



LIGHTING PRACTICE: DOCUMENTING CONTROL INTENT NARRATIVES AND SEQUENCES OF OPERATIONS

AN AMERICAN NATIONAL STANDARD



ANSI/IES LP-16-22

**LIGHTING PRACTICE:
DOCUMENTING CONTROL INTENT NARRATIVES AND
SEQUENCES OF OPERATIONS
AN AMERICAN NATIONAL STANDARD**

Publication of this document
has been approved by IES.
Suggestions for revisions
should be directed to IES.

**Prepared for IES by the
Lighting Control Systems Committee**



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1.0 Introduction and Scope

1.1 Introduction

In order for lighting control systems to work, the designer needs to create a vision for the design and provide clear instructions for how the lighting controls within the project boundaries, as well as their connections to other systems, are to operate. The design vision is documented in a Control Intent Narrative (CIN), a plain text document that can be easily understood by a layperson. The CIN is a springboard for the Sequence of Operation (SOO) document, the instructions for how to program the lighting control system. The SOO has the contractually enforceable language for informing the installer how to program the system to meet the design intent. This Lighting Practice document will describe how to create a project CIN and SOO that:

- 1) are detailed enough to ensure that the delivered system provides the functionality required;
- 2) provide enough information that the construction team can provide exactly the programming required; and
- 3) are contractually enforceable if something goes wrong.

1.2 Scope

This document provides guidance on the documentation of Control Intent Narratives and Sequences of Operation (CIN and SOO). It is not intended to be a design guide, but rather a reference manual of best practices on how the design, once formulated, is included in the project documentation and communicated to the construction and commissioning teams.

This document is intended for people in the lighting community, including building owners, managers, architects, lighting practitioners, electrical engineers, control systems practitioners, luminaire and controls manufacturers, systems integrators, and installers.

Equipment, sensors, software, and network infrastructure are necessary components of a complete lighting control system, but these are not covered here (refer to *ANSI/IES LP-6-20, Lighting Practice: Lighting Control Systems – Products, Selection, and Specification*¹ for information on these aspects of the lighting control system).

There are different ways to convey intent and sequences of operation. This document presents two of the most common formats: a matrix and a narrative. Each has its strengths and weaknesses. Information is provided to help the reader make a decision that will benefit the project. Furthermore, it is imperative that the method chosen be in harmony with the capabilities of the project team so that the SOOs will be updated as they evolve through the project.

It is not necessary to read this document cover to cover. The reader may skip to the sections of interest and the example narratives that will be useful for a given project. While the examples given are real world examples used on various projects, the example sequences should *not* be used as is; they will almost certainly not meet the requirements for a specific project. Instead, the examples should be used as a starting point and then adapted to specify the control system the project requires. The examples given may be used for their structure and level of detail, but the requirements and setpoints should be changed to meet the specific project's needs.

In addition, each specific project may require unique sequences that have never been created before. A questionnaire is provided in **Annex C** to help with creating a CIN and SOO for a specific project.

Finally, a List of **Abbreviations** and a **Glossary** can be found just before the annexes.

2.0 Control Intent Narratives and Sequences of Operation

The CIN and SOO do not hold equal positions in the work products for a project. The CIN is part of the Basis of Design (BOD) and is used to convey the overall intentions for the specified system(s). The CIN may be included in the contract documents (often the specifications or drawings); however, it should not be relied on because it deals in generalities. There is usually a lot of room for interpretation and enforcement; the language is often so vague that it is unenforceable. However, this

allows it to be a more easily understandable document for an owner or end user. The CIN can be made enforceable by the addition of details and setpoints. When measurable outcomes are added they become contractually enforceable. A side-by-side example of a CIN and an SOO is provided in **Table 2-1**. A clear CIN and SOO included with the specifications can help clarify approval or rejection of product submittals to meet project requirements.

It should be noted that the terms *Basis of Design* (BOD) and *Owner's Project Requirements* (OPR) primarily belong to the practice of systems commissioning. Within the context of this discussion, the term *OPR* refers to the specific control related requirements as articulated by the owner for the project under development. These may be extremely simple (for example, "save as much energy as possible") or more complex ("provide a seamless experience within the finished project in which the facility seems to operate independently of human operational commands"). The BOD takes the information from the OPR and combines it with the designer's vision to present a plain-language description of the design. The plain-language description of the lighting control function within the BOD creates the CIN. Readers are directed to ANSI/IES LP-8-20² for a detailed exploration of the commissioning process as it relates to both

lighting and lighting control systems. In particular, Table 4-1 in that document provides a thorough discussion of the process of writing a complete BOD document. **Section 2.1** of this document focuses on the portion of a BOD that describes the function of the lighting control system, the Control Intent Narrative. It is important to note that the entire BOD is a living document and will be revised as the project progresses.

2.1 Control Intent Narrative (CIN)

The CIN serves as the high-level descriptor of what the lighting control system is, what it will to do, and how the end users will interact with it. It is the primary means of ensuring that the ownership and user teams understand and agree with the lighting control design as it is being developed. The CIN includes:

- A general description of the project goals
- Control strategies to satisfy these goals
- A description of the control system
- A basic preliminary sequence of operation for each typical space type

It is important for the Control Intent Narrative to be written in clear, simple terms to allow an owner to review, understand, and approve the functionality of the lighting control system. Industry jargon should be avoided. This will help to ensure that the CIN describes

Table 2-1. Example: A CIN and SOO Comparison

Control Intent Narrative*	Sequence of Operation*
Provides a <i>general</i> description of the design vision.	Contains highly <i>specific</i> descriptions of what the lighting will do. It will include setpoints, will represent all the lighting of the project (interior, exterior, and emergency), and will address integration with other systems (e.g., HVAC).
<i>Example:</i> In <i>all areas</i> where lighting power within primary side-lit or top-lit daylighting zones exceeds the wattage threshold of the relevant energy code, such lighting shall <i>automatically dim</i> based on daylight contribution to maintain design illuminance and distribution.	<i>Example:</i> Adjust general lighting in <i>private offices</i> to maintain <i>300 lux</i> within the side-lit daylighting zone. When light level changes, delay change for <i>1 min. (adj.**)</i> . If daylight contribution decreases, increase lighting by <i>5% (adj.)</i> each second. If daylight increases, ramp down lighting by <i>20% (adj.)</i> each second.

Table notes:

* Italics have been added to emphasize the differences between CIN and SOO.

** adj.: Setpoints usually need to be adjusted in the field. Denoting adjustable setpoints is standard practice by mechanical engineers when writing SOOs for HVAC control systems. Adding "adjustable" (or "adj.") is an indicator to the controls contractor that the setpoint can and will be adjusted during startup and testing at no additional cost to the owner. Best practice is to reinforce setpoint adjustability by including this work in the control system specification. Note: Setpoints that do not need to be adjustable do not have "adj." after the setpoint value.

a system that meets the fundamental project needs. In addition, if there are significant departures from the OPR, they should be clearly described in the CIN and noted as changes with an accompanying justification. The owner or client should be able to understand the recommendations and specific causes and effects described in the document without assistance, in order to be confident that the system will be operationally and functionally appropriate.

2.2 Sequence of Operation (SOO)

The SOO is the contractually enforceable outgrowth of the CIN. The move from design narrative (how the system *might* or *will* behave) to how it is required to (*shall*) operate requires changing the tone of the document from a descriptive and purely informative document to a prescriptive one with specific goals, setpoints, and other attributes. Although the steps and elements of the SOO may seem similar to those described in the CIN, it is important to remember that the goal of CIN documentation is different from that of the SOO. In the former case, the documentation provides

a description of the various attributes of the system. In the latter, the focus is on the programming and functional requirements of the equipment necessary to achieve the stated goals. It may be helpful to think of the CIN as the “what” and the SOO as the “how.”

2.3 Key Elements of the CIN and SOO

Every project is different, and any list of control elements will need to be geared to the specific requirements outlined in the OPR. **Table 2-2** provides an example of the types of information addressed within a CIN and an SOO. It is not intended to be exhaustive.

It is critical that the CIN consider the scale of the system it is describing. A whole-building system will have different attributes than a single-room solution. In a whole-building project, building-level controls may originate from a master control station that propagates commands to spaces inside and outside the building. Such building-wide events usually require a master-level input or an input from an external system like a utility demand-response signal or integration with fire

Table 2-2. Key Elements for a CIN and an SOO

Element	CIN	SOO*
Scale of the system or project	Describe in general	N.A.
System topology	Wired or wireless? Centralized server or distributed devices? Combinations?	Provide network diagram in the contract documents
Special infrastructure	Existing wire type or special wire type needed?	N.A.
Integration with other system(s)	What are the systems?	How will they be integrated?
Automatic or manual control	Where are automatic controls used?	Specific devices
User interface	What kinds? (e.g., keypads, touchscreen)	Specific engraving, annunciation, or graphic details
Sensors for occupancy or vacancy response	On/off? Partial dimming?	Specific setpoints, timing, and methods
Daylight harvesting and response	Describe general approach	Specific setpoints and locations
Scene controls	Describe preliminary approach	Specific zones, output, schedule, and how to trigger
Setpoints	Preliminary and general	Specifics for all
Specialized lighting	Preliminary approach	Specifics with details
Emergency controls	General approach	Specific setpoints and how to trigger
Night lighting	General approach	Specific zones, output, and schedule

* Table note: N.A. = not applicable.

and life-safety systems. When part of the building or only a few rooms are designed, it is important to clearly describe whether the area is controlled by a new control system that interfaces with the existing control system in the building, or is an extension of the existing control system. The word “interface” can be a verb or a noun.

Most of the features of a building-level system may be available within the context of a smaller-scale system as well. As an example, a networked lighting control system that is designed appropriately can interface with other building systems if necessary, via a BACNet gateway (refer to ANSI/IES LP-6-20¹ for further information), and the presence of a processor in a networked system will provide an integral clock that can be utilized for time-based controls.

The specifier should clearly delineate the key parameters of the system, so that as the project progresses through bid, construction, and turnover the intended outcomes are achieved. This should include detailed information concerning both the system functionality and the system topology. Information about user interfaces and sensors should include details about wired or wireless methodologies and equipment. This information should also describe whether system commands may be originated by a centralized server, via devices distributed throughout the system, or a combination of the two.

The clearest way to document system topology is in a network diagram (see **Figure B-3** in **Annex B** for an example). Failure to include a network diagram within the contract documents will often result in the networking being incomplete or left out entirely because vendors and contractors often fail to connect the requirements for networked command in the SOO with system topology. Areas not connected to the central server will not be able to enact sequences that require networked commands (e.g., time switch or demand-response commands).

It is critical that any other key infrastructure or lighting network requirements be clearly defined within the CIN so that the document can function as a touchstone that can be referenced throughout the project to measure the success of the execution of the design. If there

are specific requirements, infrastructure needs, or integration requirements that could lead the project down a sole-sourcing path, those requirements need to be defined here as well. Conversely, if there are no such requirements, or no reason to choose one topology over another that needs to be specifically documented, it is important to state that all design avenues have been thoroughly considered and that the design team has made a conscious choice to allow the system to be open to a variety of proposed solutions. This serves to indicate that the design team has provided as much insight as possible.

When properly incorporated into the contract documents, the CIN and SOO work together to fully present the control design. Although the SOO gives details on how the controls operate and interact in a space, in many cases, a wide variety of lighting controls may meet the SOO needs but still not achieve the owner’s desires as articulated in the CIN. It is critical that the CIN elements be incorporated into the specifications jointly with the SOO in the contract documents so that both the control function is met and the owner’s project requirements for controls are fulfilled by the lighting control equipment.

Emergency controls are generally separate from building-level controls, as their operation may be determined by wiring rather than by control signals (in some jurisdictions, this may be a code requirement). However, they are an important layered part of the overall lighting control design that should be described in the CIN and SOO.

2.4 Creation Steps for the CIN and SOO

The steps described in this section comprise one suggested method by which a project can be broken down into smaller components. As each phase of project development progresses (see **Section 3.0 Creation Timeline**), the level of detail with which each room, action, or response is considered increases. As an example, a document created during the Schematic Design (SD) phase may identify rooms with daylight involvement, while the same document during the Design Development (DD) phase may indicate the quantity of daylight responsive zones and the types of responses each zone should exhibit. The version of

the same narrative in the Construction Documentation (CD) phase will include specific information about the sensor being deployed and its mounting (e.g., within or external to the luminaire), the illuminance to be maintained at the work surface, and the fade rate of the lighting between states.

It may be helpful to think of the various steps in this process as an opportunity for each of the several “voices” present within the general BOD documentation to be heard and captured in the CIN—specifically, the building, the code or legal statutes governing its design and construction, the owner or users, and the design team. This is what is meant by the “voice” indicators in **Section 2.4.1**.

2.4.1 CIN Steps.

Step 1: What does the owner want and consider important for end-user needs? [Owner’s “voice”]

Central question: What is the design team being asked to provide?

- Read the OPR to find out the Client’s goals and wishes.

Step 2: What are the spaces involved? [Building’s “voice”]

Central question: How will each type of space be addressed by the control system?

- List each space and function.
- List which part of the building needs what type of system, such as a standalone system or a networked system.

Step 3: Interaction (Building’s “voice”)

Central question: How do various devices interact to provide control?

- List other building systems that need to interface with the lighting control system and how they should interact.

Step 4: List the code-required and certification-required functions. [Code’s “voice,” such as energy codes, building codes, and certification and rating systems like LEED or WELL Building]

Central question: What equipment will be necessary to address each of the specific code or rating-certification requirements?

- List code and standard requirements that apply to the project.
- List spaces that have specific control requirements by code or standard, and list the device required; this may include occupancy or daylight sensors, for example.

Step 5: What is the purpose of the system? [Design team’s “voice”]

Central question: How does the control system function as an aspect of the project design?

- Define building schedule information as provided by owner.
- List spaces that require specialized control (e.g., color-changing or color tuning) to satisfy the client’s requirements (cite the OPR).
- List spaces that require automatic or other specific control—such as occupancy sensors, daylight sensors, or video teleconferencing—as a function of the design rather than code compliance.
- List spaces or space types that require multi-scene programming.
- List spaces that require integration with other systems, such as building automation, HVAC, security, and fire control.

Step 6: List the actions and functional responses.

Central question: Does the visual environment change during the use cycle?

- Think about or coordinate emergency lighting strategy.
- Think about what type of system is needed to satisfy requirements and goals.

Step 7: Identify opportunities for setpoints.

Central question: What are the quantifiable conditions that will cause the system to react?

- When is the facility operational? Are there different requirements for after-hours occupancy, for example?

- Does the space (or spaces) have different operational needs for daytime and nighttime?

Step 8: Review.

Central question: Have all space types, control types and known scenarios been considered?

- Think about how the system described in the document will ultimately be configured. Some portions of the building or project may require a networked system, while other aspects may operate more efficiently on a standalone system.

SIDEBAR: Why Describe CIN Early?

Although turning all the lights off at night can lead to significant energy savings, owners may object to the loss of visibility represented by a dark building. This is a key example of why the operation of the lighting control system should be described early. It is much easier to propose alternative solutions (e.g., night lights, occupancy sensors) that satisfy the owner's expectations during the Schematic Design and Design Development phases than it is to redesign the system in the construction documentation phase (i.e., re-zone the system to provide circuit-level nighttime lighting) or, worse yet, with a change order during Construction Administration (CA).

2.4.2 SOO Steps. Creating an SOO is its own multistep process that specifies how to achieve the CIN. As is the case with the CIN, a number of constituents or “voices” have been identified to which the finished project needs to answer. (*Note:* Additional information may be found in **Annex A – Lighting Controller Sequence of Operation.**)

Step 1: Consider code-required functions or attributes.

Primary question: What are the lighting control functions that are necessary in order to meet the statutory requirements for this project, and what equipment will be used to meet them?

Step 2: List the spaces.

Primary question: How will the various types of spaces within the project respond to both the code requirements

and the aesthetic principles outlined in the CIN? Space types include not only individual rooms, but also the building as a whole and exterior spaces. Including these large-space concepts aids in the inclusion of sequences that involve networked commands.

Step 3: Consider what the owner wants.

Primary question: What specific aspects of the OPR and BOD documents have been integrated into the LCS design, and how will each of those functions be achieved?

Step 4: Decide on actions and functional responses.

Primary question: What happens in typical use cases?

Step 5: Identify setpoints.

Primary question: What are the start and end points of each operation?

- What control parameters need to be established to allow the installation, functional testing, and commissioning teams to configure and program the system to meet the goals presented in the CIN?

Step 6: Review the SOO.

Primary question: Have all system integration and functional requirements been addressed?

- *Note:* The designer should make sure that the scene labels match the details for the wall control station. If there is no detail, the contractor may provide a wall station that is in conflict with the design vision or the Owner's needs.

3.0 Creation Timeline

The design process is iterative in that each aspect of a project is considered in increasing detail. The creation of a CIN and SOO benefits from this iterative approach, with continued development of detail and clarity through the design and construction process. Most North American projects follow a standardized progression

from Schematic Design (SD) through Construction Administration (CA). More detailed information on the lighting design and construction process can be found in ANSI/IES LP-7-20.³ While there may be variations in timing, terminology, or sequence, depending on project type or region of the world, CIN and SOO development follows a fairly set structure through the design and construction process. Post-occupancy services, while not part of the creation timeline, are often specified. **Table 3-1** shows an example timeline.

3.1 Schematic Design (SD)

The project Schematic Design, or pre-design, phase is the time to start developing the Owner Project Requirements (OPR), and from this create the project Basis of Design (BOD). It may be helpful to think of this back-and-forth as a dialog that documents the control goals, needs and requirements. For example, the OPR may identify a need to “automatically turn off luminaires in empty rooms.” The BOD may cite “All classrooms should be provided occupancy sensors to automatically turn lighting off when the room is no longer occupied.”

This high-level documentation of the intent should inform the project team about how the overall system should function. The Schematic Design phase should conclude with conceptual design approval of the OPR and BOD.

3.2 Design Development (DD)

During Design Development, the specific attributes described in the OPR and established in the BOD should be identified, and a means of achieving each should be proposed and described in the CIN. Once the Client (or the Owner’s rep) has reviewed and provided feedback, the Control Intent Narrative should be updated so that it identifies a means of achieving the goals of the BOD. As an example, where the BOD cites the relevant code for lighting shut-off control, the CIN describes in detail what needs to be accomplished by the lighting controls: “All classrooms should be provided with ceiling mounted occupancy sensors to automatically turn on the light level to 50% when someone enters the room. Lighting will be turned off when the room is no longer occupied.”

Table 3-1. Example of a CIN and SOO Timeline

Phase	Lighting Control Scope and Deliverables	CIN and SOO Development
Schematic Design (SD)	- Owner Project Requirements (OPR) - Basis of Design (BOD) - CIN to be included in BOD	- Document goals, criteria, relevant lighting control requirements, and needs - Conceptual development of control - Owner review and feedback
Design Development (DD)	- Control Intent Narrative - Preliminary SOO	- CIN further developed and completed - Preliminary SOO documentation - Owner review, feedback
Construction Documentation (CD)	- Luminaire specification with specific dimming protocol - Lighting control zoning - Controls specification - SOO - One-line Diagrams - Lighting and relay panel schedules	- SOO further developed and completed - Contractual construction documents approved
Construction Administration (CA)	- Shop drawing submittals - RFI (Request for Information) - Installation, programming, testing - Site observation - Functional testing - Training and manuals	- Review submittals against CIN and SOO - Adjust CIN and SOO as field conditions require - Programming and functional testing, based on SOO

The conceptual design is translated into formal plans. General concepts and strategies will become increasingly detailed, until a finished design is produced that satisfies the OPR and BOD. When the 100% DD documentation is presented to the owner for review, and prior to commencing with the next phase, the lighting control-system designer should have considered the system as a whole; this may include how lighting loads are zoned and to which control points, specific equipment and/or control settings, schedules, and required programming.

3.3 Construction Documentation (CD)

The lighting control system described in the project drawings and within the project manual should be identifiable as having grown directly from the earlier phases of project development. If the development process has been iterative and collaborative, there will not be major changes in approach between the system described at the end of Design Development and the fully articulated lighting specifications and control specifications that grow out of the CD process. As with other aspects of the lighting design, the move from DD to CD is one of refinement and clarification, and includes the creation of the SOO.

Although the CIN is finalized during this phase, the CIN is not contractually enforceable unless it is included in the contract documents. Project teams may accomplish this by appending the CIN to the specification as described and defined by the Control Specifications Institute (CSI). If the CIN is to be considered a contractually enforceable document, it will need to be reformatted to replace suggestive terms (should or will or could) with imperative terms (shall). The SOO is formulated and finalized during this phase and is part of the contractually enforceable documents. In the example of lighting shut-off control, the SOO would state how the lighting controls presented in the CIN operate: “Ceiling mounted occupancy sensors in a classroom shall automatically turn on all the lights to 50% light level when an occupant enters a classroom. All lights will be turned off after the classroom is vacant for 15 minutes.”

3.4 Construction Administration (CA)

During the CA phase of the project, the lighting control system submittals and shop drawings are created

and reviewed to ensure that they meet the goals and requirements of the specifications and the SOO. Manufacturers’ submittal documents should clearly indicate that sufficient hardware and software will be provided to enable installation and programming to accomplish the specified SOO. The submittal documents should clearly indicate what they are proposing to provide, as well as what they are not providing. Manufacturer-specific issues are identified and resolved in this process in order to maintain compliance with the contractually enforceable construction documents. A more complete explanation of the submittal review process can be found in ANSI/IES LP-7-20.³

Field situations arising during the lighting control installation, programming, and testing process are addressed, and the SOO is adjusted to align with any field updates and changes. Document updates resulting from field situations are critical in order to support the accuracy and efficiency of the startup and commissioning process. Through the lighting control installation process, the system is configured and programmed to operate as documented in the SOO, followed by functional testing where adopted energy codes require testing for certification of compliance.

4.0 Roles and Responsibilities

Each professional on the team has a specific role to play. These roles and responsibilities are not always clear, and it is best at the outset of a project to learn how the project will come to fruition, as well as who is responsible and at what phase. The descriptions below are specific to the various team members’ roles relative to the lighting control system.

- **Owner:** The Owner should review the BOD, including the CIN, and provide input. This basic overview of the lighting control system should be reviewed with the Project Architect as well as with the Client and, if possible, the end users, to ensure alignment with basic project requirements.
- **Architect:** The Architect is the professional with the most direct contact with the Client and therefore has the most knowledge of the requirements of the

Client, Owner, or end users, as well as their technical sophistication. Thus, the Architect can communicate those requirements to the design team, enabling them to develop the CIN and SOO and specify an appropriate control system. Additionally, when the Architect is the prime consultant and is gathering a group of sub-consultants, it is important to make sure that there is no scope gap among the sub-consultants. The Architect is responsible for ensuring that the scopes of all sub-consultants are clearly documented in detail so that it is clear which consultant is responsible for each task, such as developing zoning, writing the CIN, and developing the SOO.

- **Lighting Designer:** The lighting designer is the primary design professional responsible for the illumination on the project. Various design team professionals may serve this role, such as the Architect, Interior Designer, Electrical Engineer, or professionals that specialize in lighting design. Lighting control design responsibilities include understanding the requirements of the Client, Owner, and end users, and communicating specific needs, such as zoning, scene setting if any, or special control needs such as color tuning or tunable white control, to the Lighting Control Specifier (LCS).
- **Interior Designer:** Interior designers work intimately with clients, owners, and end users, and often know the specific needs for each space. Additionally, they are a key player in developing the programming of interior spaces, and therefore may have additional insight into the function of a space, and how lighting controls can support that function. It is important that the Interior Designer coordinate overall concepts with both Lighting Designer and Lighting Control Specifier, such as if the space needs multiple light settings or a specific user interface, so that the desired intent is captured in the CIN and SOO, and therefore delivered on the project. It is important to discuss where the control stations will go and what they look like with the LCS, so that the delivered system meets the design needs and expectations of the Interior Designer.
- **Electrical Engineer:** The Engineer may be tasked with identifying the specific components necessary to bring the control concept to fruition. It is critical that the Engineer be involved in the process and ensure that the specified system will comply with all applicable codes.
- **Lighting Control Specifier (LCS):** Various design team professionals may serve this role. These can include the project Lighting Designer, the Architect, and the Electrical Engineer. Less commonly, the Systems Integrator or Contractor may be tasked with specifying the control system. Regardless of the other roles the LCS may fulfill within the project, in this role they are responsible for specifying the lighting control system.
- **Manufacturer's Sales Representative:** The manufacturer's sales representative is a third-party representative, or agent, hired by a manufacturer to represent their brand and products in each market. They act as a "go-between" amongst the customer, distributor, and manufacturer. They help fill in whatever details are left out when orders are placed, and generally help the design team and sales partners as needed to enable a smooth flow of orders to manufacturers, and products onto job sites. They provide many services, as needed, from project to project. On any given project they might:
 - Assist with product selection based on the CIN and SOO
 - Assemble cut sheets for submittal approvals
 - Manage delivery dates
 - Provide onsite verification of product application and installation
 - Prepare lighting control plans using guidance from the manufacturer
 - Provide installation instruction to the installing contractor
 - Provide startup service and product programming
 - Assist with the activities of the commissioning provider
 - Manage the flow of money between the customer and the manufacturer
 - Manage the price margins and discounts
- **Lighting Controls System Vendor:** This person or company is responsible for translating the information put forth in the CIN, the SOO, and the material specification into a specific Bill of Materials (BOM), which can be represented by equipment cut sheets and/or catalog numbers or stock keeping units (SKUs).

- **Lighting Control System Integrator (LCSI):** This person or company trains and oversees contractors on startup, programming, and commissioning of the lighting control system, and trains the Owner or owner's representative. The LCSI may also have scope to verify controls design concepts prior to procurement, review specifications, and ensure that the products being delivered will meet the project's control design specifications. The LCSI is responsible for identifying the pieces of equipment or aspects of programming that will allow the various parts of the control system to work together. These interfaces may be required to achieve interoperability among systems from different manufacturers or across platforms.
- **Construction Manager (CM):** The CM can serve as the Owner's agent or employee, or can be a separate contractor. The role varies from project to project and may also be referred to as Project Manager.
- **Installing Contractor:** Generally, the Contractor's responsibility is part of the Construction Administration phase of the project and therefore may not start until after the CIN and SOO have been created and accepted by the design team. However, the Contractor and the rest of the construction team are typically responsible for realizing the project vision as communicated by the design team, so it is important that all terms and topics covered in both the CIN and the BOD documentation (if separate) be clearly understood and agreed to in advance of the Contractor beginning work. The typical bid process provides a mechanism for the Contractor to ask questions in advance, especially those which might create conflict or result in added costs or schedule delays. For this reason, it is extremely important that all members of both the design and construction teams take the Request for Information (RFI) process seriously and respond quickly and accurately when questions arise.
- **System Startup Provider:** This is the entity responsible for realizing the lighting controls SOO, utilizing the hardware that is delivered and

installed on the job site. The more advanced the system, or more complex the controls, the more instrumental the startup provider is in the success of the project. On simple systems, there may be no system startup provider, and the system may simply work as designed out of the box. On more complex projects, and because hardware may have no functionality out of the box, the startup provider is an instrumental part of the installation team; they rely on the work of the system startup provider to combine all inputs using the system logic as outlined in the SOO to deliver the desired outcomes.

- **Commissioning Provider:** Within the specific context of the CIN, the commissioning provider should have the opportunity to comment on the feasibility of the goals as expressed in both the CIN and the proposed SOO, and should be provided with final copies of both for use in determination of the building's successful completion of the design goals as outlined in the BOD. (*Note: Occasionally, the Commissioning Provider title is used to describe the System Startup Provider. In the context of this document, the Startup Provider is the contractor or agency executing the SOO and programming the hardware, and the Commissioning Provider is the individual or agency that ensures all energy savings and design goals are met as outlined in the BOD, and that the contractors and the Startup Provider have delivered on their promises.*) Additional information may be found in *ANSI/IES LP-8-20, Lighting Practice: The Commissioning Process Applied to Lighting and Control Systems*.²
- **Facilities Engineer:** This person is responsible for operation and maintenance of the lighting control system over its lifespan. It is important to make sure that the Facilities Engineer's input is sought whenever possible to ensure that the specified system will be able to operate as intended. Therefore, their acceptance of and education about the system are critical to the long-term success of the lighting controls. A facility engineer is an appropriate person to train end users

5.0 Lighting Control Strategies

5.1 Strategies Overview

There are many strategies used in lighting controls. **Table 5-1** lists a number of commonly used strategies a lighting controls specifier may use to provide desired outcomes. It is critical, therefore, that they provide functional, plain-language expectations (the Control Intent Narrative), as well as enforceable contract language (the Sequence of Operations) to communicate not only the inclusion of a given strategy, but also how each strategy shall be incorporated, such as, setpoints, timing values, and various other details. The following section provides examples. (See Section 4.0 in ANSI/IES LP-6-20¹ for a more comprehensive list, as well as definitions and details on each control strategy.) **Table 5-1** shows the most basic of manual control strategies, followed by some automatic control strategies, and ending with the control results.

The information in **Sections 5.2** and **5.3** provide a detailed investigation into two different ways of looking at lighting controls specifications—the lighting CIN and the SOO. The material in **Section 5.2** is broken down by strategy type, with some examples of how a strategy may be documented for a given project. The material in **Section 5.3** illustrates some examples by space type and helps to show how these various strategies can be implemented together to provide the full desired controls scheme.

5.2 Lighting Control Strategies – By Discrete Strategy Type

In the subsections that follow, CIN and SOO examples for discrete lighting control strategies are presented to demonstrate the elements needed to adequately describe a specific type of control. These examples are intended to be generic and do not contain specific setpoints, settings, or other information necessary for specific project implementation. The designer is responsible for providing this specific information to fully complete the project CIN or SOO for a given application.

Although these are discrete lighting control strategy examples, in a project, lighting control functionality for a space is made up of multiple discrete controls interacting together to achieve the lighting control objective for the space. A complete CIN and SOO for a specific space would combine individual discrete control descriptions to create a complete intent for how the lighting control is to be installed, configured, and operated in the space.

The information presented in these examples is for designers' reference. The examples provide sample content of CIN and SOO components needed to specify discrete lighting control strategies in contractual documents. These examples should not be copied and used for a real project; instead, they should be adapted and modified to suit the project's budget and specific control requirements.

5.2.1 Manual Controls. Manual controls provide a user interface to enable control of the lighting level in a space. Manual controls typically consist of a lighting

Table 5-1. Lighting Control Strategies

Control Inputs			Control Results	
Manual	Automatic			
Manual User Interface (switch or dimmer)	Occupancy Sensing	Vacancy Sensing	Switching	Lumen Maintenance Dimming
Scene Control	Daylight Harvesting	Demand Response	Continuous Dimming	Color Tuning
Room Partitioning	Institutional Tuning	Circadian Control	Step Dimming	Tunable White
Personal Tuning	Time Scheduling	Adaptation Compensation	Load Shedding	Fading: On, Off, Cross
	High End Trim	Scene Control	Shade Control	

zone switch, a step-dimming control switch, or a dimmer installed in an electrical switch box that is conveniently located for occupant access and control. More information on the application of user interfaces and manual controls can be found in Sections 3.7.2, 4.1, and 7.1 of ANSI/IES LP-6-20.¹ **Table 5-2** shows an example of manual on/off switches used to control both general and decorative lighting. These switches also provide occupants the ability to override the current lighting state until the occurrence of the next

automatic event. **Table 5-3** shows a similar example of controlling general and decorative lighting but uses manual dimming controls instead of on/off switches. This example also demonstrates utilization of low- and high-end trim settings with the dimming controls.

5.2.2 High-End Trim. High-end trim is a lighting control strategy that sets the maximum control level in a space. This strategy is often used to reduce

Table 5-2. Manual On/Off Switching Control Example

Control Intent Narrative	Sequence of Operation
General and decorative lighting in <room names or designations> is turned on and off by occupant manual operation of switches installed in electrical boxes at each entrance or exit door. Switches will be located such that the controlled lighting is within the line of sight from each switch location. Three switches will be installed providing on/off control of: uniform bi-level control for general lighting as required by code; remaining <x%> bi-level control of general lighting; and decorative wall sconce lighting. Except for automatic daylight harvesting control, the manual control switches will temporarily override any automatic control such as time-switch scheduling and occupancy sensors, until the next automatic event occurs. The manual control switches will not allow lighting to be increased above the automatic daylight-harvesting control lighting level.	• Wall switch “a” shall provide manual on/off control of “a” luminaires, uniformly operating <x%> of the general lighting. • Wall switch “b” shall provide manual on/off control of “b” luminaires, uniformly operating <y%> of the general lighting. • Wall switch “c” shall provide manual on/off control of “c” luminaires, operating the decorative wall sconce lighting. • Wall switches shall be capable of turning lighting on and off at any time regardless of automatic control by time-switch scheduling or occupancy sensors. Wall switches shall not increase the lighting level above the automatic daylight-harvesting control lighting level.

Table 5-3. Manual Dimming Control Example

Control Intent Narrative	Sequence of Operation
General and decorative lighting in <room names or designations> are turned on and off and dimmed by occupant manual operation of dimmers installed in electrical boxes at each entrance or exit door. Dimmers will be located such that the controlled lighting is within line of sight from each dimmer location. Dimmers shall operate across the range of minimum lighting power of <x%> to a maximum trimmed level of <y%> lighting power. Two dimmers will be installed providing on/off and dimming control of general lighting and decorative wall sconce lighting. Except for automatic daylight-harvesting control, the manual dimming controls will temporarily override any automatic control such as time-switch scheduling and occupancy sensors, until the next automatic event occurs. The manual dimming controls will not allow lighting to be increased above the automatic daylight-harvesting control lighting level.	• Wall dimmer “a” shall provide manual on/off and dimming control of “a” luminaires, uniformly operating the general lighting. Low-end-trim shall be set to <x%> of full lighting power, and high-end trim shall be <y%>. • Wall dimmer “b” shall provide manual on/off and dimming control of “b” luminaires, uniformly operating the decorative wall sconce lighting. Minimum allowed lighting power shall be <x%>, and high-end trim shall be <y%>. • Wall switches shall be capable of turning lighting on and off at any time regardless of automatic control by time-switch scheduling or occupancy sensors. Wall dimmers shall not increase the lighting level above the automatic daylight-harvesting control lighting level.

energy consumption, deliver task-illumination tuning, or compensate for light loss factors over the life of a luminaire. More information on the related topics of institutional tuning and lumen maintenance can be found in Sections 4.3 and 4.8 of ANSI/IES LP-6-20.¹ **Table 5-4** shows an example for a high-end trim scenario.

5.2.3 Low-End Trim. Low-end trim is a lighting control strategy that sets the minimum control level in a space. This strategy is used to ensure that lights are never dimmed below a specific lighting level. Also, low-end trim may be used to mitigate the light flicker of some lamps that can occur in the very low dimming range. While low-end trim is sometimes used to provide a minimum walk-through illuminance, it does not replace the function of emergency lighting. **Table 5-5** shows an example for a low-end trim scenario.

5.2.4 Time Scheduling Control. Time scheduling is a lighting control strategy used to automate lighting levels where there is a repeatable time-of-use space occupancy pattern. Time scheduling may turn lighting on or off, set lighting to a specific level, or change lighting parameters based on space utilization at different times and days. In many applications, overrides are needed, or required, giving occupants manual control of the space lighting at all times. Occupant overrides are typically temporary until the next scheduled event. A common scheduled event is multiple shutoff times, which turn lighting off to meet energy code and energy efficiency requirements. It is

common to refer to repeated scheduled shutoff events as a “lighting sweep off” schedule or “lighting sweeps,” as in cleaning up or sweeping through lighting left on. The time schedule may be activated by a hardwired discreet component or driven by programmable software. More information on the features and application of time scheduling control can be found in Section 4.6 of ANSI/IES LP-6-20.¹

Time scheduling control can be applied at the circuit level or via the lighting control system network. In either case, it is important that additional details be provided to ensure that the sequence is enacted properly. (See **Figure B-3** in **Annex B** for an example of a network diagram.)

Table 5-6 shows the use of time scheduled control to repeatedly turn off the lighting in a room based on the maximum amount of time the energy code allows for lighting override outside of scheduled business hours. The example also incorporates a lighting “blink” warning prior to turning the lighting off, notifying occupants of a coming shutoff event, thereby allowing them time to further override the lighting by actuating the lighting switch.

5.2.5 Occupancy and Vacancy Sensing. *Occupancy sensors* detect human occupancy in the controlled space and turn the lighting on or off based on the presence or absence of people. *Vacancy sensors* combine a manual switch for on and an occupancy sensor for automatic off operation. More information on the features and application of occupancy and vacancy sensing control can be found in

Table 5-4. High-End Trim Example

Control Intent Narrative	Sequence of Operation
Light levels will be limited to uniform levels during system startup, to allow for periodic adjustment over the life of the luminaires to compensate for normal light loss factors.	The maximum operating level shall be set to <x%> of maximum for all general lighting.

Table 5-5. Low-End Trim Example

Control Intent Narrative	Sequence of Operation
Low-end trim will be set in all common and circulation areas to provide occupants a certain minimum amount of light regardless of energy-management dimming or time of day.	The minimum operating low-end trim level shall be set for all lighting in all common and circulation areas to the minimum level specified on the luminaire schedule for each luminaire type.

Table 5-6. Time Scheduling: Off Control Example

Control Intent Narrative	Sequence of Operation
Lighting in <room names or designations> use time scheduling from a centralized system time switch to turn lighting off after business hours. User control switches override lighting after business hours. User overrides allow lighting to remain on for the maximum duration allowed by the energy code. Lighting will warn occupants <x> minutes before scheduled shutoff events by momentarily turning lighting off and back on within <y> seconds. After the shutoff warning, user control switches may cancel the pending scheduled shutoff and reset the override to the maximum time allowed or until the system enters operating business hours, whichever occurs sooner.	• All space lighting, except required egress lighting, shall be scheduled by centralized time switch to be turned off at the end of business operating hours and remain off until the beginning business operating hours the next business day. • Wall control switches or dimmers shall be configured to provide override-on control of lighting after business hours. Actuation of a wall control after business hours shall turn the lighting on for <w> minutes. • Lighting in the space shall momentarily turn off and back on within <y> seconds, to warn occupants <x> minutes before shut-off. Manual actuation of the wall control after this warning signal shall cancel the pending shutoff.

Sections 4.5 and 7.4 of ANSI/IES LP-6-20.¹ **Table 5-7** shows an example of an occupancy sensor used to automatically turn on the general lighting to the code maximum-allowed level upon detection of occupancy. All lighting in the room is automatically turned off when no occupancy is detected. **Table 5-8** demonstrates the use of a vacancy sensor control, where occupants need to manually turn on the lighting, as there is no automatic-on function. Similarly, when no occupancy is detected in the room, and following the shutoff time delay, all lighting is turned off.

5.2.6 Daylight Harvesting. Daylight harvesting entails reducing electric light output to maintain a

near-constant illuminance in a space receiving daylight. Energy codes requiring daylight harvesting (also called “daylight responsive control”) often only require daylight harvesting for general illumination, and not for decorative, accent, or supplemental task lighting. More information on the features and application of daylight harvesting control can be found in Section 4.7 of ANSI/IES LP-6-20.¹ **Table 5-9** shows an example of a daylight harvesting CIN for a single daylight zone using a closed-loop photosensor that monitors the lighting level in the room and modulates the lighting output to maintain a specified lighting level.

Table 5-7. Occupancy Sensor Example

Control Intent Narrative	Sequence of Operation
General lighting in <room names or designations> will automatically turn on to the code maximum-allowed lighting level when an occupant enters. Lighting remains on while the room is occupied. When the room is no longer occupied, all room lighting will automatically turn off after the maximum time delay allowed by the code. Controls at the entrance to the space provide users the ability to turn on, increase, decrease, or turn off the general lighting. To save energy, lighting should quickly turn off when the room is only briefly occupied.	• Upon detection of occupants, general lighting shall automatically turn on to <w%> of full power. • A wall switch at the entrance shall provide the user control to turn on, increase, decrease, or turn off the general lighting. • Occupancy sensor mounting location and sensitivity shall be set for major-motion full-room coverage and minor-motion coverage in the workstation area. • All room lighting shall be automatically turned off <x> minutes after occupancy was last detected. • The occupancy sensor walk-through mode shall be enabled, automatically turning lighting off <y> minutes after initial detection, when occupancy is detected for a duration of less than <z> seconds.

Table 5-8. Vacancy Sensor Example

Control Intent Narrative	Sequence of Operation
General lighting in <room names or designations> is turned on by user manual operation of the vacancy sensor switch (vacancy mode) at the entrance to the space. Lighting remains on while the room is occupied. When the room is no longer occupied, all room lighting automatically turns off after the maximum time delay allowed by the code. The vacancy sensor switch provides the ability for users to turn on, increase, decrease, or turn off the general lighting. To save energy, the lighting should quickly turn off when the room is only briefly occupied.	- A vacancy sensor switch shall be installed at the entrance to the space, providing user's manual control to turn on, increase, decrease, or turn off the general lighting. - Vacancy sensor mounting location and sensitivity shall be set for major-motion full-room coverage and minor-motion coverage in the workstation area. - All lighting shall be automatically turned off <v> minutes after occupancy was last detected. Lighting shall automatically turn back on if occupancy is detected within <w> seconds of automatically turning off. After <x> seconds after an automatic shutoff, the lighting shall only be turned on from the vacancy sensor switch. - The vacancy sensor's walk-through mode shall be enabled, automatically turning lighting off <y> minutes after initial detection, when occupancy is detected for a duration of less than <z> seconds.

Table 5-9. Daylight Harvesting Example

Control Intent Narrative	Sequence of Operation
General lighting is continuously dimmed in the daylit areas of <room names or designations> as daylight is contributed. A closed-loop photosensor monitors the light level at the task plane and modulates the general lighting to maintain near-constant illuminance. General lighting will be automatically turned off when the daylit area exceeds <x%> of the design illuminance target. Manual switch control of the general lighting may not increase or override the lighting level above the daylight-controlled level. Accent-lighting luminaires are not daylight harvesting controlled. A portable handheld device or app, accessible to authorized personnel, will be used for programming and setting daylight control parameters while standing on the floor.	- The daylighting control photosensor shall be set to continuously increase or decrease the electric lighting luminous intensity to maintain the target illuminance of the daylight area. - When combined electric and daylight illuminance exceeds <a%> of target levels for seconds, electric light shall be reduced by <c%> per second. - When combined electric and daylight illuminance falls below <d%> of target levels for <e> seconds, electric light output shall be increased by <f%> per second. - When the combined electric and daylight illuminance exceeds <g%> of target levels for <h> seconds, the electric lighting shall be automatically turned off. - The interface shall not allow the user to override the electric lighting controls in a way that will provide greater illuminance than allowed by the daylight control photosensor. - The daylight control photosensor shall not require physical adjustment at the sensor. All settings shall be accessible by authorized personnel when standing on the floor of the space for which the sensor has control.

5.2.7 Demand Response Control. Demand response control is a lighting control strategy that reduces building lighting power by dimming or turning off selected lighting in response to a need or a request

to reduce building power demand. Demand response events can be manually or automatically initiated within a building or can be signaled from external actions such as electrical grid events or demand response signals

from utilities and grid operators. In the U.S., demand response is becoming integrated into distributed energy resource (DER) systems, operating in conjunction with onsite power generation and storage within grid-enabled efficient buildings (GEB). More information on the features and application of demand response control can be found in Section 4.9 of ANSI/IES LP-6-20.¹

Demand response requires a networked control system because the command originates from a central server. It is crucial to include a network diagram because vendors and contractors often fail to realize that the strategy requires a networked topology. (See **Figure B-3** in **Annex B** for an example of a network diagram.)

An example of a CIN and SOO that will reduce the lighting power when a demand-response request signal is received through the commonly used Open ADR 2.0b interface (required interface standard for some energy codes) is shown in **Table 5-10**.

Table 5-10. Demand Response Control Example

Control Intent Narrative	Sequence of Operation
Building general lighting will respond to Open ADR 2.0b utility demand-response request signals from the utility or demand-response aggregator by automatically shedding or reducing lighting power by at least <x%> of the building's total lighting load. Light reduction for demand response will be accomplished through dimming the general lighting output over <y> seconds in all spaces except restrooms, stairwells, storage rooms, or any enclosed spaces under <z> square <meters or feet>. At the completion of a demand response request, the general lighting will be restored to the last commanded illuminance. If the general lighting level was adjusted during the demand response event, the lighting will remain at its current level.	- When a demand-response request signal is received, general lighting in spaces designated for demand response control shall automatically shed or reduce lighting power by at least <x%> over <y> seconds. - When a demand-response signal request concludes, general lighting in spaces designated for demand response control shall automatically be restored to the last commanded illuminance or, if the lighting level was changed during the event, shall remain at the changed lighting level. - Spaces not designated for demand response control shall not change the lighting level during a demand response event.

Table 5-11. Emergency Lighting Control Example

Control Intent Narrative	Sequence of Operation
General-lighting luminaires will automatically provide life-safety code level of emergency illumination upon loss of normal power, using battery-backup units in luminaires that will power full light output from the emergency-designated luminaires. Any lighting control (manual switch, occupancy sensor, daylighting control, or otherwise) will be circumvented so luminaires will be turned on to full light output. When normal power returns, the luminaires will revert back to normal operation and provide the last commanded illuminance.	- Upon loss of normal power, emergency-lighting designated luminaires shall be automatically turned on to full light output operating on battery-backup power. No other control shall be capable of operating or overriding the full light-output state during loss of normal power. - Upon restoration of normal power, emergency-lighting designated luminaires shall revert back to normal operation and provide the last commanded illuminance.

5.2.8 Emergency Lighting. Emergency lighting provides a required level of illumination during the loss of normal power. Requirements for where and at what illuminance emergency lighting is to be provided are found in the life safety codes enforced by the local authority having jurisdiction. More information on the application of emergency lighting can be found in Section 4.12 of ANSI/IES LP-6-20.¹ **Table 5-11** shows a CIN and SOO example that utilizes luminaires with emergency battery-backup equipment (also called “unit equipment”) serving both as general lighting during normal operation, and as emergency lighting via power from the battery during emergency events. In this example, the emergency luminaires turn to full output either when there is a loss of normal power.

5.2.9 Room Partitioning. Room partitioning is a lighting control strategy that allows joined or independent operation of lighting and controls for rooms that have movable partitions between them. This is typically found in classroom, training room, ballroom, conference room,

and convention room settings. When partitions are closed between adjoining rooms, the lighting controls within individual rooms operate just to serve the lighting in the individual partitioned room. When partitions or curtains between rooms are opened, all lighting controls and lighting serving the open space are “combined” to operate together for the now-single controlled room.

Table 5-11 shows an example of a flexible, multi-use space where movable partition walls have sensors indicating when a partition is open or closed. This allows the control system to automatically combine the wall station lighting controls in individual rooms to function together when the partitions are opened to create a larger room, or to configure the individual rooms’ lighting controls to operate separately when the partitions are closed.

5.2.10 Color or Spectrum Adjustment. For luminaires that offer color or spectrum adjustment, there are three primary strategies by which the luminous flux and/or spectral power distribution of a lamp or luminaire is adjusted: warm dim, white tuning, and color tuning.

Which strategy is used is determined by the needs of the space, and is implemented by selection of lamps or luminaires that permit the necessary control of spectral power distribution. Manufacturers use different names for these strategies for branding purposes, but any strategy of color adjustment of lamps and luminaires fits within just one of these three categories.

The specifier determines which is being used, ensures that all equipment is compatible with this feature, and documents how or by what metric the color is changed.

Some end users may prefer to have the ability to manually adjust the light spectrum to coordinate with the space utilization at a given time. Conversely, some industries or owners may choose to preprogram CCT for various reasons—for example, to match daylight, to intentionally mimic daylight at night, or to provide a warm comfortable glow at certain times of day.

5.2.10.1 Warm Dim. Warm dim, also known as “dim to warm” or “warm glow” or, less often, “amber shift,” is the simplest of the three. As the control—whether line voltage dimming, 0-10V, or a digital signal—is reduced from the maximum level, the CCT shifts toward a lower value (appears warmer), and the luminous intensity is reduced. In a warm-dim lamp or luminaire, the relationship between luminous intensity and CCT has a fixed curve. An appropriately designed LED lighting system can take advantage of this characteristic to mimic the dimming behavior of incandescent lamps without allowing the user to adjust CCT separately from luminous intensity.

5.2.10.2 White Tuning. White tuning, also known as “tunable white,” “variable white,” or “dynamic white,” is the adjustment of light source CCT through mixing of two or more independently controlled white emitters, which typically have a CCT difference of 1000 K or higher. When the control values of the luminaire or lamp are proportionally mastered, the luminous intensity may be adjusted largely independent of the CCT. White-tuning luminaires only offer adjustments nominally along the blackbody curve, and therefore the output at any setting can reasonably described as white.

Table 5-11. Room Partitioning Control Example

Control Intent Narrative	Sequence of Operation
Flexible rooms with movable partitions have lighting controls that operate only the lighting within the individual partitioned room. When partitions are opened between adjoining rooms, creating a larger room, the controls will automatically be configured for any lighting control location or interface within the combined room, to control all lighting in the combined room together. This provides convenient, uniform control from any control location or interface. The control system receives a signal from sensors detecting the partition’s open or closed status. The signal combines the operation of the user controls when the partitions between rooms are opened more than <x%>.	- When partitions between rooms are closed, only the lighting control devices within each individual room shall operate the lighting within that room. - When partitions between rooms are opened at least <x%>, a sensor signal shall combine operation of all lighting control devices within the combined room to operate all lighting within the combined room together.

Most white-tuning luminaires allow independent control of the lumen output of multiple light sources of different CCTs; varying the output of the individual sources allows the creation of varying CCTs for the luminaire as a whole. This is referred to as direct emitter control, which is preferred for most applications where there are multiple manufacturers. Occasionally, luminaires have one control channel for CCT and one for luminous intensity, which can make it difficult to match the color of their light to that of other luminaires in a space unless they are all calibrated together.

Table 5-12 shares an example of white tuning in a lobby area. In this case, the white tuning follows the CCT reading from a sensor on the building roof. If readings from the CCT sensor should cease, the white tuning system uses a preprogrammed CCT setting based on time of day from sunrise to sunset.

5.2.10.3 Color Tuning. Color tuning, also called spectral tuning, uses controls to adjust lighting color(s) in spaces. Color-tuning luminaires with three or more emitters will

Table 5-12. White Tuning Example

Control Intent Narrative	Sequence of Operation
The lobby downlights, cove lights, and entry vestibule luminaires employ white tuning to track the correlated color temperature of daylight via a CCT sensor. In this way, the CCT of the lighting in these spaces will match that of the daylight entering the space.	The CCT of lighting zones <zone names or designations> shall be white tunable. The luminaires in these zones shall be programmed to track the CCT of daylight as presented to the CCT sensor installed on a north facing wall on the roof. This CCT sensor shall be calibrated onsite at no fewer than five settings ranging from 2300 K to 6000 K, and shall interpolate all CCTs in between. For all CCTs measured below 2300 K, the system shall command the use of 2300 K for the relevant interior zones. For all CCTs read above 6000 K, the system shall command the use of 6000 K for the zones. When no light is sensed, the system shall command the use of 2300 K in the zones. All luminaires shall be calibrated onsite at no fewer than five settings ranging from the luminaires' maximum CCT to their minimum CCT, such that their CCTs match those commanded by the system. Given variations in LED chips, minor adjustments to this calibration may be required with the lighting designer onsite. CCT changes shall be applied at a rate of <x%> per second, and there shall be a CCT deadband of <y> K. If the CCT sensor input is lost, the system shall provide notification via the touchscreen and revert to a schedule of: - 2300 K: from 1 hour before sunset to 1 hour before sunrise. - 3500 K: from 1 hour before sunrise to sunrise - 4500 K: from sunrise to 1 hour after sunrise - 6000 K: from 1 hour after sunrise to 3 hours before sunset - 4500 K: from 3 hours before sunset to 2 hours before sunset - 3500 K: from 2 hours before sunset to 1 hour before sunset This backup CCT schedule shall be applied at a rate of <x%> per second.