to communicate. And so hopefully you get some idea here of how there are many levels that are required to be agreed upon for a system to really effectively communicate. Here's an example of a simplified model that maybe some of us are more familiar with. And that's the internet model, where kind of this seven layer OSI thing is discussed a little bit more simply with only four levels in order to get that internet interoperability that we're all familiar with.

There's not one standard or specification behind it. There's a whole bunch of them, right? At different levels. At this physical or data link level, there are a number of specifications that describe how data is physically created. On an electromagnetic wave or by a voltage on a wire, if you will.

Similarly, there are a number of other protocols that describe how do I interpret or use data. How do I understand data that's meant to render a web page? That's the HTTP protocol, right? How do I understand data that's meant to connect to an FTP site to download a file? That's the FTP protocol.

So the point here is to deliver interoperability in the way we're all familiar with it, there's many levels and many protocols that need to be defined. And some of these are actually competing at the same level. When talking broadly about interoperability, if you want to get down into this one lower level of the weeds, this is the most commonly referenced simplified model, three layers. How data is created physically, how it's routed around, and how it's understood.

So another point I want to mention. There is a growing interest people hear about how connecting systems, there's a push to connect more systems, internet of things, et cetera. What does that mean? Well, there's almost every few days, it seems, like some other group, some other effort going on, to develop interoperability specifications and standards. I've listed only a handful more of them here just to give you a reference point.

Here are a couple examples from what hopefully again systems you're familiar with. I have a computer. I want to connect it to the internet. What's required to do that? Is there a wall on my house that says internet? Not really. There's a wall, though, with a jack that's giving you something.

And historically an internet service provider may be providing you connection to the internet through an ISDN line or a DSL line. That's your old phone cable connection, if you will, or a cable modem line.

Well, now I need it to convert that so all the computers could connect to any of these systems. So did you go buy a computer that was designed for DSL, or buy a computer designed for cable? You didn't. You bought one of these boxes, in between, appropriately. Maybe you didn't think about it because someone just told you what to do, or the service provider gave it to you.

But the point here is that the market evolved for this application to deliver interoperability where there was a single specification, this ethernet specification that everyone decided to put in their computers. And then you translated, if you will, to a different protocol based on how the internet connection was provided to your house.

What about when I wanted to connect to other devices, like one of these buggers to a computer? That's what USB did. I get a USB cable initially, plug it in to the computer. But then that begs the question, does the USB specification know what a mouse is? Does it define what a mouse is? It doesn't. How did the computer know how to interpret that data coming over the USB cable?

How in the early days you had to install a driver to make that device work. And that's another one of these bridging elements to facilitate interoperability.

Well, what about this kind of a mouse? I need a driver for this, too. Is that the same driver? Well, this mouse is different. It's got this trackball thingy. I've never been able to use one of these things. Is it the same driver that's required? Not necessarily.

There are different ways to facilitate this. I may have a separate driver for the different mouse. And maybe some people are familiar with, at some point, Microsoft started to develop generic drivers for certain types of things that would enable you to use the mouse, for example, but maybe you didn't have all the features required.

Maybe that mouse that had a touchscreen on it wasn't enabled by the generic driver and you'd have to go install that product-specific driver to enable all those other features.

Or now we don't even think about this, because that ecosystem has evolved to the point, you plug the thing in, it recognizes it's a USB device, it recognizes I have connection to the internet, it goes to some website, download the driver, you wait a couple of minutes, have a soda, it says, I'm ready to go.

So I guess the point here, again, is it's not one protocol that is facilitating the interoperable experience that you have come to know and appreciate. It's multiple ones, and it's done in different ways. This facilitation is accomplished by gateway driver schemas, et cetera, that serve as bridges between devices and systems, providing or translating across one or more interoperable layers.

Here's the thing to think about here. What happens if one of those protocols change? There's a bug fix. I want to add new features, et cetera. Well, those bridging devices may need to get updated. Some of these changes happen more frequently than others. You maybe have experience with that with computing products or systems you own.

Some of those changes are easier to update than others. When I just need to go download a new piece of firmware, or a piece of software, that's a little bit easier than saying, I gotta go buy a new gateway. I gotta go buy a new physical piece of hardware.

Deeper levels of device to device interoperability, i.e., fewer translators, can deliver greater system flexibility and performance, but require broader, deeper adoption of specifications and standards. So there's a big trade off here, right? When you think why can't we just make this all simpler, and all agree to do it one way. That's a trade off.

So when we're talking about a lighting system, especially an advanced lighting system, again, many levels of interoperability. I could be wanting to facilitate interoperability just between a controller and a luminaire, between some centralized computer system and a particular communication network, i.e., does it have a Wi-Fi radio in it? Does it have an ethernet port in it?

Between an essential management system and a field device network, does that computer system know what those devices are? Can it understand the information that those devices are generating. Or what about between devices, direct to direct communication.

Why are these new standards organizations showing up? A lot of it's because of the characteristics and nature of LED, but it's not all just about lighting. I certainly am a believer, too, that changes are coming to lighting.

There's a drive for interconnected systems. There's likely not going to be-- again, in other fields there hasn't been-- one lighting or building protocol, all by itself, that's going to take over and dominate and facilitate this interoperability. Likely not going to be one master command center for a building or for an outdoor space.

Building and lighting systems, I think, are probably going to look a lot more like IT systems. And what does that mean? That means devices and systems connect to a communication network, exchange data, and make decisions. This is a very established model in one part of the infrastructure that we don't think about and it's probably coming to lighting, too.

Some people like the analogy that these things are going to look a whole lot like that. And this is why other people are interested in lighting. Many non-lighting companies are interested in lighting. Cisco, Qualcomm are interested in lighting because it's all semiconductor based. It's all microelectronic. It's very easy conceptually to add in other features, other devices, other sensors that facilitate this sharing of data.

OK. Specs and standards. I mentioned they have different goals. Are they trying to improve or ensure compatibility, interoperability, or interchangeability? What about these other characteristics? Are they open for everyone to use? Do you need to license them to use them? Is there a fee? Is there compliance testing?

You may think that should be a no brainer. That's not historically always been the case. And the reality is that, I said earlier, not only is no specification ever perfect, no specification ever enters the marketplace in a mature fashion. It takes a while to get there. We think, oh, I hear about this new specification. Whether it's Connected Lighting Alliance, TALQ, it's out there. It's perfect. It does everything that it's set out to do. No. It takes a little bit of time. This has been true for USB and everything else.

There's a wheel here I like to describe. It starts with, what were the goals of the specification. Then maybe there is a first draft of the specification on a sheet of paper, or usually, a hundred sheets of paper.

Then there's how do you verify that this spec does what we intended it to, the people who wrote it. When we go all interpret it and build something, that we think complies, how do we verify that it actually complies? There's usually some kind of process or test tool or plug fest, you hear this term, that needs to happen, right, in these early days.

Then there needs to be a defined compliance testing procedure. In some cases in the past, that's just been well, let the manufacturer figure that out for himself. I think I comply. I decide, I write on my logo that I comply. And my procedure may be different from your procedure in verifying compliance. Or do we have a universally accepted procedure? A universally accepted test tool that says, use this tool. If you pass it, we all agree. And maybe we refine that over time.

Manufacture adoption. There are examples of specifications that have been out there for a while that hardly anyone builds to. Requiring that specification, or being an expert on what it delivers, is not particularly useful if you can't go get it and install it in your project.

Standardization is often a process that comes quite a bit later. That's where the spec maybe will be taken to an accredited standards body. And there are a number of requirements to get something standardized. They can be regional or international requirements, but things like openness, the ability to have all stakeholders comment on the standard, even the public can comment on the standard, those are typically requirements of a standards process. And by definition when something has been standardized, it is open for use.

And then finally broad market adoption, where all the little bugs and hurdles that maybe weren't foreseen initially get worked out. Here are some potential questions that you could ask your stakeholders or your vendors when you're trying to understand what their approach is to interoperability, how they deliver it.

What aspects does your system address? Do you have a compliance test procedure?

There's no way in even an hour and a half we can all become experts. I don't think any of us would even call ourselves experts. I know I'm not. But I think we want to be able to enable better conversations about this topic of growing importance.