THE UNIVERSITY OF SYDNEY

Lighting Standard

Design, Engineering, Planning & Sustainability

University Infrastructure

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Author(s)	David Clarke

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Contents

1 Purpose

The Lighting Standard sets out the University of Sydney's minimum requirements for the design, construction and maintenance of interior and exterior lighting systems. It ensures new and refurbished lighting systems are energy efficient, fit-for-purpose, made from durable good-quality materials, contain no or minimal environmentally harmful substances, and are cost efficient to operate and maintain.

Applicable requirements documented in Workplace Health and Safety legislation, Disability Discrimination legislation, State Environmental Planning legislation, Commonwealth and State legislation, National Construction Codes (NCC), and Australian and New Zealand Standards (AS/NZS) are the minimum and mandatory compliance requirements.

Where any ambiguity exists between this standard and the aforementioned mandatory requirements then:

a. The highest performance requirements must apply
b. Applicable requirements must follow this order of precedence:
    i. Workplace Health and Safety legislation.
    ii. Safety in Design legislation.
    iii. Disability Discrimination legislation.
    iv. State Environmental Planning and Assessment legislation.
    v. All other Commonwealth and State legislation.
    vi. NCC.
    vii. AS/NZS.
    viii. This standard and other University standards.

2 Scope

This standard describes minimum requirements for design, purchase, construction, and operation and maintenance of internal and external lighting systems for buildings and spaces owned, operated, maintained and/or managed by the University of Sydney. It applies to:
a. New building construction.
b. Refurbishment spaces within existing buildings.
c. Facilities maintenance services.

The standards apply to all planners, project managers, consultants, contractors, sub-contractors, tenants, managing agents and University staff involved in the design, construction and maintenance of existing, new and proposed University buildings and facilities.

The Lighting Standard provides:
a. A reference document to enable consistency with the design and engineering objectives.
b. Details of the minimum performance requirements for planning, architectural design and maintenance.
c. Support of the University vision for the built environment and best practice.

The Standard addresses key objectives
a. Quality design which responds, enhances and complements the environment.
b. Appreciation of the heritage context and cultural history of the campuses.
c. Value for money in all aspects of the project.
d. The design of low maintenance buildings and environments.
e. Longevity of construction approach to design.
f. Standardization of key flashing and ancillary details.
g. Flexible design, to future proof building usage for expansion or adaption to new uses.

h. Safety in design.

All lighting system products and services provided or specified by designers, consultants, staff and contractors must conform to this standard.

Where specific applications are not explicitly covered, or ambiguity exists, the intent of the design standard must be satisfied. In such cases a return design brief must be provided for review and approval by the issuer of this standard or their appointed delegate who must have relevant technical competence in the subject matter. Additional more stringent requirements may apply on a project-specific basis dependent upon risk management and insurance requirements.

Any discrepancies between the extent of the lighting standard and the project scope must be clarified prior to tender award. Otherwise, it is assumed knowledge that this standard applies to the project.

3 Glossary of Terms

Circuit Breaker (C/B)	Miniature low voltage protection automatic switchgear to protect downstream cable and circuits, by automatically opening when current draw exceeds rating. Circuit breakers to be RCD protected.
COS	Central Operation Services
Colour Rendering Index (CRI)	Measure of the ability of a light source to render colours of a space accurately with respect to a referenced light source (eg. Sun, incandescent lamp). A higher index (R_a) is preferable. CRI > 80 is acceptable and typical of modern light sources.
Correlated Colour Temperature	Correlated colour temperature describes the warmth or coolness appearance of the white light, referenced to a black body radiator heated to emit light. 3000°K produces a warm white, while 5000°K has a cooler white.
CBUS	Clipsal CBUS Lighting Control Automation System
DB	Distribution Board
Dirt Depreciation (DD)	The correction factor that must be applied to calculations to account for the accumulation of dirt over a fixed period of time.
DSI	Digital Signal Interface is a proprietary data protocol standard to control and dim the electronic control gear of luminaires.
DALI	Digital Addressable Lighting Interface is an open data protocol standard to control and dim the electronic control gear of luminaires, up to 64 addresses per gateway. DALI utilises a 5-cable system: 3 for power and 2 for control, where the controls for dimming are integrated into its control gear and power supply. This allows for each fitting to be individually controlled, dimmed and switched without physical rewiring.
Dynalite	Phillips Lighting Control Automation System
KNX	Open Protocol for building, lighting, automation and control. KNX Protocol has been adopted by Standards Australia as SA/SNZ ISO/IEC TS 14543.3.1-6:2018 Technical Specification
Lamp Depreciation (LD)	The correction factor that must be applied to calculations to account for the depreciation of lamp lumen output over a fixed period of time.
LED	Light Emitting Diode. Modern electronic solid-state light source.
LOR	Light Output Ratio expressed as a percentage. The ratio of luminous flux (lumens) of the luminaire to the lumens of the lamp or light source used. Measures the efficacy of a luminaire.
Lumen	Measure of raw light flux from a lamp.

Luminaire	Light fitting complete including all hardware, reflector, diffusers, control gear, power supplies, lamps and wiring.
Luminous Efficacy	Measure of lumens per watt for a lamp.
Lux	Measure of the incident light flux on a given surface. (lumens / area).
MSB	Main Switch Board
NCC	National Construction Code
RCD	Residual Current Device (Earth leakage protection)
UI	University Infrastructure

4 Roles and Responsibilities

This standard is issued by UI. It is approved and signed off by the Chief University Infrastructure Officer. UI is responsible for maintaining the standard and keeping it up to date.

5 Construction Requirements

Due to the complex nature of the University's Infrastructure, the requirements for construction of new buildings, and the refurbishment of existing buildings differ and must be assessed on a case by case basis.

Careful consideration must be taken in relation to connection and disconnection of existing services, and the reuse of existing equipment. This section outlines the construction requirements for both new and existing buildings.

5.1 New Buildings

The lighting provided in University buildings must be designed and installed in accordance with the minimum legislative requirements incorporating all Australian Standards, National Construction Code (NCC) and Work Health & Safety (WHS).

Each building must be equipped with an appropriate lighting control system and emergency lighting system, interfacing with the requirements set out in the NCC.

The University Standards are over and above the NCC Section J from a control performance, where greater control of lights is necessary to achieve a fit for purpose space.

The consultant/contractor will consult with UI and Project User Groups (PUG), to discuss any additional lighting requirements that must be included in the design, in order to suit the user requirements and mitigate risks.

5.2 Refurbishments

Existing lighting systems must be extended as necessary into the given space/project. The design for projects within existing buildings must be assessed on a case by case basis and developed in conjunction with this standard. The project scope will drive the design requirements and the extent of upgrade of the existing services.

Any items excluded in the scope must not be priced into the overall project with the intent to reduce the need to value engineer any services/scope.

It is the responsibility of the consultant/ contractor to obtain the gate paper from the Project Manager to understand the scope of works in relation to the space and fit out requirements. New projects within existing buildings must assess what the expectation of the refurbishment will be. This will enable the right outcome for the given project to meet budget.

Where identified, redundant lighting services, equipment and wiring, including inaccessible ceiling services, must be removed as part of the project works. Make good exposed surfaces before commencing the installation of new services. This includes the removal of redundant underground services unless otherwise approved by the project superintendent.

6 Technical Requirements

6.1 Introduction

The Lighting system of a University building will include surrounding structures, external areas and annex buildings. In some cases, components of the Lighting system will be installed or are to be installed in other buildings. In these cases, the word building in this document must be interpreted as inclusive of these structures, annexes and components.

6.2 Design and Construction

6.2.1 General

This section outlines the extent of the services to be provided by the contractor under a Design and Construction project.

The contractor shall be fully responsible for the complete design of the lighting services installations, including the selection, sizes and quantity of equipment, and shall provide calculations and drawings and other documentation as necessary to demonstrate conformance with the design parameters, industry practice, UI requirements, codes, regulations and standards. This includes all calculations required to confirm that existing infrastructure is sufficient to supply the proposed systems and equipment installed under the project.

The contractor shall allow to fully co-ordinate interfaces to other services such as Architect, AV and mechanical contractors where necessary.

6.2.2 Calculations

As part of the contractor's design, lighting calculations are necessary to provide design compliance to the NCC, Australian Standards and University Standards. This includes but is not limited to:

a. Lux Levels at appropriate plane height, including AV spaces.
b. NCC/BCA Section J calculations.

Further details on calculations are provided throughout the standard.

6.2.3 Equipment Selection and Sizing

In selecting equipment, the University expects consultants and contractors to select products of proven and reliable quality, with reputable support. A **UI Deemed to Comply Luminaire Schedule Form (UI-ENG-F006)** has been provided to guide you with equipment selections for various electrical systems.

Products which are of closed systems and proprietary in nature, thus locking the University into exclusive dependence of one manufacturer must be avoided and only used if there are no other options. Any items of this nature must be approved by UI prior to procurement.
The provision of 20% spare capacity for future use must be provided when designing and sizing all lighting control systems and equipment. In making such considerations careful analysis of spare capacity against the application of diversity and balance must be considered.

This includes lighting control systems, capacities of all backbones, lines. This allows for future extension and upgrades without having to re-run new control cabling.

6.2.4 Drawings and Documentation

The contractor shall provide design, construction and as-built drawings, including design drawings produced by the contractor and shop drawings produced by equipment manufacturers.

The contractor is responsible for producing all design and as-built documentation, including, but not limited to:

a. Concept Design documentation (as required).
b. Detailed Design documentation, including:
c. Layout drawings.
d. Calculations.
e. Schematics, DALI Addressable drawings.
f. Design certification as required by building certifiers.
g. Spare capacity on each DALI Line
h. Equipment details.
i. Testing / commissioning procedures.
j. Performance Solutions.
k. Specifications.
l. Workshop drawings, including:
m. Drawings to meet manufacture requirements / system installation.

All design documentation must be reviewed by UI.

6.3 General Lighting Requirements

6.3.1 Luminaire Products and Equipment

The University is committed to maintaining a sustainable environment across all our campuses, where we can deliver world-class teaching, learning and research while minimising our ecological footprint.

The Lighting Designers involved in University projects must give precedence to fit-for-purpose, lamp quality, lighting energy efficiency, control of spaces, cost effectiveness, good quality construction, safe serviceability and maintenance over aesthetic considerations.

All spaces within a project are to incorporate motion sensors to turn spaces off when not used. Motion sensors must cover 100% of the floor space to accommodate sitting and typing actions. Sensitivity of motion sensors is paramount and high quality sensors are a must.

All lighting system products and equipment must:

a. Comply with AS/NZS and have relevant current electrical safety and compliance certifications to quality management systems, standards and codes.

b. Be readily available on-demand and in large volumes in the local market from a wide range of reputable long-standing local suppliers.
c. Be readily serviceable by a wide range of electrical contractors.
d. Be supported by large quantities of locally available critical spare parts that can be delivered to the University on demand.
e. Demonstrate proven local track record of performance and longevity in comparable applications.
f. Be made from durable good-quality materials.
g. Contain no, or minimal, environmentally harmful substances e.g. hazardous materials and chemicals.
h. Be cost efficient to operate and maintain.

All luminaires are to meet with the following parameters:

a. Each luminaire is corrected to a minimum power factor of 0.90 lagging.
b. Installations must conform to IEC 61547 for minimum radio interference.
c. Appropriate levels of visual comfort and use of low glare diffusers and systems in areas such as terraced lecture theatres, etc.
d. Resistance to dirt built up and use of luminaires with appropriate IP ratings.
e. Use of 'plug and play' luminaires method wherever possible.
f. Easily replaceable external luminaires with standard type poles and mounting equipment.

6.3.2 Luminaire Construction

Luminaires are to be well-constructed, good quality, durable and possess the following features:

a. Rigidity: The materials, body shape, and method of manufacture provide adequate rigidity to prevent warping or sagging when installed.
b. Body Shape: Rectangular and square luminaires must have straight parallel edges and square corners.
c. Surface Mounting: For fixing of surface-mounted luminaires to ceilings or walls provide fixing holes as follows:
d. Square and Rectangular Luminaires: minimum four symmetrical holes.
e. Circular Luminaires: minimum three holes.
f. Suspension Mounting: Provide suspensions and luminaire suspension connectors capable of supporting, without damage, five times the mass of the luminaire, or 25kg, whichever is the greater.
g. Reflector & Lens Retention: Provide vibration resistance and retention of the reflector or lens.
h. Manufacturer's Marking: Provide a durable non-fading permanently affixed label on all luminaires indicating the manufacturer's name, catalogue number and compliance with AS/NZS.
i. Materials: Use zinc-coated steel, grade 304 stainless steel, extruded aluminium or other equivalent performance materials unless otherwise approved by the issuer of this standard. These material thicknesses apply:
j. Minimum zinc-coated steel thickness of 0.6mm provided adequate thickness is achieved by body shape and folding Techniques, otherwise 1mm.
k. Minimum grade 304 stainless steel thickness 1mm.
l. Minimum extruded aluminium thickness 1mm.

6.3.3 Downlight Construction

Downlights are to be well-constructed, good quality, durable and have the following features:

a. Fixings: Provide a minimum of three clamping points from the rim to the ceiling fabric.

b. Support Flange: Provide a minimum of 5mm support flange around ceiling hole cut outs for small downlights, and 10mm for larger downlights. Trim less downlights are unacceptable.
c. Removability: The downlight must be removable from underneath the ceiling without damaging the luminaire or the ceiling.
d. Driver Housing: Provide central or remote Driver housings. Downlights with offset drivers and uneven balance may cause distortion of ceiling materials and are unacceptable.

6.3.4 Additional Equipment

Spotlights utilised in auditoriums and lecture theatres greater than 4m in height require mechanical lifters to enable the lights to be lowered. This allows for ease of adjustment of the spotlights. Lifters are to be provided from a reputable manufacturer – e.g. ReelTech – and be selected for the appropriate weights of the spotlight luminaires and luminaire supports.

6.3.5 The Deemed-to-Comply Lighting Approval Process

The following is UI Deemed-to-Comply lighting approval process. The designer must submit technical details and information about the proposed luminaire to the UI Electrical Services Engineer for approval, including but not limited to the following:

a. Manufacturer's data sheet/catalogue.
b. Luminaire compliance certificates.
c. LED Test reports.
d. Luminaire photometric (IES electronic files).
e. Warranty.
f. Luminaire construction.
g. Physical dimensions.
h. Mounting details.
i. Control gear.
j. DALI control capability.
k. Type of lamp and wattage.
l. Correlated colour temperature and tolerance.
m. Colour rendering index and tolerance.
n. Luminaire light output ratio.
o. Efficacy.
p. LED lamp future replacement arrangement.
q. EMC compliance.
r. Unit price.
s. Country of origin.
t. Delivery lead time and images of the luminaire.
u. Provide physical working sample.

The UI Electrical Services Engineer is to use the submitted information to assess whether the proposed luminaire meets the minimum lighting performance, construction quality and pricing requirements for the project. UI will require the suppliers to provide a sample of the proposed luminaire for review. After written approval had been granted, lamp design and selection process must take into consideration the following:

a. Long lamp life, low replacement and maintenance cost.
b. Use the University's preferred lamp types and limit the number of different lamp types used in a project.
c. Consider risk of colour shift, instability and premature failure.
d. Thoroughly scrutinise new and emerging technology and to check for risks of instability and
e. Adopt LED luminaires that have a demonstrated and proven stability, durability and illumination performance in comparable applications.

Alternative lamp products must be accepted based on evaluation of demonstrated and proven performance to the requirements of this standard and not based on cost or project program delays.

6.3.6 Luminaire and Lamp Requirements

The light fittings selected by and deemed-to-comply with the requirements of the University are based upon their Life Cycle Costing, energy efficiency as well as ease of installation and low maintenance.

The deemed-to-comply lighting should provide standardised appearance and harmonise with existing lighting installation. The University is aiming to minimise the number of spare parts from various manufacturers for routine maintenance. For the sake of standardisation of the equipment and spare parts, University has special preferences in relation to the type of energy efficient lamps, wattage and its application.

The deemed-to-comply light fittings must be utilised for new and refurbishment projects that are managed by the University Infrastructure (UI). Approved LED luminaires must be used for all University projects. Existing luminaires utilising fluorescent, incandescent, dichroic and tungsten halogen lamps are to be replaced by LED luminaires in all University projects. Each luminaire must use constant current LED drivers to achieve power factor greater than 0.90 lagging. The LED drivers used are to be as recommended by the luminaire manufacturers and must not be susceptible to heat.

A wide range of most frequently used luminaires can be found on the **UI Deemed to Comply Luminaire Schedule Form (UI-ENG-F006)** which can be downloaded from the Form section on the web site. Should the architect(s) and/or lighting designer(s) wish to utilise alternative luminaires to achieve desired illumination effect, written approval must be obtained from University UI Electrical Services Engineer prior to issuing for tendering. Refer to clause 5.2.2 for UI lighting approval process.

Lighting designers and specifiers must give precedence to:

a. Fit-for-purpose.
b. Durability and good quality construction.
c. Lamp quality and energy efficiency.
d. Local manufacturers and availability.
e. Cost effective and safe serviceability and maintenance over aesthetic considerations that incur high capital, operational and maintenance costs.

6.3.7 Correlated Colour Temperature (CCT)

All lamp correlated colour temperatures (CCT) must be reviewed and approved by the UI Planning team's architects and interior designers. The following colour temperatures apply:

a. 4000K for internal workplaces with predominantly white walls e.g. offices, computer labs and laboratories.
b. 2700K to 3000K for:
    i. Heritage building interiors.
    ii. Exterior lighting of sandstone facades and walls.
    iii. Passive recreational, dining, breakout spaces and theatres.
    iv. Residential.
    v. Where required due to interior finishes.

6.3.8 LED Control Gear

The LED control gear used in the University projects must satisfy the University's Electrical Services Engineer requirements and lamp manufacturers' recommendations.

Maximum energy loss for LED control gear should not exceed 10%.

LEDs are the dominant luminaire type across the University and their performance and efficiency is affected by the quality of the control gear used.

Constant Current Electronic Control Gears for LED Lamps must meet these requirements:

a. Type: High frequency, constant lamp current, universal multi lamp. Designers and specifiers must select from manufacturers' premium long-life range.
b. Dimming: Use DALI electronic dimming ballasts only where required.
c. LED CURRENT: Maximum constant driver current must be between 500 - 750mA unless approved.
d. Manufacturer & Warranty: Use only drivers from the lamp manufacturer with an integrated package written warranty of a minimum 5 years.
e. Losses: Include driver losses in all energy calculations.

6.3.9 Photometric, Thermal and Energy Data

Designers and specifiers of luminaires must provide photometric; thermal and energy consumption data as follows:

a. Provide and obtain approval for full photometric, thermal and energy consumption data before delivering a standard luminaire or commencing to manufacture a non-standard luminaire. Photometric data must be in IES standard electronic format and the tests must be performed by an accredited NATA or equivalent accredited reputable laboratory.
b. Provide thermal performance test data confirming compliance with AS/NZS and lamp manufacturers' recommendations.
c. To comply with the current AS/NZS for glare for relevant to the application/task.

6.4 Interior Lighting

6.4.1 Luminaire Design and Selection

Where luminaires other than those outlined in the **UI Deemed to Comply Luminaire Schedule Form (UI-ENG-F006)** are to be utilised, production quality luminaire samples are to be provided for review and approval by UI.

Incandescent, IRC, tungsten halogen and inefficient HID lamps, e.g. mercury vapour lamps must not be specified for any University building projects. The luminaire design and selection process must satisfy these requirements:

a. Lenses/diffusers are to be flushed, tight-fitting and well-secured.
b. Fittings that have to be dismantled to replace lamps must not be used where appropriate. Locate ceiling mounted fixtures so lenses can be removed, and their components can be replaced without removing adjacent mechanical or electrical equipment.
c. Stair lighting is to be located to the underside of soffit at landings; Stair treads can also be lit using handrail mounted recessed pucks with remote gear in an accessible location.
d. Aisles shall be lit using asymmetric downward pointing low wattage LEDs. The distribution shall be such that the entire width of the aisle is covered by using luminaires on either one of both sides of the aisle.
e. LED strip lights on stair nosing can also be used to highlight the aisles.
f. All aisle lighting shall be battery backed up to comply with NCC Section H1.7, Section NSW H101.20.2, Section NSW 101.20.4 and Section 101.20.5 requirements.
g. Maintenance of ceiling luminaires to be easy, safe and quick to perform using ladders for luminaires mounted up to 3m in height. Any large components of luminaires that need to be removed for maintenance whilst the individual is on a ladder, must be retained with a lanyard or hinge.

h. Luminaires to be mounted no higher than 3 m to minimise maintenance and specialist equipment like hire costs. Luminaries installed higher than 3 m must be easily accessible by lifting equipment or have a mechanism to lower the luminaire down to a height of 3m.
i. Approval is to be obtained from the issuer of this standard before locating fixtures where a lift or scaffolding is required for maintenance.
j. Reflectors must be high grade bright vacuum aluminised coated metal or plastic, accurately formed and fixed in place to prevent movement relative to the lamp.
k. Reflectors or lenses must be easily removable without a risk of damage to the luminaire or the reflector itself. Reflector clips or catches must operate smoothly and without undue force.
l. Metalized plastic reflectors are acceptable only if fixed in a way that prevents stress on the plastic materials. Fixing the reflectors using a single fixing screw through unreinforced plastic is not acceptable.
m. Lamp holders must precisely and securely hold the lamps in place both for safety reasons and to ensure photometric performance is maintained over the luminaire life with re-lamping and cleaning.
n. Luminaires in outdoor or corrosive environments must have appropriate coating finishes applied to ensure high durability in such exposed environments. Special metal primers and powder coating or equivalent coatings must be applied.
o. Robust and easy-to-use luminaire fixings to the mounting surfaces must be used. Fixings are to facilitate the removal of the luminaire without damaging the underlying mounting surface.
p. Luminaires requiring direction for theatres, must have barn doors.

6.5 Exterior Lighting

6.5.1 General Requirements

Pole or building exterior wall mounted luminaires with a downwards / horizontal direction are to be used where feasible to minimise upward spill light and light pollution. Should upward facing luminaires be utilised to illuminate facades, landscape and exterior features, approval from the UI department is to be obtained. Where exterior lighting is utilised, and where relevant, compliance with AS 4282 – 'Control of the obtrusive effects of exterior lighting' is to be adhered to.

Pole mounted lights should have the ability for power and data within the pole segregated to AS3000. This provides the ability for wi-fi or security cameras to be installed on the poles.

Review of the area is required to understand the existing pole light configuration and type (if it is a heritage luminaire required to be replaced or upgraded, discussion with the University Electrical Engineer is necessary).

In-ground up lights be generally avoided due to higher risks of damage, light pollution, moisture ingress and premature failure. They may be permitted for use selectively to graze architecturally significant surfaces provided the beam is aimed carefully and upon approval by the University Electrical Engineer.

Bollard lights must be avoided in the building entry, footpath and landscape areas due to the frequency of vandalism and accidental damage by vehicles.

Approval of the UI Electrical Services Engineer must be sought for use of exterior lighting which deviates from the **UI Deemed to Comply Luminaire Schedule (UI-ENG-F006)**.

6.5.2 Exterior Light Poles, Fixing and Wiring

Design and specification of exterior luminaires installations must fulfil the following requirements:
a. Structural Calculations: Provide wind loading calculations for all pole Installations.

b. Fixing Materials: Use stainless steel hardware and fixings with tamper-resistant heads.
c. Rag Bolt Fixings: Use hot-dip galvanised rag-bolt assemblies installed in a concrete plinth finished at the finished surface level for hard surfaces, and not less than 50mm above finished ground surface levels.
d. Direct Buried: poles are not acceptable.
e. In-Ground Wiring: Install PVC-insulated wiring in underground conduits utilising the “loop in loop out” principle to each luminaire. Do not use intermediate junction boxes or T-off boxes.
f. Wiring Sizing: Underground circuits must be wired in minimum 4mm2 cables. Use oversize conductors to the first luminaire to maintain voltage drop to less than 1% at the first luminaire.
g. Light Fittings: Must be individually protected by HRC fuses, with adequate ventilation and degree of protection (IP rating). Reflectors must be manufactured from high quality (purity) aluminium.
h. Aiming: Tilting of luminaires shall not be greater than 5° above horizontal unless using narrow beam optics and shielded baffles.
i. Poles: Multi-functional galvanised poles must be used. They are to be painted with one coat of metal primer, one undercoat, plus two topcoats of enamel paint. Approved anti-corrosive powder coating is acceptable. Colours are to be in accordance with the UI Grounds and Heritage Standards requirements. HRC fuses must be installed at the base of the pole and be accessible from the pole inspection plate. Exit conduits must be installed at the last pole for future installations. Poles must be provided with an engraved stainless-steel label affixed to the front of the inspection plate cover as a means of identification. The information must include the University asset number and lamp type and must be transferred to the University record exterior lighting 'as-built' drawings and registered according to the COS Asset Management Standard by the Contractor.

6.6 Customised Luminaires

Custom-designed, bespoke or modified special luminaries must not be specified or used without written formal approval from the UI Electrical Services Engineer as they often incur additional cost and performance is difficult to ascertain and guarantee.

Customised luminaires must only be considered for historic restoration projects where standard products may not be available.

If approved, designers are to specify, and contractors must supply:
a. Upfront purchase of 10% extra basic carcass / bodies for spares and alterations.
b. Standard commercial paint and powder coat colours that are readily and inexpensively available in the local market.
c. 12-month warranty for the installed luminaire, ballast and lamp.
d. 5-year warranty from the supplier.
e. Evidence of thermal and photometric performance testing by a NATA-accredited laboratory.

6.7 Design Parameters

6.7.1 Standards and Codes

Lighting within the University should provide the appropriate amount of functional illumination for the task, be energy efficient and provide aesthetic appeal to the building.

Designs shall consider the use of Environmental Lighting Systems (as defined by AS/NZS 1680.1 Clause 10.3.5) in addition to just providing a General Lighting System where possible.

Artificial lighting must satisfy the statutory requirement for safety. The selected lighting system must satisfy the current minimum energy efficiency performance requirements of the NCC Section J.

Interior and exterior artificial lighting are to comply with, but not limited to the following:

a. NCC.
b. AS/NZS 1680.
c. AS/NZS 1158.
d. AS/NZS 2293.
e. AS/NZS 4282.
f. AS/NZS 3000.
g. AS/NZS 1428.2.
h. AETM Design Guidelines for Tertiary Teaching Spaces.
i. Sydney University ICT Audio Visual Specification.
j. Sydney University COS Security Specification.
k. Sydney University ICT Communications Specification.
l. Glare Requirements – Green Building Council of Australia are used as our guide to direct designers and contractors to meet best practice daylight glare requirements.

6.7.2 Computerised Light Modelling

The following computerised lighting calculation point densities must be used to ensure accurate and representative values are obtained and displayed:
a. Interior spaces 0.5m grid.
b. Exterior spaces 1m grid (horizontal and vertical).

Note: Use of excessive point spacing may lead to results with inaccuracies due to the low effective sampling rate against the luminaire spacing.

Lighting design calculations must not include inter-reflection for calculations in spaces with high workstation partitions or shelving. They are to be based on minimum maintained average levels i.e. the average lighting level over the effective work area at the end of the cleaning / re-lamping cycle.

Refer to Table 1 for further info.

TABLE 1 Lighting System Calculation Parameters

Design Parameter	Calculation Requirement
Effective Work Area	0.5m from walls for enclosed spaces.
Work Plane Height	0.75m for desk / 0.9m bench and 0m for travel areas, or as otherwise clearly defined by the relevant Australian Standard and space use.
Storage or Library Shelving Work Plane	Work plane is to be a vertical surface taken from the middle of the lowest shelf to the middle of the highest shelf tiers.
Reflection Factors	Plaster, tile or white painted Ceilings 70% Painted Walls 50% Carpeted Floors15% Tiled floors 20% Off form concrete 20%

As part of the maintenance regime, a Light Loss Factor (LLF) is to be applied to all design calculations based on the requirements as outlined in AS/NZS 1680.
Where LED luminaires are utilised, the fitting is to have a rated life of 50,000 at L80B50, allowing the designer to utilise a Maintenance Factor of 0.8. Cleaning of rooms / areas is to be undertaken on a regular basis throughout the university.

Australian standards do not yet address the maintenance of Solid-State Lighting (LED Technology). However, an LLF is still required to be utilised during the design process. An LLF of 0.8 has been determined based on the above to allow for a balance between energy use (the lower the LLF, the more fittings or higher wattages are required in order to achieve the required illuminance levels) and maintenance of luminaires.

The Table 1A below applies to Audio Visual requirements. AV contrast ratio refers to projected lux to ambient lux. AV lighting calculations must be approved by the ICT Audio Visual engineer prior to design sign-off. Refer to Table 1A for Audio Visual system calculations.

TABLE 1A Audio Visual System Calculation Parameters

Design Parameter	Calculation Requirement
Projection Calculation	Vertically, indicating the screens, under all three pre-sets (pre-set '*all off*' not required).
Pre-set/Contrast Ratios	Pre-set 2 - 7:1 Pre-set 3 - 15:1 Pre-set 4 - 50:1 Blind control must be considered where daylight impacts AV projection.

AV Design Parameter:
Presenter Location(s): Vertical illuminance as per space type and function (e.g. VC) – 1.6m for standing positions (lectern/podium positions), 1.2m for seated positions (stage areas), under presets 2 and 3.

AV Calculation Requirement:
Vertical illuminance as per space type and function (e.g. VC) – 1.6m for standing positions (lectern/podium positions), 1.2m for seated positions (stage areas), under presets 2 and 3.

6.7.3 Glare Design Parameters

Lighting internally and externally shall be designed to minimise glare.

Internal areas should be lit by lighting both the vertical surfaces as well as the horizontal to reduce the contrast with the fittings.

Glare arising from daylighting must be mitigated by utilising a performance glass, building overhangs shaded and block out blinds. This will limit and control glare inside the building space making the space comfortable for its occupants.

a. Refer to the UI Building and Architecture Standard for further information on glare treatment.
b. Refer to the Green Building Council of Australia for Glare requirements and targets.

6.7.4 Design Software

Lighting designers and contractors must carry out lighting calculations for typical and unique spaces using University approved computer models. Current compliant software's are provided below. Equivalent models can be accepted after review and approval by the issuer of this standard.

Designers must provide native calculation files and PDF printouts of illuminance grids which will be used to verify the installed lighting performance.

a. AGi32 Software
b. Dialux Software

6.7.5 Illuminance Level Requirements

Table 2 provides luminaires to be used for typical interior spaces as well as the illuminance level requirements to be met.

Table 2 Interior Lighting Design Levels for General Spaces

Areas	**Minimum Maintained Horizontal Average Light Levels on Visual Task Plane**
Amenities	80 lux.
Amenities for persons with disability	200 lux.
Lecture and Seminar rooms *	Dimmable 10 - 240 lux. 200 lux vertical at 1.6m AFFL – achieved by (2) dimmable LED spotlights with barn doors.
Corridors	80 lux. Ensure walls are lit to minimise scalloping.
General Computer Classrooms *	Dimmable 10 - 240 lux. 200 lux vertical at 1.6m AFFL – achieved by (2) dimmable LED spotlights with barn doors.
General Office areas	320 lux.
Meeting or Multipurpose Room	Switchable level 240/450 lux.
Meeting room general	320 lux.
Meeting room with AV facility	Dimmable 10 - 320 lux.
Reception / Lobby	160 lux on floor, 320 lux on enquiry desks. Lighting of vertical surfaces is important to the appearance of the space, as per AS/NZS 1680.2.1.
Stairways	80 lux.
Storerooms – depends on task	80 lux, as per AS/NZS 1680.2.1.
Video Conference This is a requirement wherever video conferencing is utilised *	Horizontal illuminance - 400 lux at 0.75 m. Vertical illuminance – 400 lux at 1.6 m (standing height for presenter). Specialized dimmable LED spotlights are required for Video Conferencing equipment to match the lighting quality for the recipient.

Areas	Minimum Maintained Horizontal Average Light Levels on Visual Task Plane
Biological Hazard Area (PC1, 2, 3)	To respective code.
Chemical/Process/Research Biological/ Laboratory	600 lux.
Computer/ Internet/ Signals Instrument / Laboratory	320 lux.
General Laboratory	450 lux.
Workshop	600 lux.
General Lecture (with lectern / desk task light) *	Dimmable 10 - 240 lux (must not impact on contrast ratios). 200 lux vertical at 1.5m AFFL – achieved by (2) dimmable LED spotlights.
Sports Halls or Gymnasium	As per Australian Standards
Internal Parking Bays, Access Bays Pedestrian Areas, lifts & stairs Vehicle Entrance / Exit Zones	75 Lux 100 Lux 160 lux (night) / 800 lux (day) first 15m / Next 4m 160 lux.
Residential	As per Australian Standards

* Refer to AETM guidelines. AV lighting calculations must be approved by the ICT Audio Visual engineer prior to design sign-off.

Table 3 outlines the external illuminance level requirements.

Table 3: Exterior Design Lighting Levels

Areas	Maintained Average Horizontal Light Levels (lux)	Minimum Point Vertical and Horizontal Light at any point (lux)	Uniformity (max)
Main pedestrian walkways	AS/NZS 1158.3.1	AS/NZS 1158.3.1	AS/NZS 1158.3.1
Secondary pedestrian walkways	AS/NZS 1158.3.1	AS/NZS 1158.3.1	AS/NZS 1158.3.1
Areas with CCTV	AS/NZS 1158	AS/NZS 1158	AS/NZS 1158
Main Roads	AS/NZS 1158	AS/NZS 1158	AS/NZS 1158
Secondary Roads	AS/NZS 1158	AS/NZS 1158	AS/NZS 1158
Park / grass areas	AS/NZS 1158.3.1	AS/NZS 1158.3.1	AS/NZS 1158.3.1

Areas	Maintained Average Horizontal Light Levels (lux)	Minimum Point Vertical and Horizontal Light at any point (lux)	Uniformity (max)
Event Sports Oval	AS/NZS 2560.2.3	AS/NZS 2560.2.3	AS/NZS 2560.2.3
Tennis Courts	AS/NZS 2560.2.3	AS/NZS 2560.2.3	AS/NZS 2560.2.3
External Carpark Areas	AS/NZS 1158.3.1	AS/NZS 1158.3.1	AS/NZS 1158.3.1
Disabled Car park Spaces	N/A	>14	N/A
Disability Discrimination Act Areas	AS/NZS 1428.2	AS/NZS 1428.2	AS/NZS 1428.2

6.8 Lighting Control Requirements

6.8.1 General Requirements

The University of Sydney has implemented a Sustainability Strategy to reduce energy consumption by installing energy efficient lighting and Intelligent Lighting Control Systems (LCS).

The University of Sydney has established minimum performance requirements for the energy efficient lighting systems. A list of **Deemed-to-Comply Lighting Suppliers (UI-ENG-F006)** have been chosen to be used for the University projects.

All lighting control systems must comply with the NCC Section J to minimise energy consumption and maximise lamp life. This includes combining motion sensors with local light switches in spaces.

An important requirement of the lighting control system is to facilitate turning the lights 'OFF' when not in use. Light output and power consumption must be able to be reduced when full light output is not needed. Mandatory requirements include:

a. Lights on each floor of a building must be controlled by a separate automatic control device.
b. Light switches and motion controls must be provided in each room / area.
c. Motion sensors must be zoned in areas of 100m^2 or less.
d. Motion sensors must accommodate 100% room coverage.
e. Daylighting controls must be provided where sufficient daylight illumination can be provided to a space.
f. Automatic timer switch or programmed headend PC with occupancy sensor must be provided to ensure lights are OFF after occupants leave the room and outside of business hours.
g. Separate switching of any display lighting and general lighting must be provided.
h. LCS must control exterior lighting ON and OFF operation even with a PE Cell.

These controls can be implemented either a mains voltage standard standalone, or via a software driven programmable lighting control system, with the former acceptable where the room or area will not change in function or use through its lifetime (e.g. cupboards, switchrooms, plantrooms) and the latter preferred for all other areas and new builds.

6.8.2 Lighting Control Systems (LCS)

A high performance, intelligent and cost effect central automated lighting control system is to be incorporated and into include the following components / performance parameters:

a. Central controller including engineering system software and open protocol interface;
b. Dimmer and switch panels;
c. Dimmer and switch modules;
d. Local controllers;
e. Lighting looms;
f. Local switches;
g. Motion detectors;
h. Photocell detectors;
i. Floor override switches;
j. Ease of use and high end-user acceptance;
k. Low maintenance and open architecture system based on International standard ISO/IEC 14543.3 or Australian equivalent
l. Allow for a reduction energy consumption;
m. System reliability, flexibility and easy to integrate into existing lighting system / building environment.
n. Control of shading and window treatments as required with local and automated control based on BMS requirements
o. Integration with HVAC requirements for parameters such as temperature and air-quality
p. HLI / LLI
q. LCS connecting to ICT Network must be established.

The LCS shall have occupancy sensors, group controllers, timer switches, solid-state dimmers, photo-electric sensors, manual lighting control switches, touch screens and lighting controllers, DALI line controllers, DALI/ Line controller power supplies, AV and BMS interface units, cabling, hardware, software program and various sensors connected to the Central LCS.

Adjustment of the LCS system should be able to be carried out both at the campus-wide, building and zone based lighting controller via the ETS software program or other interface devices. The LCS interface unit should enable future interface with the BACnet Building Management Control System (BMCS) and other interface devices.

To effectively prevent attacks on the digital infrastructure of the university buildings and to achieve the highest level of data protection all LCS products connected to the IP network shall comply with encryption standards (according to ISO 18033-3, such as AES 128 CCM encryption).

The hierarchy of control systems shall be as such:
a. BMCS - high level supervisory and monitoring
b. LCS - field bus level sensors and actuators for local control of building environment (lighting, shading, windows, fans, local HVAC). and for gathering data for the BMCS
c. DALI - lighting control protocol for control of individual luminaires

The LCS network shall be commissioned, using the latest version of ETS, by a company or individual who is a registered KNX/CBUS/Dynalite Partner, having completed successfully the Basic Certification training. The Partner number to be provided on each applicable drawing.

Upon completion of the project the ETS configuration file and any other associated files shall be delivered to the university in a format that is un-protected and on a commonly used media such as USB.

All LCS products are to be certified by the KNX Association cvba of Belgium.

If CBUS/Dynalite producst to be certified by their applicable association.

Control cable to be certified by the KNX Association cvba of Belgium in the form of 2 x 2 x 0.8mm twisted pairs in a LSHF jacket with a KNX Association Certification number.

6.8.3 Acceptable Control Systems

The following four methods are identified as acceptable for lighting control within buildings.

a. KNX
b. CBUS,
c. Dynalite,
d. 240V – only with Refurbished Projects

6.8.4 KNX

The University of Sydney has adopted an intelligent International open protocol digital lighting control system for building controls using KNX systems. All new buildings must be designed using a KNX system.

KNX is an open standard protocol (see EN 50090, ISO/IEC 14543, SA/SNZ TS ISO/IEC 14543.3.1-6) for commercial and domestic building automation. Only KNX products can be used and any manufacturers must comply with KNX protocols.

KNX Secure devices comply to ISO 18033-3, including data encryption such as AES 128 CCM.

6.8.5 CBUS / Dynalite

An introduction to both CBUS and Dynalite is not required, due to its inherent knowledge with design consultants and contractors. Any requirements for CBUS/Dynalite must follow this Standard.

6.8.6 Lighting Control Groups

The Lighting Designer is to review the switching, dimming, circuit arrangement and controls to comply with the University lighting control strategy to allow staff and cleaning staff to operate the lighting system during office hours and out of hours for limited periods of time.
Overall control of the lighting is to be in the following groups:
a. Group 1: Lecture Theatre Lighting (with AV presentation).
b. Group 2: General Teaching Areas Lighting (with AV presentation).
c. Group 3: Office Lighting.
d. Group 4: Corridor Lighting.
e. Group 5: External Lighting.
f. Group 6: Sensitive Areas Lighting.

Group 5 lighting control must be connected to the LCS system and include function to set times remotely.

Group 6 requires careful consideration to identify the bespoke area like a lab. The introduction of motion sensors such as ‘Steinel’ range are the preferred product in labs of any type.

The lighting control for Groups 1 and 2 should utilise “Scene controller” which is installed in the lighting control section at the local distribution board. The “Scene controller” type Lighting control system consists of a DALI lighting control system, bus control cables and DALI dimmable electronic ballasts for each luminaire. The system must be controlled by either AV controlling panel or local lighting control panel. The DALI lighting control system must interface with AMX controller using program, scenes, time scheduler and/ or occupancy sensors for lighting

controls. An override switch for lighting control must be provided to all areas. These switches must be located in accessible areas and provided with suitable labels.

The lighting controls for Groups 3 to 5 should utilise "group controller" which is installed in the lighting control section at the local distribution board. Generally, the "group controller" type Lighting control system consists of a DALI master / slave lighting control system. The system must use the time scheduler and/ or occupancy sensors for lighting control. An override switch for lighting control must be provided to all areas. These switches must be located in accessible areas and provided with suitable labels.

All zone-based Lighting Control Systems must be connected to a Building Central Lighting Control System in each building. The building CLCS system is to monitor, control, allow for remote programming and manage all zone-based Lighting Control Systems, lighting systems, timer switches, occupancy sensors and other sensors in the building. Campus-wide CLCS with central PC stations will be established for remote control and manage all the building CLCSs and LCSs in the University. The building CLCSs and Campus-wide CLCSs must include gateways and network interfaces for future integration with the Building Management Control System (BMCS) including, but not limited to, BACnet, Modbus, Digital Addressable Lighting Interface (DALI), and TCP/IP. Systems must enable controllers from multiple vendors.

Lighting control systems network must allow high-speed control and monitoring of installed lighting systems via the TCP/IP allowing multiple systems to be controlled over the University's local or wide area network. They must have remote access from multiple computers via an intuitive, easily operable general user interface.

The Central Lighting Control Systems must be capable of interfacing with 240V, DALI, Dynalite, CBUS and KNX systems, which have been installed at a number of locations across the University.

The Central Lighting Control Systems Network must be scalable from a single LCS to an entire building Central LCS. Precincts and campuses are to be able to be linked together on the University's Ethernet.

The Central Lighting Control System Network must be installed, designed, documented, programmed and commissioned by product certified installers.

6.8.7 Lighting Control System Configuration

The lighting control system network must easily satisfy the following configuration:

a. Networks, part names, area addresses, and group addresses must be given descriptive logical names.
b. Every building level is to have its own network.
c. Networks are to be named after the building number and level e.g. A14 Level 1.
d. Area addresses within a level must relate to the compass bearings e.g. Level 1 West.
e. Group addresses must relate to the room numbers e.g. Room 141-147.
f. All addresses must be based on the building name and number, the levels and the room numbers of the location.
g. There must be a single system clock for synchronising data.
h. Allow easy configuration and reconfiguration to accommodate changing circumstances.

6.8.8 Lighting Control Systems Hardware Installation

Lighting control system network hardware installation must:

a. Be the latest model range and version.
b. Be DIN rail mounted in a Distribution Board with key-lockable to The University of Sydney Bi-Lock Electrical Master key system.

c. Use a modular to facilitate maintenance by allowing relays to be replaced individually and without having to replace any other components.
d. Be mechanically held, latching relays with a manual override switch, a quick connect plug and an appropriate short circuit current rating and not accept electrically held relays.
e. Be located in the same cupboard as the switchboard, or at a high accessible level on a wall.
f. Not be located within 240V switchboards.
g. Provide a minimum 25% spare network capacity and channels for future expansion
h. Provide DALI dimming interface modules.
i. Be connected to the University LAN using suitable communication gateways.
j. Allow all controlled switches and lighting system devices to operate independently in case of computer or software problems.
k. Re-set to the standard operating state after a power interruption without manual intervention to resume normal activity.
l. Be provided with safe isolation between the mains electricity supply and the control system circuitry.
m. Have communications cables with mains-rated sheathing.
n. Have over current protection.

6.8.9 Lighting Control Systems Software Installation

Lighting control system network software installation must:

a. Provide graphical display of lighting system energy consumption.
b. Deliver occupancy status information directly to the BMCS.
c. Be able to implement a dynamic load shed.
d. Have time clock-activated pre-set events.
e. Provide the status of all components of the system.
f. Implement after hours mode for set-point change in occupied and unoccupied states.

6.8.10 Lighting Control Systems Documentation

Schematic layout design drawings and manuals of the lighting control system network must be provided to the issuer of this standard for review and approval.

Provide diagrammatic schedules of the lighting control system network in holders adjacent to lighting control boards. Diagrammatic schedules must show:
a. Functional description of how the space/s work with the lighting control system.
b. Network diagram (Single Line Diagram).
c. Dali Addressable layouts.
d. Inputs and outputs (I.O.s) in a typed spreadsheet format and CAD floor plan marked with light fittings (or zones of lighting indicating the number and type of luminaires) and showing the output relay /dimmer number controlling each fitting or zone.
e. Control points complete with item address on each floor plan.
f. Single line diagrams showing all panels, number and type of switches, data-line, and network time-clock.
g. Drawings for each panel showing hardware configuration and numbering.
h. Panel wiring schedules.
i. Typical wiring diagrams for each component.

All lighting control system network scheduling data and documentation is to become the property of The University of Sydney and provided electronically to the issuer of this standard.

6.9 Lighting Control Components

6.9.1 Digital Addressable Lighting Interface (DALI) Lighting Controller

The University of Sydney has adopted an intelligent International open protocol digital lighting control system for lighting controls.

The new Lighting Control System (LCS) is to interface with the DALI lighting universes that include programmable electronic ballasts/ controllers, and include occupancy sensors, group controllers, timer switches, solid-state dimmers, photo-electric sensors, manual lighting control switches, touch screens and lighting controllers, DALI line controllers, DALI/ Line controller power supplies, DALI input/ output devices, AV and BMS interface units, cabling, hardware, software program and various sensors connected to the Central LCS.

Adjustment of the LCS system should be able to be carried out both at the campus-wide, building and zone-based lighting controller via the software programs or other interface devices.

The DALI LCS must enable the standalone zone-based lighting control system to create individual complex lighting scenes in the room from the location of the local zone based lighting controller and also from the network based central control computer. The new DALI LCS must provide flexibility and adaptability to control large numbers of lighting groups.

The BMS interface unit should enable future interface with the BACnet Building Management Control System (BMCS) and other interface devices.

DALI will be interfaced with CBUS, Dynalite or KNX systems.

6.9.2 Local Switches

Switches should wherever possible, be located on permanent walls or columns. All switches are to be installed approximately 1000 mm above the finished floor level, placed in a clearly visible location, be easy to identify and use and comply with the disability requirements by being placed 500 mm away from any corner spaces.

The switch mechanism is traditionally a rocker-style for direct mains voltage switching, but electronic style single-press styles are preferred for new builds and when interfaced with dimming and an automated lighting control system.

Two-way switching at entry/exit points must be provided for large spaces with two entry/exit points that are more than 10m apart. Place switches at the exits from rooms and use two-way switching to encourage occupants to turn OFF lights when leaving the room. Wherever possible locate switches on the door handle side of doors.

Local switching to individual offices and areas must be provided for energy savings.

Switching and dimming in all Lecture Theatres and Lecture rooms must be in accordance with Lighting Controls and Audio-Visual requirements.

Independent lighting switches are to be provided for each area enclosed by ceiling height partitions. Where required, a local switch is to be provided to allow occupants to manually turn off all the lights in an enclosed room.

Where a light switch is provided to a room, each 100m2 area is to be controlled separately. For larger areas, a control panel is to be provided to facilitate switching of the various control groups.

Light switches are to be used in lieu of occupancy sensors in electrical, mechanical and telecommunications rooms. These can be 2-hour push button switches, depending on the size of the space and if the space is deemed a risk to the occupant.

Gang switching of multiple rooms is unacceptable.

6.9.3 Lighting Control Panel (LCP)

Similar to local switches, LCP's is the electronic equivalent of multi-gang switches, allowing multiple switching and light scene setting and automation via a single control point. LCP's are recessed touchscreens and are located either at the front entrance of a room or within a lectern.

The intent of this is to turn everything off from a central location.

6.9.4 Time Delay Switches

Time delay switches are like local switches, but with an inbuilt timer to automatically switch off the connected lighting load after a pre-set time.
Time delay switches must be set to operate for a pre-set period and must only be used when spaces experience short periods of activity and occupancy.

Programmable automatic time switches must be used to control lighting based on sunrise and sunset hours. They must automatically adjust the turning ON and OFF lights every day of the year, typically using an internal program based on longitude and latitude. Automatic time switches must meet these requirements:

a. Sunrise and sunset prediction accuracy within +/- 15 minutes and timekeeping accuracy within 5 minutes per year.
b. Store astronomical time parameters (used to develop longitude, latitude, time zone) for at least 7 days if power is interrupted.
c. Have an automatic daylight savings time adjustment.
d. They must interface to the University lighting control network to permit remote interrogation and adjustment of the time program.

6.9.5 Occupancy Sensors

Independent occupancy sensors powered by the lighting circuit or by the DALI Bus as required, must be provided for each area enclosed by ceiling height partitions. Occupancy sensors are to be provided in general workspaces, circulation spaces and teaching and learning spaces and amenities areas.

Motion sensors such as the 'Steinel' range can be utilised in lab spaces. The control of the lab space lighting should be arranged in zones of 100m^2 or less. This will allow the sensor to pick up small hand movements and keep lights turned on during business and after hour modes. Labs should also have light switches at door entry/

Follow the manufacturer's spacing instructions to achieve 100% space coverage by the occupancy sensor. Because manufacturer's offer a range of occupancy sensors, ensure the correct high-quality occupancy sensor model is used appropriately to a particular use or space. The density of occupancy sensors in a space are to satisfy the control requirements.

Occupancy sensors must offer 360^0 sensing for ceiling mounted applications and 180^0 sensing for wall mounted applications.

They are to have a minimum detection range of 4m diameter for floor to ceiling heights of up to 2.4m, 6m diameter for floor-to-ceiling heights between 2.4m and 3m diameter, and at least 4m for other applications.

Workspace areas are to not have dead band zones, which are not covered by an occupancy sensor. The occupancy sensors must be located where line-of-sight to occupants is not inhibited by building structures e.g. beams, changes in ceiling height or other building elements such as surface mounted air conditioning ducts, cable trays and pipe work.

The sensitivity of the occupancy sensors is to be such that a single individual in a workspace typing in front of a computer is detected.

Occupancy sensors in a room must not be activated by occupants outside the room.

Sensors are to be designed to operate in temperatures from 0-35°C and relative humidity of 0-90%, non-condensing. They are to have an estimated design life cycle of 15 years.

Final location of the occupancy sensors is to strictly follow the manufacturer's recommended separation from air diffusers, return air grilles and other building features which can affect proper occupancy sensor performance.

Generally, they are to be situated at least 600mm from the edge of ceiling air conditioning grilles to avoid air drafts over the sensor and not be exposed to direct sunlight as these factors could adversely affect sensor performance.

Locate corridor sensors at each entry point to the corridor unless the corridor is less than 5m in length and can be covered by a single central sensor.

Occupancy sensors must default to "ON" in case of sensor failure. Sensors are to be utilised in the following spaces as per the below;

a. Individual offices.
b. Open plan offices.
c. Computer rooms/laboratories.
d. Corridors.
e. Lobby areas.
f. Foyers/reception areas/circulation areas.
g. Student common.
h. WC's.
i. Gymnasiums.
j. Kitchens.
k. Car parks.
l. Lounge rooms.
m. Libraries.
n. Stairwells.

Generally, occupancy sensors should be digital Passive Infrared (PIR) motion sensor consisting of a motion detector, an electronic control unit, a programmable time delay switch to ensure that lighting is turned ON when motion is detected and OFF once no motion has been detected for a selected period of time. The PIR is to be equipped with RF immunity, adjustable photocell sensor and 0-120 minutes occupancy time delay switch.

Multi-function sensors shall be able to be programmed by a handheld remote-control device or mobile app.

Where there are obstructions to preventing the field-of-view motion detection by PIR, provide Dual-Technology (Passive Infrared and Microphonic or Ultrasonic sensors) occupancy sensors for overlapping detection of human activities over the area of coverage to ensure the effective operation of the lighting control system.

Dual-Technology occupancy sensors must be used in sensitive areas where use of good quality PIR sensors are causing nuisance false "ON" and "OFF" events. PIR/ultrasonic sensors must not adversely affect hearing aids.

To prevent nuisance false "ON", PIR/ultrasonic sensors or PIR/ micro-phonic must not be used in spaces with moving mechanical equipment or mounted close to areas experiencing airflow. University spaces where dual tech sensors may be considered include:

a. Auditoriums/Lecture theatres.
b. Classrooms/seminar rooms.
c. Computer rooms/laboratories.
d. Meeting rooms.
e. Conference rooms.
f. Areas with very high ceilings.
g. Areas requiring 100% cut-off and/or small motion sensing.
h. Stairwells.

Selection of occupancy sensors must also be compatible with installed environment and the cabled lighting control system used and cannot be mixed, i.e. When Dynalite is used, only Dynalite sensors can be used; When KNX is used, the integrator shall provide KNX compatible sensors.

Motion sensors must be connectable to a high-level interface of a BACnet system.

6.9.6 Daylight Sensors

Daylight sensors and separate switching must be used to control lighting in perimeter areas adjacent to windows and in areas containing skylights, known as daylight harvesting. The lighting designer must clearly identify day lit areas on the lighting plans to clarify floor areas and luminaires to be controlled by photo sensors.
Day lit areas are floor areas without high light-obstructing vertical partitions:

a. Next to perimeter windows that extend 600mm on either side of the window in a direction parallel to the window and one window head height perpendicular to the window and having a minimum area of at least 25m^2.
b. Extending 70 percent of the floor to ceiling height from the edges of the atrium/skylight opening in the ceiling and having a minimum area of at least 250m^2.

Luminaires in day lit areas with good levels of daylight illumination must be controlled by occupancy sensors that automatically reduce the general lighting power by at least two-thirds of rated power consumption in response to available daylight, or switch lights off when there is adequate daylight illumination. Daylight photo sensors must be placed close to the source of daylight. If daylight photo sensors reduce lighting in control steps, it must incorporate time-delay circuits to prevent lights turning on and off when daylight levels are fluctuating. The daylight sensor must have an accurate linear response over the range of illuminance measured to accurately respond to wide range daylight levels. Daylight sensing capability of sensors must be easily disabled if required.

Selection of daylight sensors must also be compatible with installed environment and the cabled lighting control system used and cannot be mixed, i.e. when Dynalite is used, only Dynalite sensors can be used; When KNX is used, the integrator shall provide KNX compatible sensors.

6.9.7 Headend Computer

Refer to Attachment 1 for information relating to the Lighting Control Network – Headend Computer.

6.10 Lighting Control Methodology

The following tables describe the lighting controls methodology for University spaces and rooms.

Lighting controls methodology for the rooms not shown below must be developed based on the Project Brief and in discussions with and approved by the UI Electrical Engineer.

Sensor detection time limits have been nominated in the table below. These shall be re-programmable at time of commissioning at the client's request.

Table 4: Outlines the Lighting Control Methodology

Control Type	Lighting Controls Switch 'ON' Methodology	Lighting Controls Switch 'OFF' Methodology	Typical Areas
A	Lighting to be turned 'ON' via local switch Lighting to be turned 'ON' via Dual-Tech occupancy sensor upon first entry.	Lighting to be turned 'OFF' via local switch. In 'After Hours' mode, Lighting to be turned 'OFF' via Steinel occupancy sensor once no motion has been detected for a period of 30 minutes.	Research Labs, Wet Labs, Sensitive Areas
B	Lighting to be turned 'ON' via local switch, which activates occupancy sensor. Occupancy sensor turns lights 'ON'.	Lighting to be turned 'OFF' via local switch. PIR occupancy sensor will deactivate once movement is not detected for a period of 30 minutes.	Individual Offices, Meeting Rooms, Group Study Rooms
C	Lighting to be turned 'ON' via local switch. Lighting to be turned 'ON' via Dual-Tech occupancy sensor upon detection of motion. Lighting to the window perimeter zones of the room will only turn on should the sensor detect illuminance levels lower than the set minimum.	Lighting to be turned 'OFF' via local switch. Lighting to be turned 'OFF' via Dual-Tech occupancy sensor once no motion has been detected for a period of 30 minutes. Window Perimeter Lighting to dim down via Dual-Tech occupancy sensor should the sensor detect illuminance levels greater than the set maximum; and switch OFF after no motion is detected after 30 minutes.	Open Plan Offices, Break Out Rooms, High Ceiling Rooms, Reception, Open Spaces
D	Lighting to be turned 'ON' via local control panel (4 button panel). Lighting to be turned 'ON' via Dual-Tech occupancy sensor upon	Lighting in these spaces can be turned OFF in various ways as per below. Lighting to be turned 'OFF' via local control	Auditorium, Lecture Theatre, Seminar Room, Computer Room,

Control Type	Lighting Controls Switch 'ON' Methodology	Lighting Controls Switch 'OFF' Methodology	Typical Areas
	detection of motion at the entrances. These entrance PIRs only call 20% of luminaires 'ON' (i.e. the pathway to the lectern). Lighting system must be integrated with AV control system for calling of pre-sets and individual zones. Ethernet is required at each lectern Auditorium. Sensors must be integrated with mechanical AC. Lighting Control must integrate with Blind Control.	panel (4-button panel). 4 button panels must be located at each entrance. Lighting to be turned 'OFF' via AV control system. Lighting to be turned 'ON/OFF via Dual-Tech occupancy sensor once no motion has been detected for a period of 30 minutes. PIRs to be installed throughout venue ceiling space for occupancy of seating areas. These PIRs will send a 'FLAG' to the AV control system which will start a shutdown timer. PIR sensors must cover 100% of the room and be sensitive enough to pick up small hand movements. PIR zone for width and depth must be marked up on drawings.	Dry Laboratories
E	Lighting to be turned 'ON' via local switch and key card system.	Lighting to be turned 'OFF' via local switch. Lighting to be turned 'OFF' 3 minutes once key card is removed.	Student Bedrooms
F	Lighting to be turned 'ON' via momentary timer push button switch. Switch to have a time delay 'OFF' pre-set between 30 minutes and 2 hours.	Lighting to be turned 'OFF' via momentary timer push button switch.	Switch Rooms, Comms Rooms, Electrical Cupboards, Maintenance Plant Rooms
G	Lighting to be turned 'ON' via occupancy sensor once no motion has been detected for a period of 15 minutes.	Lighting to be turned 'OFF' via occupancy sensor once no motion has been detected for a period of 15 minutes.	Cleaners Rooms Storerooms

Control Type	Lighting Controls Switch 'ON' Methodology	Lighting Controls Switch 'OFF' Methodology	Typical Areas
H	Lighting to be turned 'ON' via local control panel (4 button panel). Lighting to be turned 'ON' via Dual-Tech occupancy sensor upon detection of motion.	Lighting to be turned 'OFF' via Dual-Tech occupancy sensor once no motion has been detected for a period of 30 minutes. All cupboard and shower doors must have self-closing doors.	24 Hour Library Library General Areas Lift Lobbies Circulation or Foyers Toilets, bathrooms, Showers, Kitchen.
I	External lights must be turned 'ON' via the LCS headend PC at pre-set times. Photo-electric cells switch lights 'ON' when external illuminance levels are below the 'sunset setting' on the PE cell.	External lights must be turned 'OFF via the LCS headend PC at pre-set times. Photo-electric cells switch lights 'OFF' when external illuminance levels are greater than the 'sunrise setting' on the PE cell.	External Circulation.

6.11 Lighting Controls Types in Interior Spaces

In order for the lighting control system to be operated in a satisfactory manner and achieve the desired energy savings, a comprehensive Lighting Control Strategy is required. The University has established the following Lighting Control Strategies. There are four (4) controls strategies: Occupancy Controls, Daylight Harvesting, Dimming Controls and local switching.

a. Occupancy Control (OC) is defined as automatic adjustment or activation/deactivation of light levels in response to the presence of occupants. It includes constant occupancy monitoring and illumination controls. This are implemented by infrared or ultrasonic motion detectors, which are triggered by movement and hence, occupation.
b. Daylight Harvesting (DH) is defined as the automatic adjustment of light levels in response to daylight. It includes constant daylight sensor monitoring and illumination controls, PE cell control or time clock-based controls. This strategy utilises the daylight sensor together with the dimming capability of the luminaires and software programming of the lighting control system.
c. Dimming Controls (DC) is defined as adjusting light levels by pre-set scene control, override dimming and override switching. It includes integration with zone based lighting control, motion sensors and a Lighting Control System.
d. Local Switching (LS) is defined as switching lighting from a 240V switch or push button.

All four control strategies noted above are to be applied to each University Project, space and room type.

With any new build, the control strategy must have a Central Lighting Control System operating the functionality required.

6.12 Lighting Systems with Audio Visual

6.12.1 Auditoriums and Lecture Theatres (with Video Projectors)

These spaces are used for conventional presentation style teaching with video projectors.
The lighting in Auditoriums or Lecture Theatres must be fully controlled by the Lighting Control System and integrated with the University ICT AV system via an AMX/ ACA control system and touch screen interface panel (AMX/ ACA control system should control audio visual equipment and screens, refer to the University of Sydney ICT AV specification and Physical Learning Spaces requirements).

AV installation can incorporate either projector with screen or TV monitor. Both have different lighting requirements which must be reviewed by the ICT/AV engineer.

The lighting should be designed in such a way that all the required modes of operation and scenes can be accommodated. Exit and emergency lighting as well as aisle lighting is to be installed and independently operated in compliance with the NCC.
All other luminaires within these spaces are to be equipped with DALI control gear, controlled by Lighting Control System (LCS) with the ability to dim / control luminaires individually or in nominated control groups. All lighting circuits originated from the LCS must be protected by RCD in the LCS which is located in the Projector room (located in the switchboard if there is no projector room).

The general lighting must be controlled by the Lighting Control Systems at the LCD touch panel, four buttons switch panel or AMX/ ACA touch screen at the lectern or automatically by occupancy sensors with the following features:

Lighting should be enabled for normal use by the LCS based on the following five (5) minimum pre-set scenes:

Pre-set 1	General teaching without the use of video projectors. All ceiling lighting and whiteboard lighting are ON with dimmable functionality. For room ceiling higher than 3m, directional LED spotlights for lectern and stage lighting are ON with dimmable functionality. Minimum ambient illuminance levels of 240 lux at 0.7m AFFL and lectern area vertical illuminance levels of 400 lux.
Pre-set 2	Teaching with the aid of video projectors on and note taking. All ceiling lighting and directional spotlights are ON with dimmable functionality. Whiteboard lighting is OFF. Minimum illuminance levels 240 lux at 0.7m AFFL, presenter and lectern area illuminance levels of 400 lux vertical at 1.6 m AFFL. ANSI contrast ratio for projected images versus ambient light on screen is 7:1. Colour temperature is to be maintained whilst luminaires are dimmed.
Pre-set 3	Teaching with the aid of video projectors, higher quality images and note taking. All ceiling lighting and directional spotlights are ON with dimmable functionality. Whiteboard lighting is OFF. Minimum note taking illuminance levels 100 lux at 0.7m AFFL in audience areas, presenter and lectern area illuminance levels of 400 lux vertical at 1.6 m AFFL. ANSI contrast ratio for projected images versus ambient light on screen is 15:1. Colour temperature is to be maintained whilst luminaires are dimmed.
Pre-set 4	Teaching with the aid of video projectors, “Cinematic” quality images, dark

	ambient and no note taking. The room ceiling lighting is user adjustable. Directional spotlights for lectern and whiteboard lighting are OFF. e. ANSI contrast ratio for projected images versus ambient light on screen is 50:1. Lighting colour temperature must be maintained during dimming.
Pre-set 5	Room not occupied. All ceiling lighting and projector lighting must be OFF. The occupancy sensors will be enabled.

a. An occupancy sensor in the spaces should ensure that the lighting is operational while the space is in use. After the occupant leaves the room for 15 minutes (5 minutes during after-hours) triggered by an occupancy sensor, the lighting should dim to 50% for 2 minutes and then switch OFF.
b. During presentation modes 1-4 as outlined above, the sensors are to be de-activated so that the pre-set levels are maintained.
c. At the completion of each teaching lesson the lighting scene is to be set to pre-set 5, whereby occupancy sensors will turn lights 'OFF' once no motion has been detected for the selected period of time.
d. Once the lights have turned OFF, the default scene upon detection of motion and re-activation of the lights is pre-set 1.

There should be minimum of five (5) lighting control groups:
a. Front of room lights (minimum 2 groups for over 200 seats Auditoriums).
b. Rear of room lights (minimum 2 groups for over 200 seats Auditoriums).
c. Lighting near window (operated by daylight sensor under scenes 1 and 2).
d. White board lighting.
e. Lecture and stage lights with barn doors.
f. Each lighting group (and individual luminaires where required) must be dimmable under the control of the Lighting Control System.
g. The lights need to be physically zoned at the board to allow an L and R or L, C, R configuration when dual projection is used. This will allow the dual use of projectors and whiteboards.
h. A separate zone-based DALI lighting control system with dimmer and AMX/ ACA interface unit must be provided in the projector room. The LCS shall operate independent of the AMX/ ACA control system if the AMX/ ACA controller or AV system fail to operate.
i. Lighting near windows should be automatically dimmed down or OFF when room lighting level is above the daylight sensor 'high' setting and switch lights ON at 'low' setting. The daylight sensors should have delay in change of output of 5 seconds to accommodate for dramatic change in outside weather conditions.
j. The LCS system should allow ad-hoc dimming control of each group by the AMX/ ACA touch screen at the lectern, LCD touch panel in Projector room or other nominated location.

6.12.2 Seminar Rooms and Learning Studios (Flat floor with Video Projectors)

These spaces are used for interactive presentation style teaching where the audience engages in participation with the presenter and each other. The rooms offer configurations of groups and pairs to promote collaboration, and problem solving.
The lighting in Seminar Rooms and Learning Studios must be fully controlled by Lighting Control System and integrated with the University ICT AV system via a AMX/ ACA control system and touch screen interface panel (AMX/ ACA control system should control audio visual equipment and screens, refer to the University of Sydney ICT AV specification and Physical Learning Spaces requirements).

The lighting should be designed in such a way that all the required modes of operation and scenes can be accommodated. Exit and emergency lighting is to be installed and independently operated in compliance with the NCC.

All other luminaires within these spaces are to be equipped with DALI dimmable control gear, controlled by Lighting Control System (LCS) with the ability to dim / control luminaires individually or in nominated control groups. All lighting circuits must be protected by RCD in the switchboard.

The general lighting is to be controlled by the Lighting Control Systems at the room entry four buttons switch panel or AMX/ ACA touch screen at the lectern or automatically by occupancy sensors.

Lighting should be enabled for normal use by the LCS based on the following four (4) pre-set scenes:

Pre-set 1	General teaching and group leaning activities without the use of video projectors. All ceiling lighting and whiteboard lighting are ON with dimmable functionality. Minimum ambient illuminance levels of 240 lux at 0.7m AFFL and lectern area vertical illuminance levels of 400 lux.
Pre-set 2	Teaching with the aid of video projectors on and note taking. All ceiling lighting and directional spotlights are ON with dimmable functionality. Whiteboard lighting is OFF. Minimum illuminance levels 240 lux at 0.7m AFFL, presenter and lectern area illuminance levels of 400 lux vertical at 1.6 m AFFL. ANSI contrast ratio for projected images versus ambient light on screen is 7:1. Colour temperature is to be maintained whilst luminaires are dimmed.
Pre-set 3	Teaching with the aid of video projectors, higher quality images and note taking. All ceiling lighting and directional spotlights are ON with dimmable functionality. Whiteboard lighting is OFF. Minimum note taking illuminance levels 100 lux at 0.7m AFFL in audience areas; presenter and front of stage illuminance levels of 400 lux vertical at 1.6 m AFFL. ANSI contrast ratio for projected images versus ambient light on screen is 15:1. Colour temperature is to be maintained whilst luminaires are dimmed.
Pre-set 4	Room not occupied. All ceiling lighting and projector lighting must be OFF. The occupancy sensors will be enabled.

An occupancy sensor in the spaces should ensure that the lighting is operational while the space is in use. After the occupant leaves the room for 15 minutes (5 minutes during after-hours) triggered by an occupancy sensor, the lighting should dim to 50% for 2 minutes and then switch OFF. During presentation modes 1-3 as outlined above, the sensors are to be deactivated so that pre-set levels are maintained. At the completion of each teaching lesson, the lighting scene is to be set to pre-set 4, whereby occupancy sensors will turn lights 'OFF' once no motion has been detected for the selected period of time:

a. Once the lights have turned OFF, the default scene upon detection of motion and re-activation of the lights is pre-set 1.

There should be minimum of four (4) lighting control groups:

a. Front of room lights.
b. Rear of room lights.
c. Lighting near window (operated by daylight sensor under scenes 1 and 2).
d. White board lighting.

Each lighting group (and individual luminaires where required) must be dimmable under the control of the Lighting Control System:

a. A separate zone-based DALI lighting control system with dimmer and dimmable electronic ballasts shall be provided in the electrical switchboard. The LCS shall operate independent of the AMX/ ACA control system if the AMX/ ACA controller or AV system fail to operate. The LCS shall not control the exit sign, emergency lighting and aisle lighting for occupant safety egress.
b. Lighting near windows should be automatically dimmed or switched OFF when room lighting level is above the daylight sensor 'high' setting and switch lights ON at 'low' setting. The daylight sensors should have delay in change of output of 5 seconds to accommodate for dramatic change in outside weather conditions.
c. The LCS system should allow ad-hoc dimming control of each group by the AMX/ ACA touch screen at the lectern or room entry four buttons switch panel.

6.12.3 Computer Teaching Laboratories and Teaching Laboratories

These spaces are used with teacher and student computers for interactive teaching style where the students engage in participation with the teacher and each other. A simplified lighting control system is to enable these spaces to be easy-to-use and maintained.
The lighting in Computer Teaching and Teaching Laboratories must be fully controlled by Lighting Control System and integrated with the University ICT AV system via a AMX/ ACA control system and touch screen interface panel (AMX/ ACA control system should control audio visual equipment and screens, refer to the University of Sydney ICT AV specification and Physical Learning Spaces requirements).

The lighting should be designed in such a way that all the required modes of operation and scenes can be accommodated. Exit and emergency lighting is to be installed and independently operated in compliance with the NCC.

All other luminaires within these are to be controlled by the Lighting Control System (LCS) and are to be equipped with DALI dimmable control gear. All lighting circuits originated from the LCS must be protected by RCD in the switchboard or LCS.

The general lighting must be controlled by the Lighting Control Systems at the room entry four buttons switch panel or AMX/ ACA touch screen at the lectern or automatically by occupancy sensors.

Lighting should be enabled for normal use by the LCS based on the following four (4) pre-set scenes:

Pre-set 1	General teaching and group leaning activities without the use of video projectors. All ceiling lighting and whiteboard lighting are ON with dimmable functionality. Minimum ambient illuminance levels of 240 lux at 0.7m AFFL and lectern area vertical illuminance levels of 400 lux.
Pre-set 2	Teaching with the aid of video projectors and student learning activities. All ceiling lighting are ON with dimmable functionality. Whiteboard lighting is OFF. Minimum illuminance levels 240 lux at 0.7m AFFL, presenter and lectern area illuminance levels of 400 lux vertical at 1.6 m AFFL. ANSI contrast ratio for projected images versus ambient light on screen is 7:1. Colour temperature is to be maintained whilst luminaires are dimmed.
Pre-set 3	Teaching with the aid of video projectors, higher quality images and student

	learning activities. All ceiling lighting are ON with dimmable functionality. Whiteboard lighting is OFF. Minimum note taking illuminance levels 100 lux at 0.7m AFFL in audience areas; presenter and lectern area illuminance levels of 400 lux vertical at 1.6 m AFFL. ANSI contrast ratio for projected images versus ambient light on screen is 15:1. Colour temperature is to be maintained whilst luminaires are dimmed.
Pre-set 4	Room not occupied. All ceiling lighting and projector lighting must be OFF. The occupancy sensors will be enabled:

An occupancy sensor in the spaces should ensure that the lighting is operational while the space is in use. After the occupant leaves the room for 15 minutes (5 minutes during afterhours) triggered by an occupancy sensor, the lighting should dim to 50% for 2 minutes and then switch OFF. During presentation modes 1-3 as outlined above, the sensors are to be deactivated so that pre-set levels are maintained;

There should be minimum of four (4) lighting control groups:
a. Front of room lights.
b. Rear of room lights.
c. Lighting near window (operated by daylight sensor under scenes 1 and 2).
d. White board lighting (provided as required by the users).

At the completion of each teaching lesson, the lighting scene is to be set to pre-set 4, whereby occupancy sensors will turn lights OFF once no motion has been detected for the selected period of time (15 mins).
Once the lights have turned OFF, the default scene upon detection of motion and re-activation of the lights is pre-set 1.
A separate zone based DALI lighting control system shall be provided in the room. The LCS shall operate independent of the AMX/ ACA control system should the AMX/ ACA controller or AV system fail to operate. The LCS shall not control the exit sign, emergency lighting and aisle lighting for occupant safety egress.
Switch panels should not be located at the entry/ exit door to prevent the lighting being accidental switch OFF when the room is occupied.
Lighting near windows should be automatically dimmed or switched OFF when room lighting level is above the daylight sensor 'high' setting and switch lights ON at 'low' setting. The daylight sensors should have delay in change of output of 5 seconds to accommodate for dramatic change in outside weather conditions.
The LCS system should allow ad-hoc dimming control of each group by the AMX/ ACA touch screen at the lectern or room entry four buttons switch panel.
Motion sensor coverage must cover the occupant's working area of the room and sensors sensitive enough to pick up small movements.

6.13Emergency and Exit Lighting

Emergency and exit lighting are to be designed in compliance with AS/NZS 2293 and the NCC.

Design Engineers/Contractors must also consider the areas adjacent to the project boundaries, as the emergency exit strategy may need to be updated to suit the new scope and to comply with the NCC. A simple example of this is reviewing all the adjacent rooms to the project and identifying if the emergency exit strategy complies or needs upgrading.

6.13.1 General

Emergency lighting systems will be of single point unit or computer monitored type design, except in the case of step lighting, where connection to a central UPS may be permitted. For details of UPS requirements refer to the section UPS Services Standard.

Existing buildings will utilise or extend existing emergency lighting systems whatever that may be. New buildings fit outs with over 100 emergency points will utilise a computer monitored type.

Where existing buildings served by an 110V DC central battery emergency lighting system are proposed to be refurbished, new single point emergency light fittings will be installed in the refurbishment area and the existing central system modified to suit the new installation.

As many University buildings contain areas classified Class 9b, emergency lights must be installed in every room or space to which there is public access, in order to suit the requirements of the NCC Section NSW H Addenda.

6.13.2 Light Fittings

Emergency light fittings must comply with the following details:

a. Emergency light fittings must generally be premium type, non-maintained, high temperature lithium-iron phosphate battery pack, LED lamps with not less than 50,000-hour lamp life, similar or equal to Clevertronics, LeGrand Galaxy or Stanilite LED Spitfire.
b. LED battery type must be of premium type.
c. Emergency lighting must be independent of the general light fittings, except in required exit stairs where the emergency lighting may be incorporated into the general lighting fittings.
d. Emergency light fittings must be recessed type wherever possible.

6.13.3 Discharge Test Switches

Emergency and exit lighting discharge test switches must comply with the following details:

a. Emergency/exit light manual discharge test switches must be installed within all new electrical distribution boards (EDBs).
b. Where new exit and emergency light fittings are connected to existing EDBs without discharge test facilities, new test switches must be installed adjacent to the EDB.
c. In cases where the new test switches are installed in accessible areas, the test switch must be contained within a lockable enclosure to prevent unauthorised use.
d. Utilise non-computer monitored testing to provide automatic 6-month testing and test result logging.

6.13.4 Computerised Monitoring and Testing Systems

Emergency and exit lighting computerised monitoring and testing systems must comply with the following details:

a. Computerised monitoring and testing systems for emergency and exit lighting must be Clevertronics Zoneworks, Stanilite Nexus LX, or approved equivalent.
b. For new buildings with greater than 100 emergency and exit light fittings proposed to be installed, a new computerised monitoring and testing system must be installed.
c. Where existing buildings containing greater than 100 single point unit emergency and exit light fittings are being substantially refurbished, a new computerised monitoring and testing system must be installed to serve the refurbishment area. The system must be designed to allow for the staged upgrade of the system throughout the entire building.
d. Where existing buildings contain a computerised monitoring and testing system for emergency and exit lighting, the system must be upgraded and extended to incorporate monitored fittings throughout all newly refurbished areas. This includes but is not limited to

the installation of monitored fittings, cabling, equipment hardware, networking, software and updating of graphical interface(s), as required to ensure a fully functioning system.

e. All computerised monitoring and testing systems must be connected into the University data network to allow each building emergency and exit lighting system to be monitored and tested via a graphical interface from one or several remote locations.
f. The University will consider Radio Frequency type systems for new large building projects.

7 Commissioning

Comprehensive pre-commissioning, commissioning and quality monitoring must be specified by the consultant/designer or contractor/builder.

A project specific commissioning plan is to be developed and provided to the University for review and approval.

Detailed testing and commissioning records must be provided for each system and each component as appropriate. All such records must be witnessed and verified by the project consultant/head contractor prior to witness commissioning by the University Infrastructure engineers.

Project handover plan must be developed by the consultant/designer to allow the system to be handed over to the University. A twelve-month building tuning process will commence at project handover with systems monitored monthly, reported and assessed quarterly, and include assessment of feedback from the occupants.

A project specific commissioning plan is to be developed and provided to the University for review and approval. UI have developed a **Lighting Services Commissioning Form (UI-ENG_F029)** which should be used as a minimum guide when preparing the project specific commissioning plan.

8 Safety in Design

The contractor must consider risk during the design. A design safety report must be submitted to the relevant UI Project Manager for every design project. Contractors must confirm, so far as it is reasonably practicable (SFAIRP), that the structure is without risks to health and safety.

Design risks must be considered for the asset lifecycle covering construction, operational and maintenance, refurbishments and decommissioning.

The design safety report must include the following:

a. Description of design element.
b. Description of potential risks and hazards associated with the design element.
c. A low/medium/high risk assessment considering likelihood and consequence.
d. Proposed measures to eliminate risks where practicable.
e. Control measures to mitigate and manage design risks.
f. Nominating responsibilities for managing the design risks.

This may be provided as a design risk register where appropriate and must include results of any calculations, testing and analysis etc.

9 Documentation and Records

9.1 Design Documentation

Prior to commencing construction of new or refurbishment projects, the consultant/contractor must fully investigate and document the requirements for each lighting system required to be installed, altered or modified as part of the project works.

This must include:

a. Return Brief defining the lighting systems proposed and any deviations from this specification using the **UI Request for Dispensation Form (UI-ENG-F001).**
b. Computer design illuminance level illuminance level points, including maintenance factors used.
c. Point-to-point photometric layout for each typical space showing average, maximum and minimum illumination values in the horizontal work plane.
d. Reflected ceiling plans.
e. **Costing** Isolux diagrams for all exterior floodlighting or landscaping area lighting calculations.
f. Lighting energy consumption summaries for each area type and/or the whole building demonstrating NCC Section J compliance.
g. Statement of design compliance with NCC Section J energy requirements.
h. Complete the Design & Construct checklist using the **UI Design & Construct Services Checklist Form (UI-ENG-F009).**
i. Luminaire specification sheet or legend drawing detailing.
j. Luminaire and lamp type.
k. Luminaire manufacturer and product number.
l. Mounting configuration.
m. Ballast type.
n. Luminaire body colour where applicable.
o. Details of product accessories.
p. Current luminaire budget costs.
q. Luminaire photometric data.

This documentation must be provided by the consultant/contractor in electronic copy formats and approved by the University before constructions begins.

9.2 Completion Documents

At the completion of all projects, the following documentation must be provided for each essential fire safety measures installed or altered as part of the project works:

a. O&M manual(s).
b. As-built drawings (including schematics, RCPs and network diagrams) including lighting control systems network spare capacity
c. Asset schedules and labelling (as per the Asset Identification and Labelling Standard).
d. Commissioning test results.
e. Product manufacturer specific information.
f. Copies of computerised lighting and emergency and exit lighting system programs.
g. Licensed versions of lighting and computerised emergency and exit lighting system graphics computer software required to program panels and monitoring systems.
h. Details of all user names and passwords required to access all equipment and software.
i. Warranty schedules for all major items of equipment, including but not limited to luminaires, drivers or control systems.
j. Maintenance requirements for all items of equipment.

k. Building User Guide.
l. Installer's Statutory Certificates.
m. Certification of (Design/Install) compliance to The University Standards, Australian Standards and NCC.

This documentation must be provided by the contractor in electronic format and approved by the University prior to Practical Completion being granted.

10 Assets and Warranties

Assets are to be tagged in accordance with the **COS Universities Asset & Labelling Standard** for the purpose of maintenance and operation of University Assets. For refurbishment projects the project manager is to provide the existing asset list to the contractor to ensure modified and redundant equipment are captured in the contractors submitted asset list.

Each asset required to be collected can be found in the Asset Form **COS-ASSET-F001**, each asset required to be coded will be identified by a unique equipment code.

The equipment code will be one the three following types:
a. Virtual asset (This is a concatenation Building Code - Floor - Room Number)
b. Item count asset (This is a concatenation Building Code - Floor - Room number)
c. Unique bar code asset (Unique bar code in the million series number affixed to the asset)

Asset lists are to be submitted prior to practical completion of the project for review and approval by COS.

Equipment Warranties are to be provided for a minimum of 12 months from the date of practical completion. Warranties are to be provided as certificates as part of the O&M from the supplier of the equipment. It is the responsibility of the installation contractor to ensure all maintenance\servicing required to the equipment is provided to ensure warranties are valid at the end of the project DLP period.

All new luminaires (emergency and non-emergency) shall have a supplier backed minimum 5-year warranty, covering the manufacture, LED lamp and driver of the luminaire.

11 Defects Liability Period

Consultants/designers must include in the project specification detailed requirements for the defects and liability period following completion of the lighting services installation.

The contractor must include and allow for recommissioning of all major plant and equipment in the last month of the 12-month defects and liability period and confirm they achieve the original design requirements. In addition, all commissioning must be witnessed by UI engineering and FM staff with commissioning reports/results formally submitted to UI Engineering.

11.1 Maintenance and Testing

For lighting services installed as part of a refurbishment project of an existing building, regular statutory maintenance and testing must be carried out by the contractor who installed the equipment. The installation contractor must provide a comprehensive handover and the required completion documentation at Practical Completion.

All defects arising from regular statutory maintenance and testing performed during the DLP will be documented and passed onto the installation contractor for rectification. The installation contractor must be responsible for all defect rectification works identified during the DLP.

For new buildings, the installation contractor must provide statutory maintenance and testing of all lighting services for the building, throughout the DLP.

Prior to the completion of the DLP, the installation contractor will perform all annual maintenance procedures in the presence of the University essential services maintenance contractor and provide documentation confirming the provision of all statutory maintenance has been performed during the DLP.

Any details which will affect the future maintenance and performance of the new or upgraded equipment must be supplied by the installation contractor at Practical Completion.

Prior to completion of the DLP, a final inspection of the installed systems will be carried out by the: installation contractor, appropriate University staff, and the University services maintenance contractor, in order to reconcile the performance of the equipment during DLP to produce a final list of project defects. All project defects identified must be rectified by the installation contractor prior to finalisation of the DLP.

12 Operation and Maintenance Manuals

Consultants/designers must include in the project specification detailed requirements for operation and maintenance manuals, including system description, operation procedures, testing and commissioning records, maintenance instructions, product support information and recovery protocols for any computer related systems. Contractors must provide these to the satisfaction of the consultant/designer. Providing a collection of manufacturers' brochures and catalogues is not acceptable to the University.

Discuss with UI to understand what format to submit the O&M Manuals. Typical submissions come via soft copy (editable) and used via a system like Aconex.

Contractors must submit the university designed Sydney University Asset Register, designed for recording operational and maintenance activities including materials used, test results, comments for future maintenance actions and notes covering asset condition. Completed log book pages recording the operational and maintenance activities undertaken for Practical Completion and during the Defects Liability Period must also be provided.

Facilities Maintenance must establish, document and implement procedures for lighting system operation and maintenance to ensure lighting is fit-for-purpose, complies with the requirements of this standard and lighting controls in all buildings and spaces are adjusted to optimise energy efficiency and reduce energy costs:

a. Facilities maintenance must shutdown lighting systems in buildings or operate them at reduced capacity during University holiday shutdown periods or to support special events.
b. Facilities maintenance must not operate the central lighting control systems (C-BUS/Dynalite) unless proper training has been completed. The reason for this is to stop facilities maintenance altering the programmed settings, which have been designed by an external consultant.
c. Facilities maintenance must inform the UI Electrical Engineer of any required reprogramming of the central lighting control systems. All proposed reprogramming is to be provided to the UI Electrical Services Engineer for review and approval.

13 Authorisation of Variations

Project managers, consultants, contractors, commissioning agents and facilities maintenance personnel must ensure compliance with the requirements outlined in this standard are achieved.

Variations to this standard must only be considered where:

a. The University Standard's requirement cannot physically or technically be achieved, or
b. The alternative solution delivers demonstrated and proven superior performance for equal or improved capital and life cycle cost.

Consultants and contractors must identify and justify requirements of the standard that do not apply to the project or which need to be varied. These must be submitted to and approved by the issuer of this standard. Formal requests for all variations to this Standard must be submitted using the **UI Request Dispensation from Standard Form (UI-ENG-F001)**. The issuer of this standard or their delegated authority must review and consider requirements of stakeholders from clients, projects and facilities management before deciding whether to approve variations. Their formal sign-off is required for acceptance of any non-compliances and departures from this standard's requirements.

Where alternative luminaires are proposed by contractors, all information and detailed calculations must be submitted for review in accordance with this standard. The contractor must pay any costs associated with design verification for the alternative proposal. All proposed alternative luminaires are to be provided to the UI Electrical Services Engineer for review and approval.

14 Quality Control

14.1 Design Standard Compliance

Compliance with requirements of this standard must be checked throughout the design, construction and commissioning phases of projects by UI's services consultant. Any issues or deviations from this standard must be reviewed and approved in writing by the author of this standard.

Competent UI consultants and representatives must check compliance with this standard during design reviews and formal site inspections. Any non-conformances with requirements of this standard must be documented and provided to the UI Project Manager for issue to contractors and their consultants.

Project Managers must maintain a formal register of non-conformances and manage close out of outstanding non-conformances. Contractors and their consultants issued with non-conformances must take appropriate corrective actions. The UI Project Manager must ensure:

a. Proposed corrective actions are implemented.
b. Close out of non-conformances in relation to this standard is formally approved and signed off by the author of the standard or their delegate.

14.2 Design Standard Certification

Contractors and Consultants must certify compliance to the design standard by submitting a company Design Certification Form to the UI Project Manager at each of the following project phases:

a. Design and Documentation
b. Tender
c. Construction

Notwithstanding UI's internal quality control processes, contractors and their consultants must implement their own robust quality assurance and control procedures to ensure compliance with requirements of this standard.

14.3 Shop Drawings

The Contractor must submit the following shop drawings, document and samples to the UI Electrical Services Engineer for approval prior to final placement of order:

1. Lighting calculations with digital printouts.
2. Lighting layouts (1:100 scale) or as appropriate to the site layout.
3. Lighting control system schematic diagrams.
4. DALI Addressable drawings showing DALI Gateway capacities.
5. Technical catalogue and documents for lighting and lighting control systems.
6. Compliance certifications from accredited Lighting Designer.

Sample of all proposed luminaires and lighting control system hardware.

15 Document Amendment History

Revision	Amendment	Commencing
001	**First Issue**	16 August 2013
002	**Second Issue – Amendments:** a. Criteria for selecting downlight clause 5.2.2.6 added. b. Additional equipment clause 5.2.5 added. c. Lighting system design clause 6 added. d. External lighting areas clause 6.4 added. e. Lighting control strategy clause 7.3 added. f. Pre-set lighting scene selection clause 7.5 added. g. Lighting control systems clause 7.6 added. h. Lighting control system network clause 7.7 added. i. Emergency & exit lighting clause 8 added. j. Shop drawing clause 9 added. k. Safety in design clause 10 added. l. Asset Labelling and Bar-Coding clause 12.1added. **New Forms added to the website:** a. UI Deemed-to-Comply Luminaire Schedule Form (UI-ENG-F006). b. UI Deemed-to-Comply Central Lighting Control Network Systems Form (UI-ENG-F007). c. UI Design and Construct Services Checklist Form (UI-ENG-F009).	18 September 2015
3.0	Third Issue a. Section 6: Relabelled luminaire types Specified LED lumen depreciation L/B factors Specified luminaire efficacies. b. Updated computerised light modelling grid point requirements. c. Updated illuminance level requirement table. d. Lighting Control Systems Updated, defining Lighting Control Components. e. Updated Lighting Control Methodology, streamlining types. f. Updated Lighting Control Strategies, streamlining types and luminaire types. g. Updated Central Lighting Control Systems h. Updated Lighting Control Strategy i. Updated Lighting Control Deemed to Comply Supplier List j. Removed any reference to lights that are non LED k. Updated Asset Maintenance Requirements l. Added KNX lighting control for new builds. CBUS or Dynalite are only to be used on refurbished projects	30 September 2020

16 Attachments

Attachment 1
Lighting Control Systems (LCS) and Lighting Control Systems Network (LCSN) Installation Requirements

Attachment 2
Lighting Control Methodology Example

16.1 Attachment 1 – Lighting Control Systems and Network Systems

16.1.1 Overview

The Lighting Control Systems and Lighting Control Systems Network must be installed and commissioned by a contractor that is certified and approved by the LCS equipment manufacturer as a LCS integrator, who will be responsible for the overall system implementation and project management. The Contractor must provide shop drawings, functional/addressing details, device programming, on site commissioning/ verification, as-built documentation and defects liability maintenance. Where high-level integration is required, the contractor must consult with UI Electrical Services Engineers prior to commencement of installation, to review the methodology/protocols and document the responsibility of each party to ensure the system operates seamlessly.

16.1.2 Documentation

Prior to project sign-off, the electrical contractor must compile an operation and maintenance manual to be submitted to the project manager. The LCS and LCSN Operation and Maintenance Manuals must include the following information:

a. System architecture diagram.
b. Switchboard layout drawings.
c. System tags and programmed functions.
d. Channel connection identification.
e. Floor plans identifying system device and load.
f. Recommended scheduled maintenance procedures.
g. Technical literature for each type of system device used in the project.
h. System configuration files on CD-ROM including system programming software.
i. Soft copies of all databases files, programming software installable files.
j. Documentation for integration with the University's existing Building Control Management Systems (BCMS).

All drawings and diagrams must be provided as hard (printed) copies and software files (in PDF and either DWG or DXF format). Drawings must be updated to an "as installed" state for placement in the Operation and Maintenance Manual.

16.1.3 Network Topologies

The backbone of LCS and LCSN is to utilise a dedicated Ethernet Network Topology (refer to line diagram on the next page). This backbone must be designed and installed ensuring:

a. Ethernet cabling must be blue Cat-5e unshielded twisted pair (UTP) and must be segregated from mains cabling in accordance with AS/NZS 3000.
b. LCS must be designed and installed to individual levels of each building to eliminate the possibility of service work on one LCS affecting another. Each level must be networked back to the central PC station in the building and back to UI office for the updating of schedules.
c. Cable must be continuous, joined only by RJ45 connectors. The RJ45 terminations must be completed in align with TS568A data standard.
d. Ethernet cable and twin CAT 6A RJ45 Telecommunication outlets must be installed for LCP in each Distribution Board for connecting to the university network.
e. The LCSN must include a System Network Interface and a dedicated power outlet to accommodate a 12V plug pack. This power outlet is to originate from a dedicated circuit from the switchboard control circuit.

f. The Ethernet Switch must be installed in a suitably sized wall mounted lockable data rack enclosure. The location of the enclosure must be in central electrical or communications cupboard adjacent to an existing LCSN system central PC station.
g. The Ethernet switch must have at least 25% spare capacity for future expansion.

The purpose of this network topology is:

h. The Ethernet network allows for high data traffic and can accommodate the large amounts of data travelling to and from central LCSN.
i. The Ethernet network allows for fast connectivity and interrogation of LCSN from the central PC station software.
j. Provide a local zone based LCS system for individual levels eliminates the possibility of a LCSN fault affecting LCS on other levels.
k. The local zone based LCS for individual levels must eliminate the possibility of changes and additions to a LCP on one level affecting other levels;
l. The design of local zone based LCS per level provides maximum scalability for any future expansions of the system.

16.1.4 Head end software and PC

A dedicated Lighting Control PC with necessary accessories must be installed in each building to provide central monitoring and control of the Lighting Control System Network. The head-end PC must also be provided at the UI office for monitoring. Where a dedicated PC is already installed it must be upgraded to meet the following minimum requirements:

a. Intel I5 3GHz.
b. 8 Gb RAM.
c. 19" LCD monitor.
d. Minimum Windows or 7 Professional Operating System.
e. Provision of mouse and keyboard.
f. System software and Network licence with 25% spare network capacity.
g. Copy of all information requested in the Documentation section of this document.

16.1.4.1 System Software

The head end software must be the latest version of Lighting Control System available and utilise a Network licence with at least 25% spare capacity. The LCP and LCSN software must be setup to provide the following minimum functions:

a. Setup and store all time-based schedules in head end software.
b. Provide simple and clear method of monitoring and adjusting of time schedules from main graphics screen.
c. Provide the ability to manually enable / disable time schedules from main graphics screen.
d. Provide the ability to manually override areas controlled by time schedules.
e. Provide the ability to manually control and monitor all LCP controlled loads via buttons or graphical floor plans. The layout and descriptions of these components are to be logical and utilise per University naming conventions.

16.1.5 Logic and scene processing

Each LCS and LCSN must include a local logic controller. The function and purpose of these controllers is to:

a. Provide all local conditional logic processing for the respective network. This must increase system reliability by removing critical reliance on backbone topology and central head end PC for essential tasks.
b. Store and process all lighting scenes that apply to the local network. Lighting scenes are to be stored in the respective LCP central control unit whenever possible.
c. The building central PC station should have the ability to override all other LCS controlled devices on that network that are not controlled by any other local System device (e.g. local light switch panels, PIRs etc.). All graphic components on the system software are to be clearly labelled for easy navigation by the end user.
d. The location and basic function of each logic controller (i.e. local light switch panels and AMX touch screens) must be noted in the head-end software. Comprehensive manuals must be provided to detail the function of the logic controller and where applicable assist the end user to operate all relevant menus on touch screens.

16.1.6 Interfacing to BMCS

In buildings where interfacing to the BMCS is implemented (via BACnet), this interface must be upgraded to:

a. Make all necessary wiring changes to ensure physical connectivity between LCSN and BMCS.
b. Ensure BACnet gateways are setup with suitable IP settings and are operating correctly.
c. Test and confirm connectivity between LCSN and BMCS at each BACnet gateway location. This must be completed with the BCMS services contractor.
d. Work with mechanical services contractor to determine lighting zones across all levels and ensure BCMS graphics represent LCS layout.

16.1.7 Site Testing

A test plan must be produced by the Contractor prior to commencement of installation. Once the installation and programming of the LCSN is complete, the Contractor must carry out site testing in accordance with the test plan. As each test is performed with a passing result this must be recorded on the test plan. As a minimum, the following tests must be included in the test plan and performed prior to sign-off.

16.1.7.1 System to Earth short test

Use a multi-meter to measure absolute voltage on the communications bus as stipulated by the manufacturer of the LCS system.

16.1.7.2 Minimum System Voltage

Use a multi-meter to test the voltage from System negative to System positive. Test the voltage at various points on the network, particularly at points where System units are located at the greatest distance from a System power supply.

16.1.7.3 System Functionality Test

Verify that all System inputs and outputs function correctly by carrying out the following minimum checks:

a. Confirm that every output channel controls the correct load.
b. Confirm that every input unit controls the correct outputs.
c. Test all power failure recovery settings.
d. Test all movement sensor time out operations.
e. Test and calibrate any light level sensors.

f. Test all Ethernet backbone connectivity and devices.
g. Test all BMCS interfacing with mechanical services contractor.

16.2 Attachment 2 – Lighting Control Methodology Example

Below represents a lighting control methodology for business hours and after-hours functionality. The intent of the methodology is to inform the client how a room space operates during business hours and after-hours and what other systems the lighting system integrate with. Some key notes are below:

h. The Control Type Reference (A, B) are references from Section 6.10 of this standard.
i. The second image relates to a design plan layout and how the space operates and should align with the table.

USYD CONTROL METHODOLOGY_Rev0						
Control Type - Reference to CIS Standard	**Business Hours / After Hours**		**Daylight Harvesting**	**Motorised Blind Control Integration**	**AV Integration**	**Mechanical Integration**
	ON	**OFF**				
	EXAMPLES ONLY	**EXAMPLES ONLY**				
A	Lighting to be turned 'ON' via local switch.	Default mode of luminaires is OFF. Lighting to be turned 'OFF' via local switch.	N/A	N/A	N/A	Sensors must be integrated with mechanical AC.
B	Lighting to be turned 'ON' via local switch, which activates occupancy sensor. Occupancy sensor turns lights 'ON'.	Lighting to be turned 'OFF' via local switch. PIR occupancy sensor to be activated once lighting is switched on. Should no motion be detected for a period of 15 minutes, the sensor will switch lights 'OFF'.	N/A	N/A	N/A	N/A