



LIGHTING & CONTROL

# The Sequence of Operations and Lighting Controls



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Everything electrical professionals need to know about the sequence of operations (SOO) and why it's so important

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If you work with HVAC and other building systems, you've probably encountered a sequence of operations (SOO). However, those of you involved in the design and installation of electrical and lighting systems may be unfamiliar with this phrase. Either way, the SOO is important — even critical — in getting today's lighting control systems to perform as expected. Understanding an SOO can save money by identifying redundant equipment and reducing callbacks.



Among many other benefits, the SOO provides clear direction to the installation team.

An SOO is a document that provides the specific settings for each configuration component in a control system, providing the information needed to set up, or commission, that system. Now, the increasing complexity of lighting control systems has made the SOO a natural fit. It's easy to see why.

### **Why do we need a sequence of operations?**

Studies conducted at the Pacific Northwest National Laboratory (PNNL) and elsewhere reveal that many lighting control systems do not perform as their designers and users expect. You probably recognize the common symptoms: Lighting turns on or off when it's not supposed to; dimmed lighting is too bright or too dim; users can't understand how to use control devices mounted in the room (not to mention those that reside in a computer); and the lighting doesn't turn on when the fire alarm system tells it to. Moreover, those trying to troubleshoot often can't find what the control settings should be.

With these problems and more, you can appreciate why the U.S. Department of Energy is interested in reducing the unreliability and cost of lighting control systems, which have promised to limit wasted energy. The SOO can address these problems by providing a clear set of instructions to those responsible for setting up the system.

### **What is in the SOO?**

The IES recently published LP 16-22, *Lighting Practice: Documenting Control Intent Narratives and Sequences of Operations*. This comprehensive American National Standard explains the controls intent narrative (CIN) and the SOO, highlights the differences between these documents, and shows how they are

connected in the design process. Simply put, the CIN lays out the various control strategies to be used in the different spaces of a project based on the lighting and the owner’s project requirements. Generally, the CIN is written during the schematic design phase of a project and is updated as the controls design progresses (**Fig. 1**).

Control Intent Narrative	Sequence of Operation
<i>Big picture overview of lighting controls approach</i> Prepared by the designer or architect during schematic design	<i>A detailed and contractually enforceable document</i> Prepared by the designer, electrical engineer, lighting controls specialist or system integrator during design development
<b>Example Language:</b>  Lighting controls shall comply with IECC 2018. →  Automatically turn off all lighting when unoccupied →  Turn emergency lighting on to full output when power is lost →	<b>Example Language:</b>  General lighting in each ≤ 600 ft <sup>2</sup> zone (zone a, zone b, and zone c) shall automatically turn on to 50% during business hours (8 a.m.-6 p.m.).  Lighting in individual zones (a, b, c) shall turn off within 15 minutes of occupants leaving an individual zone.  Emergency lighting transfers to emergency power source and shall turn on to full output within 10 seconds of normal power loss.

**Fig. 1.** The SOO builds on the CIN, adding detail and the specific settings for each element of the control system.

What Information is Included in an SOO?
+ Initial light level settings
+ Dimming fade rates
+ User interface settings
+ Scene programming
+ Occupancy or vacancy settings, timeout setpoints, and methods
+ Time-based schedules and triggers
+ Daylight-response setpoints and methods
+ Building system integration methods
+ Night lighting methods
+ Emergency lighting methods, zoning, and triggers
+ Controls component descriptions and locations

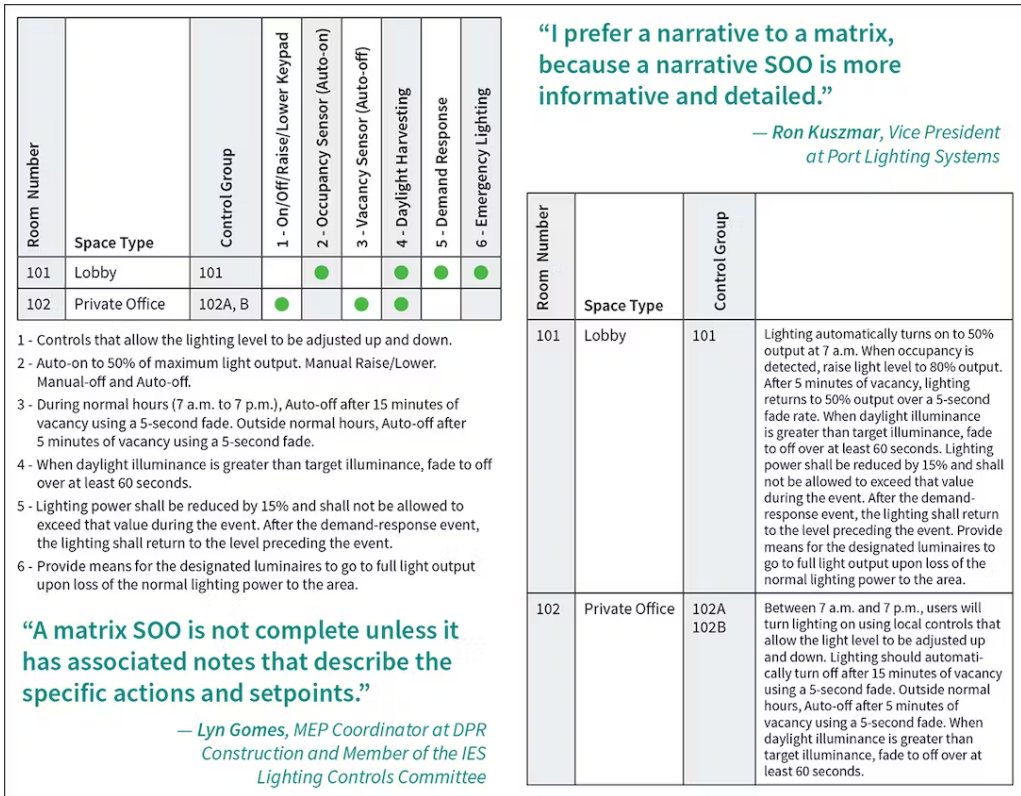
**Fig. 2.** The SOO provides a clear set of instructions to those responsible for setting up the lighting control system.

The SOO builds on the CIN, adding detail and specific settings for each element of the control system (**Fig. 2**). For this article, I asked some industry experts to help me put the SOO in context.

“Generally, the SOO is written during the design development phase,” explains Lyn Gomes, MEP coordinator at DPR Construction in Northern California and vice chair of the IES team that produced LP 16. “There are numerous examples that can be adapted to project specifics and help develop the SOO.”

Entries include such details as the time-out period for occupancy sensors, fade rates for dimmers, light levels for scenes, and on/off times for scheduled events. Network diagrams and integration into other systems, such as HVAC, can be important components as well. Unfortunately, these specifics are significant drivers of system cost and are frequently forgotten.

If any element of the control system includes programmable features or settings, the SOO needs an entry so that each of these elements of the system can be correctly and fully configured, and startup can be completed. Some sequences will also include a coordination matrix identifying which contractors are responsible for which aspects of installation, startup, and programming. The details, settings, and diagrams together create a best-in-class SOO that decreases risk for the installing contractor.



**Fig. 3.** A matrix SOO (left) vs. a narrative SOO (right) — two approaches to providing specifics regarding the lighting control system.

A common approach to presenting the SOO, favored by many engineers, creates a matrix that provides the details for each element in each space (**Fig. 3**). Gomes stresses that “a matrix SOO is not complete unless it has associated notes that describe the specific actions and setpoints. Not having this additional detail is the most common failure I see.” Another option is a narrative, which is favored by Gomes and by Ron Kuszmar, vice president at Port Lighting Systems outside of Boston. “I prefer a narrative to a matrix, because a narrative SOO is more informative and detailed,” says Kuszmar.

Whichever type best suits a project, the SOO needs to be thorough and completely prepared for it to be really useful.

### Who prepares the SOO?

The sequence of operations should be prepared by someone who understands the lighting control design, the parameters of its operation, and the needs of users. Typically, the designer of the lighting control system, who may be an electrical engineer (or electrical designer), lighting designer, or lighting controls specialist, develops the SOO. While the person who writes the CIN might also write the SOO, it doesn’t have to be the same person. For example, the CIN might be written by a lighting designer, and the SOO by an electrical engineer or a systems integrator.

## Contractually enforceable

The SOO is a contract document. A well-written SOO includes specific set points (e.g., light levels, timing, initiation cues, and so on), which are contractually enforceable. In other words, the SOO provides clear performance parameters for determining when the installation and startup have been completed — or more work is required. As Gomes explains, “The SOO establishes specific criteria for determining when controls installation and setup are done — so that done really means done.”

If the owner wants changes, the SOO can help determine whether or not a change order is required.

## Who uses the SOO?

With the sequence of operations prepared, electrical contractors, general contractors, systems integrators, startup technicians, field support personnel, and facility maintenance teams can all profit from its use.

Electrical estimators can read the SOO to develop a detailed understanding of a project’s requirements and refine their bids. Purchasing agents and project managers can find it helpful in preparing material orders and logistics.

Critically, whoever is responsible for system startup needs the SOO. It’s a must. The SOO provides all the specific settings necessary to set up the system. Without it, those programming the system must guess what settings will meet user requirements. When inappropriate or no settings are implemented, the system will not perform as expected, and complaints/callbacks will ensue. In my experience, it’s inevitable.

System integrators find the SOO particularly valuable in understanding the cost of time and equipment they will bear. “When I don’t find a sequence of operations on a project, one of the first things I do is ask the design team to create one. It usually offers savings,” says Kuszmar.

Although an SOO is most common for major projects — especially those with a mix of different control systems — smaller projects, such as a restaurant, or even a conference room, benefit from the forethought that goes into the SOO.

## Financial impacts

An SOO, or the lack of one, can significantly affect a contractor’s cost for lighting controls, beginning with the bid stage. An SOO, especially with a network diagram, clarifies the extent and complexity of the control system. “The sequence can reveal critical information that is ‘hidden’ in drawings and specifications,” says Kuszmar. Gomes adds, “Savvy bidders can refine their estimates and — importantly — identify high-cost components and aspects of the installation.”

Of course, the SOO only helps those who understand how to read it. Some contractors use the SOO as a guide for staging the numerous controls components required in various rooms in the project. “The SOO helps to present the full scope of a project,” says Kuszmar, “especially details and interconnections and ‘handshakes’ between systems.”

The logistical preparation off site enabled by the SOO can save valuable time and money during installation. And with an effective SOO, installers and technicians can follow a clear set of instructions for startup, reducing the likelihood of the kind of mistakes and repeated modifications that consume costly labor hours (see **Photo** above). Without the SOO, controls left in default mode often do not function as the owners intended, and callbacks are required to remedy the problem.

Building owners and their design and construction consultants benefit from the clarity offered by an SOO as well. An SOO can establish whether an “or equal” substitution is functionally equal or not. Clear set points can be enforced without adding to contract costs. Without those details, revising the startup settings may result in additional payments.

After the project has been in use for some time, settings for controls may need to change: conference room lighting scenes, sensor parameters, and the times for lights to turn on and off. Here, the SOO provides a reference to the original settings, which can help those responsible for reconfiguring the system.

## Challenges

The No. 1 problem is no SOO! The solution: Ask that one be prepared; write an RFI. Other problems with an SOO include the omission of key information, such as scene controls, time settings, or network diagrams. Information in different parts of the SOO may overlap and contradict itself, adds Chris Randall, senior project manager at Patricia Electric and an instructor in construction management. “Even a well-written SOO may not reach a contractor until it’s too late,” says Randall.

Such issues are not difficult to address. At this point, the case for using an SOO in lighting control systems is overwhelming. The next step involves refining best practices for using this valuable tool.

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