



San Francisco
International
Airport

A&E Standards

Electrical – Lighting Control Systems

Division 26 – Electrical

PREFACE

PURPOSE OF THIS DOCUMENT

The intent of this document is to disseminate the San Francisco International Airport's (SFO's or Airport's) expectations regarding the information presented to designers, engineers, general contractors and other industry specialists. The material provided in the following sections includes the minimal requirements, general information, design criteria, guide specifications and details for electrical and lighting installed at SFO. While this document addresses major areas of concern to SFO, it is not an all-inclusive document.

HOW TO USE THIS DOCUMENT

This document should be used as a resource for the development of project specific design documents including drawings, details and specifications. It is the responsibility of the design, engineering and construction professionals to adhere to all codes and regulations related to the content presented.

SCOPE

This section contains the Standards and Criteria for Electrical Lighting Control Systems. Any questions or concerns regarding the items or equals specified must be submitted to the Standards Committee in writing. All final decisions regarding products shall be made at the Airport's discretion. If the Engineer of Record presents items that are not specified or named equals, they must be brought to the Standards Committee for evaluation of those products.

GENERAL INFORMATION

- A. Due to rapid technological advancement, all supplied products shall be the latest approved equivalents of the specified products. The following requirements shall be met:
1. Hardware shall be ordered as close as possible to the installation date (within reason) to ensure that products installed are the latest.
 2. Based on a comparison of technology specified under this section and the technology available when products are ordered for each project phase, technical and operational product equivalents shall be provided upon approval by the Airport. Product equivalence shall be based on technical and operational equivalence to the specified products.
 3. All products shall be compatible and integrate with the existing system. Contractor shall verify that all products supplied are compatible with the existing systems that are being interfaced with, as required.
 4. Lighting Controls Design shall be coordinated with either the existing or the expected Lighting Design. Sequence of Operations and Implementation is subject to SFO review and approval.

DRAWING REQUIREMENTS

- A. All design disciplines including the architectural/engineering sub-consultants and the trade bid package subcontractors shall prepare documents using Revit in the current version utilized by the Airport in compliance with the Airport's Building Information Modeling (BIM) Requirements as described in Document 00 73 87: BIM Requirements, unless waived by the Chief Development Officer.
- B. When Revit models may not be applicable, (for example, tasks with underground infrastructure beyond a building footprint), Civil 3D may be used to model utilities and applicable infrastructure if approved by the

Chief Development Officer.

- C. Refer to technical specifications for As-Built requirements.
- D. Documents and plans submitted to SFO shall be searchable using PDFs with live text. This includes, but is not limited to, text and symbols. The document shall also provide the capability to turn layers on and off. Any project using legacy documents which may be composed image files shall be converted to live text via Optical Character Recognition (OCR).

Version	Publish Date	Revisions	Reviewed By
2.1	March 2018 <i>The March 2018 version was uploaded to SFOConstruction.com in November 2018</i>	BIM language updated	Josephine Pofsky, N. King
2.0	December 2017 October 2017	Review; Formatting Made Lighting Control Systems its own A&E Standard	Norman Clevenger, Greg McCarthy; N. King SFO Facilities Maintenance
1.0	July 2017	---	SFO Facilities Maintenance

SECTION 26 09 43 – LIGHTING CONTROL SYSTEMS

PART 1 – GENERAL

1.1 SECTION INCLUDES:

- A. Digital-network lighting control system and associated components:
 - 1. Power panels
 - 2. LED drivers
 - 3. Power interfaces
 - 4. Lighting control modules (Lutron Energi Savr Node)
 - 5. Lighting management hubs
 - 6. Lighting management system computers
 - 7. Lighting management system software
 - 8. Control stations
 - 9. Low-voltage control interfaces
 - 10. Wired sensors
 - 11. Accessories

1.2 RELATED REQUIREMENTS

- A. Section 26 27 26 - Wiring Devices
 - 1. Finish Requirements for wall controls specified in this section.
 - 2. Accessory receptacles and wall plates, to match lighting controls specified in this section.

1.3 REFERENCE STANDARDS

- A. CAL TITLE 24 P6 - California Code of Regulations, Title 24, Part 6 (California Energy Code); latest version as contracted.
- B. IEC 61000-4-5 - Electromagnetic Compatibility (EMC) - Part 4-5: Testing and Measurement Techniques - Surge Immunity Test; latest version as contracted.
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction; latest version as contracted.
- D. NECA 130 - Standard for Installing and Maintaining Wiring Devices; National Electrical Contractors Association; latest version as contracted.
- E. NEMA 410 - Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts; National Electrical Manufacturers Association; latest version as contracted.
- F. NEMA WD 1 - General Color Requirements for Wiring Devices; National Electrical Manufacturers Association; latest version as contracted.
- G. NFPA 70 - National Electrical Code; National Fire Protection Association; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements; latest version as contracted.
- H. UL 508 - Industrial Control Equipment; Underwriters Laboratories Inc.; latest version as contracted.
- I. UL 508A - Industrial Control Panels; Underwriters Laboratories Inc.; latest version as contracted.

- J. UL 924 - Emergency Lighting and Power Equipment; latest version as contracted.
- K. UL 1472 - Solid-State Dimming Controls; latest version as contracted.
- L. UL 1598C - Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits; latest version as contracted.
- M. UL 2043 - Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces; latest version as contracted.
- N. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products; latest version as contracted.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. See Division 01 Specification Sections of the contract associated with Coordination.
 - 2. Coordinate the placement of daylight sensors with windows, skylights, and luminaires to achieve optimum operation. Coordinate placement with ductwork, piping, equipment, or other potential obstructions to light level measurement installed under other sections or by others.
 - 3. Coordinate design with Dynamic Glazing.
 - 4. Coordinate the work to provide luminaires and lamps compatible with the lighting controls to be installed.
 - 5. Notify Architect of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.
- B. Pre-Wire Meeting: Conduct on-site meeting with lighting control system manufacturer prior to commencing work as part of manufacturer's standard start-up services. Manufacturer to review with installer:
 - 1. Low-voltage wiring requirements.
 - 2. Separation of power and low voltage/data wiring.
 - 3. Wire labeling.
 - 4. Lighting management hub locations and installation.
 - 5. Control locations.
 - 6. Load circuit wiring.
 - 7. Network wiring requirements.
 - 8. Connections to other equipment and other Lutron equipment.
 - 9. Installer responsibilities.
 - 10. Power panel locations.
- C. Sequencing:

1. Do not install sensors and wall controls until final surface finishes and painting are complete.

1.5 SUBMITTALS

- A. Design Documents: Where Lighting Control Manufacturer Sensor Layout and Tuning service is specified in Part 2 under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS," Lighting Control manufacturer shall provide plans indicating occupancy/vacancy and/or daylight sensor locations.
- B. Product Data: Include ratings, configurations, standard wiring diagrams, dimensions, colors, service condition requirements, and installed features.
 1. Occupancy/Vacancy Sensors: Include detailed basic motion detection coverage range diagrams.
- C. Shop Drawings:
 1. Provide schematic system riser diagram indicating component interconnections. Include requirements for interface with other systems.
 2. Provide detailed sequence of operations describing system functions.
- D. Samples:
 1. Wall Controls:
 - a. Show available color and finish selections.
 - b. Provide one sample(s) for each product proposed for substitution upon request.
 2. Sensors: Provide one sample(s) for each product proposed for substitution upon request.
- E. Project Record Documents: Record actual installed locations and settings for lighting control system components. See Division 01 Specification Sections of the contract associated with Project Record Documents.
- F. Operation and Maintenance Data: Include detailed information on lighting control system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals. See Division 01 Specification Sections of the contract associated with Operations and Maintenance Data and Manuals.
- G. Software: One copy of project database provided under this section.

1.6 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain a copy of each referenced document that prescribes execution requirements at the project site.
- C. Manufacturer Qualifications:
 1. Company experience in manufacturing lighting control systems of similar complexity to specified system(s) not less than 10 years.
 2. Registered to ISO 9001, including in-house engineering for product design activities.

3. Qualified to supply specified products and to honor claims against product presented in accordance with warranty.
- D. Title 24 Acceptance Testing Technician Qualifications: Certified by a California approved Acceptance Test Technician Certification Provider (ATTCP) as an Acceptance Test Technicians (ATTs) in accordance with CAL TITLE 24 P6.
- E. Maintenance Contractor Qualifications: Manufacturer's authorized service representative.

1.7 WARRANTY

- A. See Division 01 Specification Sections of the contract associated with contract closeout and warranties.
- B. Manufacturer's Standard Warranty, With Manufacturer Start-Up; Lutron Standard 2-Year Warranty; Lutron LSC-B2 or equal:
 1. Manufacturer Lighting Control System Components, Except Lighting Management System Computer, Ballasts/Drivers and Ballast Modules:
 - a. First Two Years:
 - 1) 100% replacement parts coverage, 100% manufacturer labor coverage to troubleshoot and diagnose a lighting issue.
 - 2) First-available on-site or remote response time.
 - 3) Remote diagnostics for applicable systems.
 - b. Telephone Technical Support: Available 24 hours per day, 7 days per week, excluding manufacturer holidays.
 2. Ballasts/Drivers and Ballast Modules: Five years 100% parts coverage, no manufacturer labor coverage.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Basis of Design manufacturer: Lutron Electronics Company, Inc.

2.2 DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS

- A. Sensor Layout and Tuning: Include as part of the base bid additional costs for Lighting Control Manufacturer's Sensor Layout and Tuning service; Lutron LSC-SENS-LT or equal.
- B. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) as suitable for the purpose indicated.
- C. Contractor to utilize Lighting Control Manufacturer Installation Instructions to place/install sensors. At Pre-wire and Start-up, Lighting Control manufacturer to provide a rough sensor calibration only. Sensor fine-tuning to be the responsibility of contractor.
- D. Unless specifically indicated to be excluded, provide all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a

complete operating system that provides the control intent indicated.

- E. Design lighting control equipment for 10-year operational life while operating continually at any temperature in an ambient temperature range of 32 °F (0 °C) to 104 °F (40 °C) and 90% non-condensing relative humidity.
- F. Device Finishes: Standard Colors: Comply with NEMA WD1 where applicable.
- G. Interface with SFO-ITT ICS Network and Network Integration Consultation; LSC-INT-VISIT or equal.
- H. Interface with Existing Lutron Networked Lighting Control Systems.

2.3 POWER PANELS

- A. Provide power panels with configurations as indicated on the drawings.
- B. General Requirements:
 - 1. Listed to UL 508 as industrial control equipment.
 - 2. Comply with UL 508A and IEC 60669-2-1 as applicable.
 - 3. Delivered and installed as a listed factory-assembled panel.
 - 4. Field wiring accessible from front of panel without removing dimmer assemblies or other components.
 - 5. Passively cooled via free-convection, unaided by fans or other means.
 - 6. Shipped with each dimmer in mechanical bypass position by means of jumper bar inserted between input and load terminals. Jumpers to carry full rated load current and be reusable at any time. Mechanical bypass device to allow for switching operation of connected load with dimmer removed by means of circuit breaker.
 - 7. Provided with branch circuit protection for each input circuit unless the panel is a dedicated feed-through type panel or otherwise indicated on the drawings.
 - 8. Branch Circuit Breakers:
 - a. Listed to UL 489 as molded case circuit breaker for use on lighting circuits.
 - b. Provided with visual trip indicator.
 - c. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
 - 1) 10,000 rms symmetrical amperes at 120 VAC.
 - 2) 14,000 rms symmetrical amperes at 277 VAC for dimming.
 - 3) 18,000 rms symmetrical amperes at 277 VAC for switching.
 - d. Thermal-magnetic construction for overload, short-circuit, and over-temperature protection. Use of breakers without thermal protection requires dimmers/relays to have integral thermal protection to prevent failures when overloaded or ambient temperature is above rating of panel.

- e. Equipped with provision for tag-out/lock-out devices to secure circuit breakers in off position when servicing loads.
 - f. Replaceable without moving or replacing dimmer/relay assemblies or other panel components.
 - g. Listed as switch duty (SWD) so that loads can be switched on and off by breakers.
9. Provide panels with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
- a. Minimum Short Circuit Current Rating (SCCR): 25,000 A.
10. Panel Processor; Lutron Circuit Selector or equal:
- a. Provide the following capabilities:
 - 1) Operate circuit directly from panel processor for system diagnostics and provide feedback of system operation.
 - 2) Electronically assign each circuit to any zone in lighting control system.
 - 3) Determine normal/emergency function of panel and set emergency lighting levels.
 - b. Where indicated on the drawings, panels to provide two control links. Each circuit to be capable of transferring control based on independent programming between architectural control system and theatrical controls utilizing the USITT DMX-512 1990 or ESTA DMX-512A protocol.
 - c. React to changes from control within 20 milliseconds.
11. Diagnostics and Service:
- a. Replacing dimmer/relay does not require re-programming of system or processor.
 - b. Include diagnostic LEDs for dimmers/relays to verify proper operation and assist in system troubleshooting.
 - c. Include tiered control scheme for dealing with component failure that minimizes loss of control for occupant.
 - 1) If lighting control system fails, lights to remain at current level. Panel processor provides local control of lights until system is repaired.
 - 2) If panel processor fails, lights to remain at current level. Circuit breakers can be used to turn lights off or to full light output, allowing non-dim control of lights until panel processor is repaired.
 - 3) If dimmer fails, factory-installed mechanical bypass jumpers to allow each dimmer to be mechanically bypassed. Mechanical bypass device to allow for switching operation of connected load with dimmer removed by means of circuit breaker.
- C. Product(s):
- 1. Specification Grade Dimming Panels:

- a. Product: Lutron GP Series Dimming Panels or equal
 - b. Mounting: Surface.
 - c. Dimmers designed and tested specifically to control incandescent/tungsten, magnetic low voltage, electronic low voltage, neon/cold cathode, fluorescent dimming ballasts, and non-dim loads.
 - d. Unless otherwise indicated or required, utilize universal 16A continuous-use listed dimmers.
 - e. For loads requiring 0-10V, PWM, or DSI control, utilize compatible multiple load type low voltage dimming modules.
 - f. Limit current rise time to minimum 350 microseconds as measured from 10 to 90% of load current waveform and minimum 525 microseconds as measured from 0 to 100% of load current waveform at 50% rated dimmer capacity at a 90° conduction angle. Current rise time to be minimum 400 microseconds as measured from 10 to 90% of load current waveform and minimum 600 microseconds as measured from 0 to 100% of load current waveform at 100% rated dimmer capacity at a 90° conduction angle.
 - g. Load faults only affect the given circuit.
2. Modular Dimming Panels:
 - a. Product: Lutron LP Series Dimming Panels or equal.
 - b. Provide surface-mounted or flush-mounted enclosures as indicated.
 - c. Unless otherwise indicated or required, utilize multiple load type 16A feed continuous-use listed dimming/switching modules.
 - d. For switching only circuits, utilize relays rated for minimum of 1,000,000 cycles at fully rated current for all lighting loads.
 - e. For loads requiring 0-10V, PWM, or DSI control, utilize compatible multiple load type low voltage dimming modules.
 3. Modular Combination Panels:
 - a. Product: Lutron CCP Series Custom Combination Panels or equal.
 - b. Provide surface-mounted or flush-mounted enclosures as indicated.
 - c. Unless otherwise indicated or required, utilize multiple load type 16A feed continuous-use listed dimming/switching modules.
 - d. For switching only circuits, utilize relays rated for typical 1,000,000 cycles at fully rated 16A for all lighting loads.
 - e. For loads requiring 0-10V, PWM, or DSI control, utilize compatible multiple load type low voltage dimming modules.
 4. Relay Panels:

- a. Product: Lutron XP Series Switching Panels or equal.
- b. Provide surface-mounted or flush-mounted enclosures as indicated.
- c. Switching Requirements:
 - 1) Utilize 20A continuous-use rated switching modules; able to switch 20A receptacles.
 - 2) Rated Life of Relay: Typical of 1,000,000 cycles at fully rated 16A for all lighting loads.
 - 3) Switch load in a manner that prevents arcing at mechanical contacts when power is applied to and removed from load circuits.
 - 4) Provide output fully rated for continuous duty for inductive, capacitive, and resistive loads.

2.4 LED DRIVERS

A. General Requirements:

1. Operate for at least 50,000 hours at maximum case temperature and 90% non-condensing relative humidity.
2. Provide thermal fold-back protection by automatically reducing power output (dimming) to protect LED driver and LED light engine/fixture from damage due to over-temperature conditions that approach or exceed the LED driver's maximum operating temperature at calibration point.
3. Provide integral recording of operating hours and maximum operating temperature to aid in troubleshooting and warranty claims.
4. Designed and tested to withstand electrostatic discharges incurred during manufacturing, installation, or field troubleshooting without impairment of performance when tested according to IEC 61000-4-2.
5. Manufactured in a facility that employs ESD reduction practices in compliance with ANSI/ESD S20.20.
6. UL 8750 recognized or listed as applicable.
7. UL Type TL rated where possible to allow for easier fixture evaluation and listing of different driver series.
8. UL 1598C listed for field replacement as applicable.
9. Designed and tested to withstand Category A surges of 4,000V according to IEEE C62.41.2 without impairment of performance.
10. Class A sound rating; inaudible in a 27 dBA ambient.
11. Demonstrate no visible change in light output with a variation of plus or minus 10% change in line-voltage input.
12. LED drivers of the same family/series to track evenly across multiple fixtures at all light levels.

13. Offer programmable output currents in 10 mA increments within designed driver operating ranges for custom fixture length and lumen output configurations, while meeting a low-end dimming range of 100 to 1% or 100 to 5% as applicable.
14. Meet NEMA 410 inrush requirements.
15. Employ integral fault protection up to 277V to prevent LED driver damage or failure in the event of incorrect application of line-voltage to communication link inputs.
16. LED driver may be remote located up to 100 feet (30 m) from LED light engine depending on power outputs required and wire gauge utilized by installer.

B. 3-Wire Control:

1. Provide integral fault protection to prevent driver failure in the event of a miswire.
2. Operate from input voltage of 120 V through 277V at 50/60 Hz.

C. Digital Control (when used with compatible Lutron lighting control systems):

1. Employ power failure memory; LED driver to automatically return to the previous state/light level upon restoration of utility power.
2. Operate from input voltage of 120 V through 277 V at 50/60 Hz.
3. Automatically go to 100% light output upon loss of control link voltage and lock out system commands until digital control link voltage is restored. Manufacturer to offer UL 924 compliance achievable through use of external Lutron Model LUT-ELI-3PSH interface or equal upon request.
4. Each driver responds independently per system maximum:
 - a. Up to 32 occupant sensors.
 - b. Up to 16 daylight sensors.
5. Responds to digital load shed command. (Example: If light output is at 30% and a load shed command of 10% is received, the ballast automatically sets the maximum light output at 90% and lowers current light output by 3% to 27%).

2.5 LIGHTING CONTROL MODULES (LUTRON ENERGI SAVR NODE or equal)

A. Provide lighting control modules as indicated or as required to control the loads as indicated.

B. General Requirements:

1. Listed to UL 508 as industrial control equipment.
2. Delivered and installed as a listed factory-assembled panel.
3. Passively cooled via free-convection, unaided by fans or other means.
4. Mounting: Surface.
5. Connection without interface to wired:
 - a. Occupancy sensors

- b. Daylight sensors
 - c. IR receivers for personal control
 - 6. Connects to lighting management hub via RS485.
 - 7. LED status indicators confirm communication with occupancy sensors, daylight sensors, and IR receivers.
 - 8. Contact Closure Input:
 - a. Directly accept contact closure input from a dry contact closure or sold-state output without interface to:
 - 1) Activate scenes.
 - a) Scene activation from momentary or maintained closure.
 - 2) Enable or disable after hours.
 - a) Automatic sweep to user-specified level after user-specified time has elapsed.
 - b) System will provide occupants a visual warning prior to sweeping lights to user-specified level.
 - c) Occupant can reset timeout by interacting with the lighting system.
 - 3) Activate or deactivate demand response (load shed).
 - a) Load shed event will reduce lighting load by user-specified amount.
 - 9. Emergency Contact Closure Input:
 - a. Turn all zones to full output during emergency state via direct contact closure input from UL 924 listed emergency lighting interface, security system or fire alarm system.
 - b. Allow configurable zone response during emergency state.
 - c. Disable control operation until emergency signal is cleared.
 - 10. Supplies power for control link for keypads and control interfaces.
 - 11. Distributes sensor data among multiple lighting control modules.
 - 12. Capable of being controlled via wireless sensors and controls.
- C. Switching Lighting Control Modules:
- 1. Product(s):
 - a. Lutron SoftSwitch Energi Savr Node; Model QSN-4S16-S: 16A continuous-use per channel as basis of bid or equal.
 - b. Lutron SoftSwitch Energi Savr Node; Model QSN-4S20-S: 20A (16A ballast) continuous-use per channel; able to switch 20A receptacles as basis of bid or equal.

2. Switching:
 - a. Rated Life of Relay: Typical of 1,000,000 cycles at fully rated 16A for all lighting loads.
 - b. Load switched in manner that prevents arcing at mechanical contacts when power is applied to and removed from load circuits.
 - c. Fully rated output continuous duty for inductive, capacitive, and resistive loads.
 - d. Module to integrate up to four individually controlled zones.
 - e. Utilize air gap off, activated when user selects "off" at any control to disconnect the load from line supply.

- D. 0-10V Lighting Control Modules:
 1. Product(s):
 - a. Lutron 0-10V Energi Savr Node; Model QSN-4T16-S: 16A continuous-use per channel as basis of bid or equal.
 - b. Lutron 0-10V Energi Savr Node; Model QSN-4T20-S: 20A (16A Ballast) continuous-use per channel; able to switch 20A receptacles as basis of bid or equal.
 2. Coordination between Low Voltage Dimming Module and Line Voltage Relay: Capable of being electronically linked to single zone.
 3. Single low voltage dimming module; capable of controlling following light sources:
 - a. 0-10V analog voltage signal.
 - 1) Provide Class 2 isolated 0-10V output signal conforming to IEC 60929.
 - 2) Sink current per IEC 60929.
 - b. 10V-0V analog voltage signal.
 - 1) Provide Class 2 isolated 0-10V output signal conforming to IEC 60929.
 - 2) Sink current per IEC 60929.
 4. Switching:
 - a. Rated Life of Relay: Typical of 1,000,000 cycles at fully rated 16A for all lighting loads.
 - b. Load switched in manner that prevents arcing at mechanical contacts when power is applied to and removed from load circuits.
 - c. Fully rated output continuous duty for inductive, capacitive, and resistive loads.
 - d. Module to integrate up to four individually controlled zones.
 - e. Utilize air gap off, activated when user selects "off" at any control to disconnect the load from line supply.

2.6 LIGHTING MANAGEMENT HUBS

- A. Product: Lutron Quantum Light Management Hub as basis of bid or equal.
- B. Provided in a pre-assembled NEMA listed enclosure with terminal blocks listed for field wiring.
- C. Connects to controls and power panels via RS485.
- D. Enables light management software to control and monitor compatible dimming ballasts and ballast modules, power panels, and power modules.
 - 1. Utilizes Ethernet connectivity to light management computer (virtual server) utilizing one of the following methods:
 - a. Industrial Control Server Network (ICS).
 - b. Dedicated VLAN.
 - c. Shared network with Building Management System (BMS).
 - d. Corporate network where managed switches are configured to allow multicasting and use of IGMP.
- E. Integrates control station devices, power panels, preset lighting controls, and external inputs into a single customizable lighting control system with:
 - 1. Multiple Failsafe Mechanisms:
 - a. Power failure detection via emergency lighting interface.
 - b. Protection: Lights go to full on if ballast wires are shorted.
 - c. Distributed architecture provides fault containment. Single hub failure or loss of power does not compromise lights connected to other lighting management hubs.
 - 2. Manual overrides.
 - 3. Automatic control.
 - 4. Central computer control and monitoring.
 - 5. Integration with BMS via BACnet.
- F. Furnished with astronomical time clock.
- G. Maintains a backup of the programming in a non-volatile memory capable of lasting more than ten years without power.
- H. BACnet Integration License:
 - 1. Provide ability to communicate by means of native BACnet IP communication (does not require interface) to lighting control system from a user-supplied 10BASE-T or 00BASE-T Ethernet network.
 - 2. Requires only one network connection per system.
 - 3. Lighting control system to be BACnet Test Laboratory (BTL) listed.

4. Basic BACnet integration license:
 - a. The BACnet integrator can command:
 - 1) Area light output.
 - 2) Area enable or disable after "hours" mode.
 - 3) Area load shed level.
 - 4) Area load shed enable/disable.
 - 5) Enable/Disable:
 - a) Area occupancy sensors.
 - b) Area daylighting.
 - 6) Daylighting level.
 - 7) Area occupied and unoccupied level.
 - 8) Occupancy sensor timeouts.
 - b. The BACnet integrator can monitor:
 - 1) Area on/off status.
 - 2) Area occupancy status.
 - 3) Area fault.
 - a) Lamp failures.
 - b) Control devices not responding.
 - 4) Area load shed status.
 - 5) Area instantaneous energy usage and maximum potential power usage.
 - 6) Energy savings broken out by strategy (occupancy, time clock, daylighting, personal control, tuning, load shed) down to the individual area.
 - 7) Daylighting level.
 - 8) Light levels from photo sensors or Radio Window sensors.
 - 9) Area occupied and unoccupied level.
 - 10) Occupancy sensor timeouts.
5. Integration with other devices over Ethernet via Telnet using the Lutron Integration Protocol or equal.
6. Control other devices over Ethernet via TCP or Telnet by sending device specific strings.

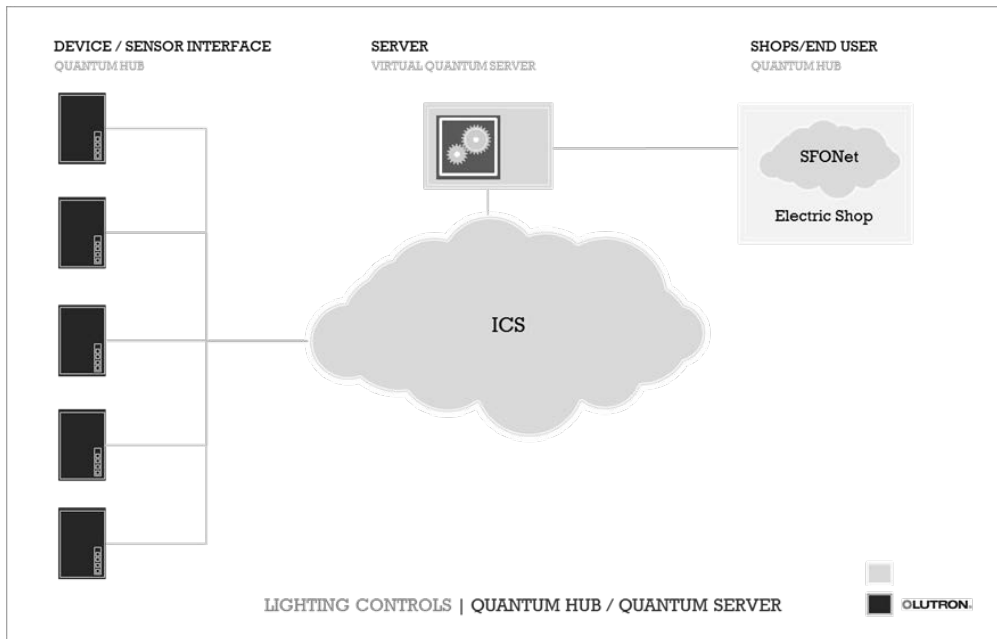
2.7 LIGHTING MANAGEMENT SYSTEM COMPUTERS

- A. Server: Existing, Virtualized Industrial Control System Network (ICS) - Physical server not required on a per project basis.

2.8 LIGHTING MANAGEMENT SYSTEM SOFTWARE

- A. Provide system software license and hardware that is designed, tested, manufactured, and warranted by a single manufacturer.
- B. Configuration Setup Software:
 - 1. Product: Lutron Q-Design or equal.
 - 2. Suitable to make system programming and configuration changes.
 - 3. Windows-based, see section 2.14 for networking requirements.
 - 4. Allows end-user (with training) to:
 - a. Capture system design:
 - 1) Geographical layout.
 - 2) Load schedule zoning.
 - 3) Equipment schedule.
 - 4) Equipment assignment to lighting management hubs.
 - 5) Daylighting design.
 - b. Define the configuration for the following in each area:
 - 1) Lighting scenes.
 - 2) Control station devices.
 - 3) Interface and integration equipment.

4) Occupancy/after hours.



- 5) Partitioning.
- 6) Daylighting.
- 7) Emergency lighting
- 8) Night lights.

c. Start-up:

- 1) Addressing.
- 2) Daylighting.
- 3) Provide customized conditional programming.

C. Control and Monitor Software:

1. Products:

- a. Lutron Quantum Vue (web-based application) or equal.
- b. Lutron Q-Administrative (desktop application) or equal.

2. Accessibility and Platform Support:

- a. The existing Airport platform supports the Lutron Quantum Vue Web-Based Application:
 - 1) Web-based; runs on most HTML5 compatible browsers (including Internet Explorer,

- Chrome, and Safari).
- 2) Supports multiple platforms and devices; runs from a tablet, desktop, laptop, or smartphone; optimized for displays of 1024 by 768 pixels or higher.
- 3) User interface supports multi-touch gestures such as pinch to zoom, drag to pan, etc.
- 4) Utilizes HTTPS (industry-standard certificate-based encryption and authentication for security).
- b. Lutron Q-Administrative Desktop Application:
 - 1) Client installation for Windows-based operating systems only.
- 3. System Navigation and Status Reporting:
 - a. Lutron Quantum Vue Web-Based Application or equal: Performed using graphical floor plan view or a generic system layout.
 - 1) Graphical Floor Plan View: Utilizes customized CAD based drawing of the building. Pan and zoom feature allows for easy navigation; dynamically adjusts the details presented based on zoom level.
 - 2) Area, scene, and zone names can be changed in real time.
 - b. Lutron Q-Administrative Desktop Application or equal: Performed using basic system tree view.
- 4. Control of Lights:
 - a. Area lights can be monitored for on/off status.
 - b. All lights in an area can be turned on/off or sent to a specific level.
 - c. For areas that have been zoned, these areas may be sent to a predefined lighting scene, and individual zones may be controlled.
 - d. Area lighting scenes can be renamed and modified in real-time, changing the levels that zones go to when a scene is activated.
 - e. High and low end of area lighting can be tuned/trimmed.
 - f. Control and monitor area partition status.
- 5. Occupancy:
 - a. Area occupancy can be monitored.
 - b. Area occupancy can be disabled to override occupancy control or in case of occupancy sensor problems.
 - c. Area occupancy settings including level that lights turn on to when area is occupied, and level that lights turn off to when area is unoccupied can be changed in real-time.
 - d. Monitor energy savings due to occupancy down to an individual area.

6. Daylighting:
 - a. Daylighting can be enabled/disabled. Can be used to override the control currently taking place in the space.
 - b. Daylight calibration can be adjusted for each day lit area.
 - c. Daylight status can be monitored.
 - d. Monitor energy savings due to daylight harvesting down to an individual area.
7. Load Shedding Ready; Lutron IntelliDemand: Allows the building manager to monitor whole building lighting power usage and apply a customized load shed reduction to selected areas, thereby reducing a building's power usage; load shedding triggered via Quantum software or BACnet. SFO does not participate in a demand response program.
8. Scheduling: Schedule time of day and astronomic time clock events to automate functions.
 - a. Adjust or disable a single occurrence of a repeating scheduled event.
 - b. Easily monitor and adjust scheduled events using a weekly calendar view.
9. Reporting: Provide reporting capability that allows the building manager to gather real-time and historical information about the system as follows:
 - a. Energy Reports: Show a comparison of cumulative energy used over a period of time for one or more areas.
 - b. Power Reports: Show power usage trend over a period of time for one or more areas.
 - c. Energy Density Report: Show energy usage in W/sq. ft.
 - d. Energy Savings by Strategy Report: Show energy savings for any area broken down by strategy (tuning, occupancy, daylighting, scheduled events, personal control, and load shedding).
 - e. Activity Report: Show what activity has taken place over a period of time for one or more areas. Activity includes occupant activities (e.g. wall controls being pressed), building manager operation (e.g., controlling/changing areas using the control and monitor tool), and device failures (e.g., keypads or ballasts that are not responding).
 - f. Lamp Failure Report: Shows which areas are currently reporting lamp failures.
 - g. Sensor Level Report: Shows the light level in foot-candles of any photo sensor in the system.
 - h. Alert Activity Report: Capable of generating historical reports of all alert activity within the system.
10. Diagnostics: Allows the building manager to check on the status of all equipment in the lighting control system. Devices to be listed with a reporting status of OK, missing, or unknown.
11. Alerts and Alarms: Monitors the system for designated events/triggers and automatically generates alerts according to configured response criteria.
 - a. Capable of monitoring for the following events/triggers:

- 1) A failed piece of equipment (e.g., ballast, control, sensor, etc.); alert cleared when equipment is replaced.
 - 2) A lamp outage (for compatible EcoSystem digital electronic dimming ballasts only); alert cleared when lamp is replaced.
 - 3) Low battery conditions in battery-operated sensors and controls; alert cleared when battery is replaced.
 - 4) Luminaires with lamp operating hours in excess of designated time.
 - 5) A load shed event; alert generated for beginning and end of trigger.
 - 6) Energy usage higher than designated threshold target.
 - 7) Potential light level condition discrepancies (daylight sensors not agreeing with expected lighting status).
 - 8) Potential sensor failures (Radio Window sensors that have not seen a change in light level).
- b. View alerts on a customized graphical floor plan.
 - c. Capable of generating alerts through visible changes in software or through email messages.
 - d. Capable of customizing the frequency of alerts and providing notifications immediately or through daily, weekly, or monthly summaries.
 - e. Capable of sending different alerts to different system users.
 - f. Capable of generating historical reports of all alert activity within the system.
12. Administration:
- a. Users: Allows new user accounts to be created and existing user accounts to be edited. Supports Active Directory (LDAP) tying user accounts to network accounts.
 - b. Area and feature access can be restricted based on login credentials with three levels of access rights (Administrative, Programmer, and Controller) and customized access levels available.
 - c. Publish Graphical Floor Plan: Allows administrative user to publish new graphical floor plan files, allowing users to monitor the status of lights, occupancy of areas, and daylighting status.
 - d. Back-Up Project Database: Allows administrative user to back up the project database that holds all the configuration information for the system, including keypad programming, areas scenes, daylighting, occupancy programming, emergency levels, night lights, and time clock.
 - e. Publish Project Database: Allows administrative user to send a new project database to the server and download the new configuration to the system. The project database holds all the configuration information for the system, including keypad programming, area scenes, daylighting, occupancy programming, emergency levels, night lights, and time clock.

13. Favorite Buttons: Provide global scene control or modes of operation across the entire system.
14. Provides control/monitoring of partition status to automatically reconfigure how the space operates based on the partition's open/closed status.

2.9 CONTROL STATIONS

- A. Provide control stations with configuration as indicated or as required to control the loads as indicated.
- B. Wired Control Stations:
 1. General Requirements:
 - a. Power: Class 2 (low voltage).
 - b. UL listed.
 2. Multi-Scene Wired Control:
 - a. General Requirements:
 - 1) Allows control of any devices part of the lighting control system.
 - 2) Allows for easy reprogramming without replacing unit.
 - 3) Replacement of units does not require reprogramming.
 - 4) Communications: Utilize RS485 wiring for low-voltage communications link.
 - 5) Engrave keypads with button, zone, and scene descriptions as indicated on the drawings.
 - 6) Software Configuration:
 - a) Customizable control station device button functionality:
 - (1) Buttons can be programmed to perform single defined action.
 - (2) Buttons can be programmed to perform defined action on press and defined action on release.
 - (3) Buttons can be programmed using conditional logic off of a state variable such as time of day or partition status.
 - (4) Buttons can be programmed to perform automatic sequence of defined actions.
 - (5) Capable of deactivating select keypads to prevent accidental changes to light levels.
 - (6) Buttons can be programmed for raise/lower of defined loads.
 - (7) Buttons can be programmed to toggle defined set of loads on/off.
 - 7) Status LEDs:

- a) Upon button press, LEDs to immediately illuminate.
- b) LEDs to reflect the true system status. LEDs to remain illuminated if the button press was properly processed or LEDs to turn off if the button press was not processed.
- c) Support logic that defines when LED is illuminated:
 - (1) Scene logic (logic is true when all zones are at defined levels).
 - (2) Room logic (logic is true when at least one zone is on).
 - (3) Pathway logic (logic is true when at least one zone is on).
 - (4) Last scene (logic is true when spaces are in defined scenes).
- b. Wired Keypads; Lutron see Touch QS Wallstations:
 - 1) Style: Architectural Non-Insert Style.
 - 2) Mounting: Wall box or low-voltage mounting bracket; provide wall plates with concealed mounting hardware.
 - 3) Button/Engraving Backlighting:
 - a) Utilize backlighting for buttons and associated engraving to provide readability under all light conditions.
 - b) Backlight intensity adjustable via programming software.
 - 4) Design keypads to allow field-customization of button color, configuration, and engraving using field-changeable replacement kits.
 - 5) Contact Closure Interface: Provide two contact closure inputs on back of unit which provide independent functions from front buttons; accepts both momentary and maintained contact closures.
 - 6) Terminal block inputs to be over-voltage and miswire-protected against reversals and shorts.
 - 7) Provide integral infrared receiver for personal control where indicated.
- 3. Wired Key switch:
 - a. Product: Lutron QS Key switch as basis of bid or equal.
 - b. Allows control of any devices part of the lighting control system.
 - c. Communications: Utilize RS485 wiring for low-voltage communications link.
 - d. Functionality:
 - 1) Allows for easy reprogramming without replacing unit.
 - 2) Requires key insertion to activate actions.

- e. Engrave keypads with button, zone, and scene descriptions as indicated on the drawings.
- f. Software Configuration:
 - 1) Customizable control station device button functionality:
 - a) Key positions can be programmed to perform single defined action.
 - b) Key positions can be programmed using conditional logic off of a state variable such as time of day or partition status.
- 4. Single-Scene or Zoned Wired Control:
 - a. Product: Lutron Pico Wired Control.
 - b. Turn an individual fixture or group of fixtures on and off.
 - c. Raise and lower light levels.
 - d. Recall favorite light levels.

2.10 LOW-VOLTAGE CONTROL INTERFACES

- A. Provide low-voltage control interfaces as indicated or as required to control the loads as indicated.
- B. Connects to lighting management hub via RS232, RS485 or Ethernet as appropriate.
- C. UL listed.
- D. Contact Closure Interface:
 - 1. Product: Lutron Model QSE-IO as basis of bid or equal.
 - 2. The contact closure input device to accept both momentary and maintained contact closures.
 - 3. The contact closure output device can be configured for maintained or pulsed outputs.
 - 4. Contact closure can be programmed using conditional logic off of a state variable such as time of day or partition status.
- E. RS232 and Ethernet Interface:
 - 1. Product: Lutron Model QSE-CI-NWK-E as basis of bid or equal.
 - 2. Provide ability to communicate via Ethernet or RS232 to audiovisual equipment, touchscreens, etc.
 - 3. Provide control of:
 - a. Light scene selections.
 - b. Fine-tuning of light scene levels with raise/lower.
 - c. Shade group presets.

- d. Fine-tuning of shade preset levels with raise/lower.
 - e. Simulate system wall station button presses and releases.
4. Provide status monitoring of:
 - a. Light scene status.
 - b. Shade group status.
 - c. Wall station button presses and releases.
 - d. Wall station LEDs.
 5. Provide ability to send custom output strings.
- F. DMX Interface:
1. Product: Lutron Model QSM-CI-DMX basis of bid or equal.
 2. Provide ability to:
 - a. Map a single zone intensity to a single DMX512 lighting channel.
 - b. Map a single zone intensity to three DMX512 channels for RGB/CMY color control.
 - c. Map a single zone intensity to a single DMX512 integration channel.
 - d. Smoothly transition from one color to another in a cross fade.
 - e. Automatically sequence through a variety of colors.
 - f. Download, program, and customize a color wheel for each unit.
- G. Sensor Modules:
1. Products:
 - a. Sensor module with both wired and wireless inputs; Lutron Model QSM2-4W-C basis of bid or equal.
 2. Wired Modules:
 - a. Provide wired inputs for:
 - 1) Occupancy sensors.
 - 2) Daylight sensors.
 - 3) IR receivers for personal control.
 - 4) Digital ballast wall stations.
 3. Communicate sensor information to wired low-voltage digital link for use by compatible devices.

2.11 WIRED SENSORS

A. Wired Occupancy Sensors:

1. General Requirements:

- a. Connects directly to compatible ballasts and modules without the need of a power pack or other interface.
- b. Turns off or reduces lighting automatically after reasonable time delay when a room or area is vacated by the last person to occupy the space.
- c. Accommodates all conditions of space utilization and all irregular work hours and habits.
- d. Comply with UL 94.
- e. Self-Adaptive Sensors: Continually adjusts sensitivity and timing to ensure optimal lighting control for any use of the space; furnished with field-adjustable controls for time delay and sensitivity to override any adaptive features.
- f. Provide capability to:
 - 1) Add additional timeout system-wide without need to make local adjustment on sensor.
 - 2) Group multiple sensors.
- g. Power Failure Memory: Settings and learned parameters to be saved in non-volatile memory and not lost should power be interrupted and subsequently restored.
- h. Furnished with all necessary mounting hardware and instructions.
- i. Class 2 devices.
- j. Ceiling-Mounted Sensors: Indicate viewing directions on mounting bracket.
- k. Wall-Mounted Sensors: Provide swivel-mount base.
- l. Color: White.

2. Wired Passive Infrared Sensors:

- a. Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
- b. Ceiling-Mounted Sensors: Provide customizable mask to block off unwanted viewing areas.

3. Wired Ultrasonic Sensors:

- a. Utilize an operating frequency of 32 kHz or 40 kHz, crystal-controlled to operate within plus/minus 0.005% tolerance.

4. Wired Dual Technology Sensors:

- a. Passive Infrared: Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.

- b. Ultrasonic: Utilize an operating frequency of 32 kHz or 40 kHz, crystal-controlled to operate within plus/minus 0.005% tolerance.
 - c. Ceiling-Mounted Sensors: Provide customizable mask to block off unwanted viewing areas.
 - d. Isolated Relay: Provide an internal additional isolated relay with Normally Open, Normally Closed, and Common outputs for use with HVAC control, Data Logging and other control options where indicated.
 - e. Integral Photocell: Provide an integral photocell with adjustable sensitivity to prevent lights from turning on when there is sufficient natural light where indicated.
- B. Power Packs for Wired Sensors:
- 1. Provide sensor power packs where required for power connection to sensors.
 - 2. For ease of mounting, installation and future service, power pack(s) to be able to mount through a 1/2 inch knockout in a standard electrical enclosure and be an integrated, self-contained unit consisting internally of an isolated load switching control relay and a transformer to provide low-voltage power. Transformer to provide power to a minimum of three sensors.
 - 3. Plenum-rated.
 - 4. Control Wiring between Sensors and Control Units: Class 2, 18-24 AWG, stranded UL Classified, PVC insulated or TEFLON jacketed cable suitable for use in plenums, where applicable.
- C. Wired Daylight Sensors:
- 1. Digital Interior Daylight Sensor:
 - a. Use Class 2 wiring for low voltage communication.
 - b. Can be replaced without reprogramming.
 - c. Open-loop basis for daylight sensor control scheme.
 - d. Stable output over temperature from 32 °F (0 °C) to 104 °F (40 °C).
 - e. Partially shielded for accurate detection of available daylight to prevent fixture lighting and horizontal light component from skewing sensor detection.
 - f. Provide linear response from 0 to 500 foot-candles.
 - g. Integral IR receiver for personal control.
 - h. Mountable on lighting fixtures or recessed acoustical ceiling tiles.
 - i. Constructed via sonic welding.
 - j. Color: White.
 - 2. Daylight Control Package:
 - a. Controller:

- 1) Automatically switches a dry contact according to changes in ambient light levels.
 - 2) Fully adjustable separate high and low set points, with an adjustable dead band between set points to prevent unwanted cycling.
 - 3) Input time delay to prevent unwanted cycling due to intermittent light level fluctuations.
 - 4) Signal/set point and relay status indication.
 - 5) Sensor calibration input.
- b. Sensors:
- 1) Class 2, three-wire analog devices.
 - 2) Provision for zero or offset based signal.
- D. Infrared Partition Sensors: Provide contact closure based on status of the partition wall (open/close) enabling automatic linking of controls.

2.12 ACCESSORIES

A. Emergency Lighting Interface:

1. Provides total system listing to UL 924 when used with lighting control system.
2. Senses all three phases of building power.
3. Provides an output to power panels or digital ballast interfaces if power on any phase fails and sends all lights controlled by these devices to an emergency light level setting. Lights to return to their previous intensities when normal power is restored.
4. Accepts a contact closure input from a fire alarm control panel.

2.13 SOURCE QUALITY CONTROL

A. See Division 01 Specification Sections of the contract associated with Quality Control.

B. Factory Testing; Lutron Standard Factory Testing or equal:

1. Perform full-function factory testing on all completed assemblies. Statistical sampling is not acceptable.
2. Perform full-function factory testing on 100% of all ballasts and LED drivers.
3. Perform factory audit burn-in of all dimming assemblies and panels at 104 °F (40 °C) at full load for 2 hours.
4. Perform factory burn-in of 100% of all ballasts at 104 °F (40 °C).

2.14 NETWORK REQUIREMENTS

- A. The network architecture that forms the Local Area Network (LAN) for the Quantum® processor and server communications of the Quantum® lighting control system through the Quantum Vue browser

can be adapted to an existing airport VLAN infrastructure. The responsibility, setup, and authority for that network falls directly under SFO-ITT administration. When using an airport's network infrastructure, the Quantum® LAN must have unrestricted communication within the IT parameters. The Quantum® light management system requires an IEEE 802.3 Ethernet link to enable communications between Quantum® processors as well as between Quantum® processors and the Quantum® server. When this Ethernet link is supplied by the IT department, it must be designed and configured to meet SFO-ITT requirements and the Quantum® LAN requirements.

1. All network equipment that is required to enable connectivity between Lutron® equipment must have the following ports open:
 - a. For communication between processors: UDP Port Range 2055 thru 2184 - Used for Lutron® subsystem processor communication (required)
 - b. For communication between processors and server: UDP Port Range 2055 thru 2184 or TCP Port 51023 (an option for Quantum Vue™ only)
 - c. For communication between processors and other equipment: UDP Port 2647 - Used for Lutron® Processor Configuration and detection software (only required while performing initial commissioning/maintenance)
 - d. UDP Port 47808 (BAC0) - Used for BACnet IP communication from a third party Building Management System (only required if the Quantum® system is integrating with a BMS through BACnet)
 - e. TCP Port 5327 - Used for Q Control+ App communication (only required if using the Quantum® Control+ App for the iPad and not connecting app to server) QuantumR and Quantum Vue™ Ethernet Network Configuration
 - f. For communication from administrative client to the server (only required if administrative client is in a separate PC) • TCP Port 8888 - Used for the Quantum® Runtime Service (required) • TCP Port 9999 - Used for the Quantum® Reporting Service (required) • TCP Port 4444 - Used for the Lutron® Service Manager (required)
 - g. TCP Port Range 49152 thru 65535 - Ephemeral ports used for communication between server and client
 - h. TCP Port 1433 and UDP Port 1434 - Used for Microsoft® SQL Database Connection (required)
 - i. For communication from browser hosting Quantum Vue™ to the server: TCP Port 80 or 443
 - j. For communication from Q Control + IPAD app to the server: • TCP Port 5327 - Used for Q Control+ App communication (only required if using the Q Control+ App for the iPad) All network equipment required to enable connectivity to the Lutron® system must have all ports and protocols mentioned enabled/opened by default after a power-up to prevent system downtime after a power-cycle.

2. IP Multicast Configuration Lutron® uses IP any-source multicast for system communication between Quantum® processors. Each sub-system of the Quantum® system must have its own unique multicast address. These multicast addresses are assigned to Lutron® for use with the Quantum® system only. Multicast addresses must be determined and configured prior to the Lutron® field service engineer's arrival on site to commission the system. Class D addresses may be assigned by end user or will be supplied by default by field service engineer IGMP (Internet

Group Management Protocol) In order to properly route multicast traffic between Layer 2 and Layer 3 devices, "IGMP snooping" needs to be enabled on all switches in both directions from the Quantum® server to the Quantum® processor and from the Quantum® processor to the Quantum® server. The Quantum® system multicast supports the IGMP standard Versions 1, 2, and 3. PIM (Protocol Independent Multicast) if routing multicast traffic between Layer 3 devices over a LAN or WAN, Protocol Independent Multicast will need to be enabled to properly route the multicast traffic. Both sparse mode and dense mode are supported. Quantum® Processor Configuration Software During system commissioning the multicast address of 224.0.37.42 must be configured. This multicast address will be used by the Quantum® processor Configuration Software to set up Lutron® processors in the system. All Lutron® devices will respond to the multicast address of 224.0.37.42, and Lutron® processors will join the multicast group 224.0.37.42 using IGMP. Note: The multicast address of 224.0.37.42 is only used during the initial start-up and commissioning of the system. It is also used for diagnostics if a Lutron® field service engineer is on site. It is not a constant requirement to have this multicast address active.

3. Quantum® Server and Windows® SQL Server® Requirements: The Quantum® server hosts a Quantum® specific instance of Microsoft® SQL Server®. The Quantum® instance of Microsoft® SQL Server® has two functions; historical data collection for reporting and acts as the host for server/client software. The Quantum® instance of the Microsoft® SQL Server® does not affect the normal functionality of the Quantum® lighting system. If communications to the Quantum® processors from the server were suspended, the lighting system and its components would function as normal. However, any historical energy data and management software access would be lost during the downtime.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that ratings and configurations of system components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive system components.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Perform work in a neat and workmanlike manner in accordance with NECA 1 and, where applicable, NECA 130, except for mounting heights specified in those standards.
- B. Install products in accordance with manufacturer's instructions.
- C. Provide dedicated network between lighting management system computer and lighting management hubs.
- D. Define each dimmer/relay load type, assign each load to a zone, and set control functions.
- E. Sensor Locations:
 1. Where Lighting Control Manufacturer Sensor Layout and Tuning service is specified in Part 2

under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS," locate sensors in accordance with layout provided by Lighting Control manufacturer. Lighting Control manufacturer may direct contractor regarding sensor relocation should conditions require a deviation from locations indicated. Where Lighting Control Manufacturer Sensor Layout and Tuning service is not specified, locate sensors in accordance with Drawings.

2. Sensor locations indicated are diagrammatic. Within the design intent, reasonably minor adjustments to locations may be made in order to optimize coverage and avoid conflicts or problems affecting coverage, in accordance with manufacturer's recommendations.
- F. Mount exterior daylight sensors to point due north with constant view of daylight.
 - G. Ensure that daylight sensor placement minimizes sensor view of electric light sources. Locate ceiling-mounted and luminaire-mounted daylight sensors to avoid direct view of luminaires.
 - H. Lamp Burn-In: Operate lamps at full output for prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.
 - I. LED Light Engine/Array Lead Length: Do not exceed 100 feet (31 m).
 - J. System and Network Integration Consultation; Lutron LSC-INT-VISIT: Include as part of the base bid additional costs for Lighting Control manufacturer to conduct meeting with facility representative and other related equipment manufacturers to discuss equipment and integration procedures.
 1. Coordinate scheduling of visit with Lighting Control manufacturer. Manufacturer recommends that this visit be scheduled early in construction phase, after system purchase but prior to system installation.
 - K. Identify system components in accordance with Section 26.

3.3 FIELD QUALITY CONTROL

- A. See Division 01 Specification Sections of the contract for additional Quality Control requirements.
- B. Manufacturer's Start-up Services; Lutron Standard Start-up Services or equal:
 1. Manufacturer's authorized Service Representative to conduct minimum of 2 site visits to ensure proper system installation and operation.
 2. Conduct Pre-Installation visit to review requirements with installer as specified in Part 1 under "Administrative Requirements."
 3. Conduct second site visit upon completion of lighting control system to perform system start-up and verify proper operation:
 - a. Where Lighting Control Manufacturer Sensor Layout and Tuning service is specified in Part 2 under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS," authorized Service Representative to verify sensor locations, in accordance with layout provided by Lighting Control manufacturer; Lighting Control manufacturer may direct contractor regarding sensor relocation should conditions require a deviation from locations indicated.
 - b. Verify connection of power wiring and load circuits.

- c. Verify connection and location of controls.
 - d. Energize lighting management hubs and download system data program.
 - e. Address devices.
 - f. Verify proper connection of panel links (low voltage/data) and address panel.
 - g. Download system panel data to dimming/switching panels.
 - h. Check dimming panel load types and currents and supervise removal of by-pass jumpers.
 - i. Verify system operation control by control.
 - j. Verify proper operation of manufacturer's interfacing equipment.
 - k. Verify proper operation of manufacturer's supplied PC and installed programs.
 - l. Configure initial groupings of ballast for wall controls, daylight sensors and occupancy sensors.
 - m. Provide initial rough calibration of sensors; fine-tuning of sensors is responsibility of contractor unless provided by Lighting Control manufacturer as part of Sensor Layout and Tuning service where specified in Part 2 under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS."
 - n. Train Owner's representative on system capabilities, operation, and maintenance, as specified in Part 3 under "Closeout Activities."
 - o. Obtain sign-off on system functions.
4. Correct defective work, adjust for proper operation, and re-test until entire system complies with contract documents.

3.4 ADJUSTING

- A. On-Site Scene and Level Tuning; Lutron LSC-AF-VISIT or equal: Include as part of the base bid additional costs for Lighting Control manufacturer to visit site to conduct meeting with Engineer to make required lighting adjustments to the system for conformance with original design intent.
- B. Sensor Fine-Tuning: Where Lighting Control manufacturer Sensor Layout and Tuning service is specified in Part 2 under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS," Lighting Control manufacturer to provide up to two additional post-start-up on-site service visits for fine-tuning of sensor calibration. Where Lighting Control Manufacturer Sensor Layout and tuning service is not specified, contractor to provide fine-tuning of sensor calibration.

3.5 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.6 COMMISSIONING ACTIVATION AND SIMULATION

- A. See Division 01 Specification Sections of the Contract associated with commissioning requirements.

- B. The subcontractor will participate in project Commissioning (Sustainability Commissioning and Airport Commissioning), Activation and Simulation.
- C. Subcontractor providing either system components/equipment and/or an overall system shall:
 - 1. Include Systems Test Scripts that outline testing procedures as a part of their overall Trade Quality Control Plan "TQCP," which validates that systems are functioning, integrated with overall building elements and operations, and comply with SFO Standards, Criteria & Guide Specifications, Manufacturer Best Practices or a combination thereof.
 - 2. Include with the delivery of the component/equipment to the project site records of completed testing pursuant to requirements in the project specification governing the subject component/equipment and/or system.
 - 3. Coordinate with the Design-Builder, other subcontractors, PMSS and Airport representatives in the Activation and Commissioning activities of each phase of construction. Subcontractor shall be required to participate in, coordinate and schedule these activities. Subcontractor shall correct any issues identified with their components, equipment, or portions of a system that are impacting the performance of the overall system.
 - 4. Where required, participate in Simulation activities of related systems to simulate the actual facility operations and assess the effectiveness of the facility's components, operational processes and procedures prior to the facility opening.
 - 5. Provide reporting of testing and issue resolution in an acceptable frequency to manage the projects progress toward facility operational readiness to the Airport Commissioning Authority (ACxA), for each phase of occupancy in the overall project schedule.

3.7 CLOSEOUT ACTIVITIES

- A. See Division 01 Specification Sections of the contract associated with closeout activities and submittals.
- B. Demonstration:
 - 1. On-Site Performance-Verification Walkthrough; Lutron LSC-WALK: Include as part of the base bid additional costs for lighting control manufacturer to provide on-site demonstration of system functionality to commissioning agent.
- C. Training:
 - 1. Include services of manufacturer's authorized Service Representative to perform on-site training of Owner's personnel on operation, adjustment, and maintenance of lighting control system as part of standard system start-up services.
 - a. Include training on software to be provided:
 - 1) Configuration software used to make system programming and configuration changes.
 - 2) Control and monitor.
 - 3) Energy savings display software.

- 4) Personal web-based control software.

3.8 PROTECTION

- A. Protect installed products from subsequent construction operations.

3.9 MAINTENANCE

- A. See Division 01 Specification Sections of the Contract associated with maintenance service.
- B. System Optimization Visit; Lutron LSC-SYSOPT or equal: Include as part of the base bid additional costs for Lighting Control System manufacturer to visit site six months after system start-up to evaluate system usage and discuss opportunities to make efficiency improvements that will fit with the current use of the facility.

END OF SECTION 26 09 43



San Francisco
International
Airport

Standards Adoption

The "Electrical – Lighting Control Systems" Version 2.1, March 2018 standards were adopted by the Standards Committee on April 5th, 2018, and are effective immediately.

Confirmed:

A handwritten signature in black ink, appearing to read "G. Neumayr", is written over a horizontal line. The signature is fluid and cursive, extending to the right beyond the end of the line.

Geoffrey W. Neumayr, Standards Committee Chair