Smart Campus

Design Standard

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TAFE NSW would like to pay our respect and acknowledge Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of the Land, Rivers and Sea. We acknowledge and pay our respect to the Elders; past, present and emerging of all Nations.

TAFE NSW Deniliquin Connected Learning Centre - Collaboration Pod

Rev	Issue date	Issue	Amendments since previous issue
2	18 April 2022	Second Draft	Updates and Inclusions from Workshops
3	12 May 2022	Third Draft	Updates and inclusions from Workshops
A	01 June 2022	Final	Updates and inclusions from Workshops
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This document is a design standard only. The project team retains responsibility for the coordination, design, procurement and delivery of Smart Campus infrastructure which will include taking all reasonable steps to make sure that the selection complies with all applicable Australian Standards required by the NCC, WHS Legislation, Statutory planning approval processes, TAFE NSW Procedures & Policies, and all other relevant statutory requirements.

TAFE NSW Deniliquin Connected Learning Centre - Media Lounge

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Introduction

1 Introduction

1.1 Overview

The TAFE NSW Smart Campus Design Standard outlines the principles of implementing connected technologies, improving the consistency of TAFE NSW sites, and providing a roadmap towards the progressive implementation of Smart Campus systems across the TAFE NSW portfolio.

This Design Standard provides specific guidelines for the planning, design, operation and maintenance of smart campus systems and sub-systems within built environment projects across TAFE NSW.

Smart Campus is not an additional layer on top of current building design practices. Rather, all projects are to use this Design Standard to inform the integration of inherent Smart Campus principles and initiatives.

This Design Standard applies to a variety of physical environments including but not limited to new buildings, refurbishments, external campus spaces, clusters of learning areas or individual spaces within existing or new buildings.

The key principles for the development of this Design Standard have been derived from intensive user workshops and an iterative design process.

Based on guiding principles, this Design Standard is designed to inform the infrastructure and design requirements today to enable scalable implementations of Smart Campus technology into the future.

1 Introduction

1.2 Audience

The table below broadly defines the diverse audience this Design Standard is written for and the roles they play through the design, selection and delivery process.

Group	Members	Group's Roles
Consultants	▪ ICT Consultants ▪ Architects ▪ Engineers ▪ Building Information Modellers ▪ Security Consultants ▪ Project Managers ▪ NSW Government Agencies ▪ Universal Design Experts	▪ To understand the design requirements, and work together to design and develop building intelligence systems to suit project needs, completely integrated with the interior and exterior architecture; ▪ To facilitate an integrated, collaborative design process across the TAFE NSW Project Team and Operations & End User groups; ▪ To research global smart infrastructure innovations and develop best-practise Smart Campus solutions for TAFE NSW in line with the Design Fundamentals in this Design Standard.
TAFE NSW Project Team	▪ Programme Managers ▪ Design Managers ▪ Strategic Planning ▪ Procurement Group ▪ Sustainability Group ▪ Teaching & Learning Representatives ▪ Logistics ▪ Systems Group ▪ Safety & Security Group ▪ Physical Access Advisory Group	▪ To assist with project technology briefing requirements and identify educational and operational needs; ▪ To continually review the design & deliverables across multiple disciplines to ensure compliance with this Design Standard; ▪ To guide project stakeholders through design development & facilitate collaboration with all stakeholders; ▪ To assist in the installation, commissioning and handover processes.
TAFE NSW Operations & End Users	▪ Teaching Staff ▪ Product Team ▪ Data Analysts ▪ Facilities Management ▪ TAFE NSW Digital Stakeholders ▪ Education Planning & Services Delivery ▪ Learner Experience Group ▪ Product Group ▪ Change Management Group ▪ Delivery Implementation & Performance ▪ Customer & Stakeholder Relations ▪ Learner Support Services	▪ Resolve relevant Smart Campus systems for each project; ▪ To use data gathered from Smart Campus systems or otherwise to inform design requirements and focus areas; ▪ To collaborate with the Consultants and TAFE NSW Project team and provide feedback on design strategies; ▪ To gather feedback from users and customers to enable the continued rollout of Smart Campus.

1 Introduction

1.2 Audience

Group	Members	Group's Roles
Contractors	▪ Head Building Contractors ▪ Master System Integrators ▪ Services Contractors ▪ Software Developers ▪ Systems Programmers	▪ To build the virtual and physical Smart Campuses in accordance with the design and this Design Standard; ▪ To engage competent individuals to complete commissioning of Smart Campus devices, systems and associated software; ▪ To understand the obligations of a building contract with respect to engaging sub-contractors skilled in software development, networking and integration; ▪ To provide training of end-users in the operation and maintenance of installed Smart Campus systems.
Suppliers	▪ Technology platform suppliers ▪ Sensor and device manufacturers ▪ Electrical and mechanical system manufacturers ▪ Software suppliers ▪ Human interface system suppliers	▪ To recommend suitable technology systems that may be implemented in a smart campus, and that meet TAFE NSW's systems and operational requirements; ▪ To provide integration advice and application programming interfaces to facilitate the delivery of Smart Campus using one's products; ▪ To provide and honour warranty and support structures to support the ongoing maintenance of Smart Campuses; ▪ To provide advice to the project team regarding products or systems that comply with this Design Standard; ▪ To assist in providing training to end-users.

1 Introduction

1.3 Standards & Documents

The following standards and documents, as relevant to the project, should be read in conjunction with this Design Standard. This list is not exhaustive and other documents may apply.

1.3.1 External Requirements

Statutory Requirements

The planning and design must incorporate the relevant requirements as stipulated by the following Statutory Authority bodies:

- State Environmental Planning and Assessment Legislation;
- All Commonwealth, State and Local Government Legislation;
- Insurance Council of Australia;
- Fire & Rescue NSW;
- Australian Communication Authority;
- National Construction Code/Building Code of Australia;
- Principal Certifying Authority;
- Electricity Distributor's (Network) Requirements;
- Electricity Retailer's Requirements;
- NSW Wiring and Installation Rules;
- Clean Energy Council;
- Work Health and Safety Act;
- Disability Discrimination Act;
- Safe Work NSW Authority Requirements;
- Australian Signals Directorate - Australian Cyber Security Centre - Essential 8 and the Information Security Manual;
- Any authority identified as part of the Conditions of Consent;
- Any other authority having jurisdiction.

External Certification Schemes

- Green Building Council of Australia (GreenStar) and other recognised certification schemes (e.g. GECA, etc.).

NSW Government Policies

- NSW DPIE Workplace Design Principles;
- NSW Government Electric Vehicle Strategy;
- NSW Climate Change Policy Framework;
- Better Placed - Design objectives for NSW;
- NSW Government Resource Efficiency Policy (GREP);
- NSW Government Net Zero Plan Stage 1 2020-2030;
- DigitalNSW Artificial Intelligence (AI) Policy;
- DigitalNSW NSW Digital Government Strategy;
- DigitalNSW NSW Cyber Security Policy;
- DigitalNSW Internet of Things Policy Guidance;
- DigitalNSW NSW Government Smart Infrastructure Policy;
- DataNSW NSW Government Open Data Policy;
- DataNSW NSW Data & Information Custodianship Policy;
- DataNSW Smart Places Data Protection Policy.

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1.3 Standards & Documents

1.3.2 TAFE NSW Requirements

TAFE NSW Overarching Policies

- Environmental Sustainability Policy;
- Reconciliation Action Plan;
- Diversity and Inclusion Policy;
- Work Health and Safety Policy;
- Disability Inclusion Action Plan and Implementation Guide;
- Information Security Management System Controls Manual.

TAFE NSW Interconnected Training Network

- Interconnected Training Network Design Principles;
- Interconnected Training Network Design Procedures;
- TAFE NSW Structured Cabling System Specification v2
- TAFE NSW SCS Specification for Patch and Fly Leads December 2020
- Other Design Standards relevant to project.

1 Introduction

1.3 Standards & Documents

1.3.3 Standards

The following are international standards, some of which have been adopted by Standards Australia, informing agreed best practises for preparing building designs, data infrastructure and supporting information technology systems to support the technologies outlined in this Design Standard. These should be used as a guideline.

Code Standards	Description
ANSI/BICSI 007	Information Communication Technology Design and Implementation Practices for Intelligent Buildings and Premises
ANSI/TIA 862-B	Structured Cabling Infrastructure Standard for Intelligent Building Systems
AS IEC SRD 63235	Smart city system — Methodology for concepts building
ISO/IEC 18033-7	Information security — Encryption algorithms
ISO/IEC 38507	Information technology — Governance of IT — Governance implications of the use of artificial intelligence by organizations
ISO/IEC 19944-2	Cloud computing and distributed platforms — Data flow, data categories and data use — Part 2: Guidance on application and extensibility
SA TS ISO 22330	Security and resilience — Business continuity management systems — Guidelines for people aspects of business continuity
Project Haystack	An Open Source suite of technology standards used for modelling Internet of Things data

The following Australian Standards and international standards form the basis of best practises for building information modelling (BIM), as a standard requirement for all TAFE NSW projects.

Code Standards	Description
BIM-MEPAUS	Guidelines for creation of reliable data management schema in BIM software
NATSPEC NBG	NATSPEC National BIM Guide and Project BIM Brief Template
ISO 22057	Sustainability in buildings and civil engineering works — Data templates for the use of environmental product declarations (EPDs) for construction products in building information modelling (BIM)
ISO 19650 - Series	Organization and digitisation of information about buildings and civil engineering works, including building information modelling (BIM)
Australian Standard AS ISO 16739	Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries
Australian Standard AS 1100 - Part 1	Technical Drawing – General Principles
Australian Standard AS 1102	Graphical Symbols for Electrotechnology
Australian Standard AS 4383	Preparation of Documents Used in Electrotechnology

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1.3 Standards & Documents

The following Australian Standards must be followed for any electrical components or installations designed whilst following this Design Standard:

Code Standards	Description
Australian Standard AS/NZS 3012	Electrical Installations - Demolition and Construction Sites
Australian Standard AS/NZS 3000	Wiring Rules
Australian Standard AS/NZS 3008	Electrical Installations - Selection of Cables
Australian Standard AS/NZS 3013	Electrical Installations - Wiring Systems for Specific Applications
Australian Standard AS/NZS 3017	Electrical Installations - Testing and Inspection Guidelines
Australian Standard AS/NZS 61009.1	Residual current operated circuit breakers with integral overcurrent protection for household and similar uses (RCBOs)
Australian Standard AS/NZS 3131	Plugs and Socket Outlets for use in Installation Wiring Systems
Australian Standard AS/NZS 3760	In-service Safety Inspection and Testing of Electrical Equipment
Australian Standard AS/NZS 61000	Electromagnetic Compatibility (EMC) - General standards

The following Australian Standards must be followed for any telecommunications components or installations designed whilst following this Design Standard:

Code Standards	Description
Australian Standard AS/NZS 3084	Telecommunications installations – Telecommunications pathways and spaces for commercial buildings
Australian Standard AS/NZS 3085	Telecommunications installations – Administration of Communications cabling systems – Basic Requirements
Australian Standard AS/NZS 11801 - Series	Information Technology – All Parts (Particular reference is made to Part 6 which determines Distributed Building Systems)
Australian Standard AS/CA S008	Requirements for Customer Cabling Products
Australian Standard AS/CA S009	Installation Requirements for Customer Cabling (Wiring Rules)

1 Introduction

1.3 Standards & Documents

The following International Standards must be followed concerning the manufacture, design and implementation of systems conforming to this Design Standard:

Code Standards	Description
ISO 9001	Criteria for Quality Management System
ISO 14001	Criteria for Environmental Management System
ISO 27001	Criteria for Information Security Management

The following Australian Accessible Design Standards and Regulations must be followed concerning the manufacture, design and implementation of systems conforming to this Design Standard:

Code Standards	Description
Australian Standard AS 1428.1	Design for access and mobility – General requirements for access – New building work
Australian Standard AS 1428.2	Design for access and mobility – Enhanced and additional requirements – Buildings and facilities
Australian Standard AS 1428.3	Design for access and mobility – Requirements for children and adolescents with physical disabilities
Australian Standard AS 1428.4	Design for access and mobility – Part 4: Means to assist the orientation of people with vision impairment
Australian Standard AS 1428.5	Communication for people who are deaf or hearing impaired
IEC 62489-1	Electroacoustics - Audio-frequency induction loop systems for assisted hearing - Part 1: Methods of measuring and specifying the performance of system components
IEC 62489-2	Electroacoustics - Audio-frequency induction loop systems for assisted hearing - Part 2: Methods of calculating and measuring the low-frequency magnetic field emissions from the loop for assessing conformity with guidelines on limits for human exposure

1 Introduction

1.4 Definitions

1.4.1 Abbreviations

Abbreviation	Definition
AI	Artificial Intelligence
API	Application Programming Interface
BIM	Building Information Modelling
BLE	Bluetooth Low-Energy
BMCS	Building Management & Control System
DBR	Digital Building Representation
DEP	Digital Execution Plan
EMS	Energy Management System
ESD	Ecologically Sustainable Development
HPD	Human Presence Detector
ICT	Information & Communications Technology
IT	Information Technology
ICN	Integrated Communications Network
IP	Internet Protocol (context-dependent, typically shortform for TCP/IP)
IP	Ingress Protection (context-dependent, where referring to waterproofing/dustproofing ratings)
ITN	Interconnected Training Network
LAN	Local Area Network
LOD	Level of Detail (in the context of BIM)
ML	Machine Learning
MSI	Master System Integrator
NFC	Near-Field Communication
OT	Operational Technology
PMS	Parking Management System
PoE	Power over Ethernet
QR	Quick-Response Code
TCP	Transmission Control Protocol
VLAN	Virtual Local Area Network

1 Introduction

1.4 Definitions

1.4.2 Terms

Terms	Description
Approved	"Approved", "reviewed", "directed", "rejected", and similar expressions mean "approved (reviewed, directed, rejected) in writing by the TAFE NSW appointed delegate"
Endorsed	"Endorsed", "sighted", "noted" and similar expressions mean "endorsed (sighted, noted) by a TAFE NSW appointed delegate with no formal comment given"
Give notice	"Give notice", "submit", "advise", "inform" and similar expressions mean "give notice (submit, advise, inform) in writing to the TAFE NSW appointed delegate"
LOD	"Level of Detail" in the context of Building Information Modelling refers to the complexity of the representation of objects in the 3D model. A guide to the levels of detail referenced in this document is as follows: ▪ LOD 100: Symbol, massing or other generic representation; ▪ LOD 200: 3D model with approximate geometry and metadata; ▪ LOD 300: Detailed 3D model with realistic geometry, metadata and interdisciplinary coordination; ▪ LOD 400: 3D model with accurate dimensions, suitable for fabrication; ▪ LOD 500: Equal to LOD 400 with the inclusion of asset metadata representative of real-world installation.
Obtain	"Obtain", "seek" and similar expressions mean "obtain (seek) in writing from the TAFE NSW appointed delegate"
Principal Certifying Authority	Person qualified to conduct a certification of Crown building works
Proprietary	"Proprietary" mean identifiable by naming manufacturer, supplier, installer, trade name, brand name, catalogue, or reference number
Provide	"Provide" and similar expressions mean "supply, install and commission"
Supply	"Supply", "furnish" and similar expressions mean "supply only"
Samples	Includes samples, prototypes and sample panels
this Design Standard	TAFE NSW Smart Campus Design Standard

1 Introduction

1.4 Definitions

1.4.3 How this Design Standard applies

Compliance

This Design Standard is intended to support and assist the selection, design and procurement of technology systems required to meet TAFE NSW's Smart Campus strategy.

This Design Standard must also be read in conjunction with:

- Statutory and legislative requirements
- Any project or supplier contractual agreement with TAFE NSW
- The project brief and relevant project requirements
- Any other TAFE NSW Design Standards

Where there is a conflict between this Design Standard and any statutory or legislative requirement, the higher standard applies.

Mandatory/must:

Where the word "must" is used, this indicates that a statement is mandatory.

Preferred/should:

Where the word "should" is used, this indicates that a statement is a recommendation.

Contractual Responsibility

The contents of this Design Standard does not relieve any consultant, contractor or supplier from their contractual responsibility relevant to the project.

It remains the responsibility of the consultant, contractor or supplier to fully complete, coordinate and identify any errors or omissions in the documentation produced for the architectural and engineering designs.

Queries

Any project specific queries are to be raised through the TAFE NSW project lead, or project manager as applicable.

If this document appears to contradict or deviate from good industry practice or any statutory requirements, this is to be brought to the attention of the TAFE NSW project lead responsible for the delivery of the Smart Campus design project.

Design Fundamentals

2 Design Fundamentals

2.1 General

TAFE NSW's definition of a Smart Campus is a high-performance built environment, utilising emerging sustainable technologies to enhance educational and operational outcomes that respond to the needs of individuals, industry and communities across NSW.

A Smart Campus merges Information Technology (IT) - the computer systems that create, process, store and exchange data that people interact with every day; with Operational Technology (OT) - the systems that monitor and control physical assets in the real world.

The successful implementation of a Smart Campus requires the design process to meet these Design Fundamentals, ensuring that open standards and industry standard design approaches are used. A Smart Campus design requires critical thinking and input from all involved parties.

Whilst many aspects of Smart Campus applies to building engineering services, a mutual understanding and respect of the Design Fundamentals that follow is required by all stakeholders. For example, the architect must ensure that application of technologies are aesthetically sound, and TAFE NSW stakeholders must ensure that any proposed new learning systems carry a sound pedagogical benefit.

The overall intent of defining Smart Campus principles in this Design Standard is that the planning, design, installation and configuration is to be holistic, accessible, integrated, and consistent across all future TAFE NSW campuses.

2 Design Fundamentals

2.2 Approach to Technology

When devising the application of a new technology, follow the five fundamental paradigms of Smart Campus – Automated, Sustainable, Human-Centric, Flexible, and Value-Added to ensure that the technology system is fit for purpose.

The tables below detail these five fundamental requirements that must be applied when researching, benchmarking, developing and integrating Smart Campus technology.

2.2.1 Automated

A smart building regulates its own environment, is driven by data to learn the behaviour of its occupants, and uses cloud computing power to create new data from sources already in existence.

Strategy	Requirement
Acquisition	It is preferable for systems to be built on a data-acquisition first framework, using arrays of sensors and detection equipment to gather real-life data. Systems that estimate or use artificial intelligence to infer conditions may be acceptable in limited circumstances, however their use should be minimised. Systems should use the best data acquisition tools available in the present day, and take advantage of continual technological improvements.
Global Data Handling	All data produced and used by a system must be processed on the global TAFE NSW Data Platform, as all data gathered is to provide TAFE NSW with overall intelligence across all campuses. Data produced by any device must contain key metadata to enable a user or an automation system to identify the source and context of the data.
Local Conditions	Automation of systems must be considerate of local conditions even when globalised data is used to control or oversee a system's operation. A typical example is climate – a system should not rely on climate data for one region to inform the operation of a system in a different region.
Processing	It is preferable that data processing for the purpose of automation, e.g. artificial intelligence/machine learning be completed using cloud services on the TAFE NSW Data Platform, and not on local 'head-end' units, to ensure that data can be collected for analysis. Note that this does not forbid edge devices from completing basic computations to ensure a sensible, controlled flow of data.

2 Design Fundamentals

2.2 Approach to Technology

2.2.2 Sustainable

Intelligent building design and ecological sustainability are two key goals that are co-dependent. Smart building technologies are integral to reducing and monitoring energy consumption, tracking water and other natural resource usage, regulating clean energy production and distribution, and encouraging sustainable lifestyles such as stimulating active transport and uptake of electric vehicles.

Strategy	Requirement
Controls	Smart Campus technology used in the areas of energy, water/resources or mechanical services must exceed the minimum ecologically sustainable development (ESD) goals applicable to the project. These controls will allow future optimisations, as well as a potential learning tool for related courses.
Data Collection	Any data collected regarding resource usage must be used and implemented in the TAFE NSW Data Platform to further TAFE NSW’s goals on monitoring resource production and consumption. TAFE NSW is committed to several environmental goals, including minimising environmental degradation, responsible waste management, reduction of sociological harm, and combating the effects of climate change. Data is not to be acquired, stored or otherwise used without prior TAFE NSW agreement (data sovereignty may also apply).
Resource Usage	Implementation of any Smart Campus technology must not adversely increase the use of resources such as power, water and the waste management cycle. Smart Campus devices are preferred to comprise extra low-voltage, low-powered units, free of consumables. Where possible, devices selected should be able to be upcycled or recycled at end of life, and any packaging should be manufactured from recyclable and/or biodegradable material.
Longevity	Commensurate with TAFE NSW's commitment to reducing electronic waste, selection of hardware devices for Smart Campus technology implementations must be considerate of a long-term installation. Degradation and disposal of materials is to be minimised. Device selection must strike a balance between longevity, recyclability or minimisation of components as a strong consideration during the planning phase. In the event of failure, devices should be serviceable with parts, rather than require wholesale replacement.
Locality	It is preferable for Smart Campus systems to be sourced from local companies with sustainability credentials where possible. Vendors are expected to have sufficient stock and parts available in Australia.
Verification	Smart Campus technologies allow for the benefit of verification of adopted initiatives and design principles. These benefits can be communicated to TAFE NSW and its communities and support future business cases for the adoption of these initiatives.

2 Design Fundamentals

2.2 Approach to Technology

2.2.3 Human-Centric

Closely linked to sustainability is the human factor of wellness. Through the incorporation of Smart Campus technology, a building and its wider campus should facilitate TAFE NSW's learners and staff to be their most comfortable, productive, healthy and happy selves.

Strategy	Requirement
Accessibility	Systems that interface with or require input and control by TAFE NSW end users must be accessible for all users regardless of level of ability. Designs must incorporate principles of universal design and "design with dignity", exploring considerations beyond the obvious and throughout the design phase, never as an afterthought. Use cases should be workshopped with end users, and needs assessed from many perspectives, e.g. physical ability, mental ability, digital literacy, language, cultural diversity, etc.
Diversity	It is important to consider user comfort and usability for systems involving user input. Systems must be designed to consider the diversity of the various potential users. For example, interactive technologies designed for public use should have an option for operation in multiple common languages.
Digital Divide	If a Smart Campus technology implementation requires interaction with a system or device provided by its user - such as a smartphone application, it should be reasonably considerate of alternate technologies suitable for users with all types of devices. For example, a system that requires mobile phones to use may support QR codes as a fallback method for users whose devices may not support near-field communication or the latest versions of Bluetooth.
User Experience	Systems involving user input must be simple to use and intuitive. User input tasks should be completed in a minimum number of steps – the goal is to minimise interaction with technology, as the technology should be working in the background. User interfaces must be written with plain language accessible to a wide audience. The user interface also is required to be non-distractive in nature - the interface should not get in the user's way nor provide excessive visual or aural distractions, such as push notifications.

2 Design Fundamentals

2.2 Approach to Technology

2.2.4 Flexible

Smart building technology needs to be adaptable to existing spaces, and when incorporated into new spaces, it must last the distance, and not fall into obsolescence. As a guide, consider implementation of technology to be based on 'data' and not 'gadgets'.

As innovation occurs over time, systems and applications that have not been traditionally connected to a data or telecommunications network are now utilising Ethernet and network infrastructure as a means to provide new or expanded functions or as a wholesale replacement for 'traditional' methods of connectivity.

Because of this increased focus on convergence, and the widespread use of IT & OT transmission media (e.g., balanced twisted–pair, optical fibre, wireless) within these systems, the design and implementation methodology based on the historical practice of using legacy, proprietary or application specific cabling systems (such as one or two pair solid copper conductor wire) is now obsolete.

Strategy	Requirement
Adaptability	Devices used as part of Smart Campus systems must not be hard-wired. Instead, devices are to be selected to be removable or upgradable through flexible wiring and connectors, or use wireless technology.
Agility	Smart Campus systems must be agile; able to be replaced, updated or upgraded when requirements change over time. The supporting architecture and infrastructure thus must consider access and configurability. Good access to devices and wiring is a requirement for any repairs or upgrades.
Expandability	Systems included in Smart Campus applications should not impose finite limits on add-ons. Systems should be expandable to include additional devices and technologies.
Longevity	Smart Campus applications must be designed and built with a minimum 10-year design life cycle. This is applicable to both hardware and software. Systems should demonstrate increased responsiveness to issues, both present and potential.
Plug and Play	Devices used as part of Smart Campus systems must readily integrate with the system with minimal configuration.
Repeatability	Devices used as part of Smart Campus systems must be able to be replicated based on previous installations with minimal additional configuration.
Supporting Infrastructure	New builds and major refurbishments must be designed so that common areas and learning spaces are provided with sufficient wired and wireless infrastructure consistent with the best practises of the day to support the addition, modification and removal of devices.

2.2.5 Value-Added

A smart building should make good business sense, and overall improve the performance of TAFE NSW campuses. Facilities maintenance aspects, like systems that report of potential problems before they occur, or creating a ‘digital twin’ building using 4D BIM techniques, are examples of methods that smart campus integration will make tangible financial sense in the long-term.

Strategy	Requirement
Business Case	Any new system included as part of the Smart Campus ecosystem must be presented to TAFE NSW with a business case document to note educational and/or operational outcomes to be realised through the implementation of that technology. Doing so should be encouraged with minimal impediments, as TAFE NSW recognises that Smart Campus investments are fundamental to future learning and teaching objectives.
Digitisation	Digitisation of buildings and infrastructure, as key NSW Government policy, must be applied to all Smart Campus design and implementation projects. It is key that all building assets are digitised to the level of detail stipulated in this Design Standard, to facilitate the ingestion of a completed project into the TAFE NSW Data Platform. Digitisation shall also facilitate the analysis of built infrastructure to note redundancy and resource wastage.
Operational Cost	Implementation of Smart Campus infrastructure must be considerate of ongoing operational costs to remove or reduce the ongoing upkeep of systems and supporting software. Duplication of costs at different layers of the system architecture should be removed - for example, the use of proprietary Software-as-a-Service installations to perform tasks that could already be achieved by TAFE NSW's Azure platform should be avoided.
Working World	Smart Campus should prepare learners for the working world, providing valuable analogues to the workplace. The systems should simulate systems, tools, environments and also modern working cultures to promote a positive, healthy workforce.

2 Design Fundamentals

2.3 Educational Outcomes

When undertaking research and development for new Smart Campus technology systems, ensure the technology system provides an investment for the future, and is consistent with TAFE NSW's goals for realising pedagogical benefits.

Application of Smart Campus technologies must directly or indirectly realise benefits to teaching, learning and ancillary outcomes.

The introduction of new smart campus technologies into the learning environment will also trigger the need to develop digital pedagogies for teachers to ensure they have effective strategies, resources and methods to deliver training using digital technologies.

Strategy	Outcome
Accessibility	Application of technology must follow the principles of universal design, and be delivered in a manner that does not discriminate against, nor disadvantage, any learners or staff members.
Availability	Application of technology should allow learners the opportunity to embrace a flexible learning schedule, in response to industry demands for skilled workers. Systems designed to facilitate decentralised learning should be available to use across all TAFE NSW campuses, enabling equitable availability of course material and technologies from all regions in NSW.
Cross-Pollination	Application of technology that delivers an operational outcome to TAFE NSW should whenever appropriate be used as a teaching and learning tool to further the practical advantages of Smart Campus. For example, digital representations of TAFE NSW buildings should be used as an educational tool in building related curricula.
Equity	Learners must have access to technologies that support their learning in an equitable manner. Under no circumstances should application of technologies cause a 'digital divide' or 'equity gap' either to a learner's personal situation, or between TAFE NSW campuses.
Industry	Application of technology should expose learners to real-world technological advancements in their industry. The use and familiarity of such technology to learners should empower them to further their employment opportunities upon graduation from TAFE NSW.
Learner-Focused	Application of technology should ensure that learners are given education delivery options suitable to a range of learning styles, that helps them do their best work.
Participation	Application of technology in a learning environment should reduce "barriers" to class participation, and never create additional "barriers".
User Experience	Application of technology used in a teaching and learning environment should be user-friendly and intuitive for both learner and instructor. For example, user interfaces should be free of technical jargon, and enable the user to perform their task in a minimum of steps.

2 Design Fundamentals

2.4 Operational Outcomes

Technology systems included as part of Smart Campus must be designed and built to support operational advances across the wider TAFE NSW ecosystem.

Strategy	Outcome
Deduplication	Interconnectivity of technology systems and use of data must be applied where possible to avoid duplication of tasks. As an example, usage of data gathered by one system that would provide useful information to another should be identified and implemented.
Efficiency	Application of technology must improve the efficiency in delivery of business operations. No technology shall introduce a burden, additional work, or complications to an officer's daily routines.
Intelligence	Artificial Intelligence (AI) may be incorporated to programmatically interpret and adjust building systems based on long-term data gathering. Use of AI however must be considerate of Section 2.5 of this Design Standard.
Neutrality	No technology systems shall be dependent on any one supplier, or involve proprietary closed technologies to realise its outcome. Considered application of technologies must not create costing, transition, and legacy issues due to a closed or defunct ecosystem.
Maintenance	Application of data-driven control platforms within Smart Campus will minimise maintenance requirements and/or improve productivity of building systems through issue identification, preventative maintenance scheduling, and continual monitoring of operational performance.
Relevance	Technology systems must be designed to provide useful data and operational outcomes over the long-term – 10 years or more. Where this is not possible/ achievable, an upgrade path must be identified and documented upon technology system selection. Technology systems selected must be maintainable and supportable with all required manufacturer upgrades and software patches over the operational life of the system.
Support	Information Technology (IT) and Operational Technology (OT) systems implemented as part of Smart Campus must be designed and built to be adequately supported by TAFE NSW Systems Group. Technology should be seamless and low-maintenance; no system should be installed that requires constant technical support to operate. Conversely, technology systems must be well supported by their suppliers, vendors or manufacturers. Any systems/tools/applications that will be networked must be compliant with current Systems Group standards and operating models, or, where innovative must be reviewed and approved for adoption into the TAFE NSW operating environment. Systems nominated must be centrally manageable on scale via a single management tool, and/or be manageable via established Systems Group tools and techniques to permit remote diagnostics, alerting, reporting, log capture, incident management and general operations. All operating systems and applications must be upgradable via a central management tool. Patch software must be available for TAFE NSW implementation within the prescribed period to be compliant with the ACSC Essential 8. Note: A security assessment will need to be conducted for any solution not meeting these requirements. Treatment may include isolating the solution to an unreachable network.
Trialled	Technology systems must be trialled and tested in staging environments prior to final implementation, to gauge end-user feedback and acceptance.

2.5 Data Collection and Use Strategy

Introduction of connected technology systems has the potential for data collection and usage to be applied at a far greater scale than in a traditional campus installation.

The implementation of Smart Campus systems must enable effective collection and use of data, ensure the continued safety and security of personal information, and discourage abuse of data.

Strategy	Outcomes
Attribution	All data collection must be pre-defined with metadata attributes following accepted naming conventions consistent across all installations. This is closely linked to the 'Sanitisation' requirement. Refer to Section 4.1.2 for further guidance.
Availability	Data from a Smart Campus system should be highly available, irrespective of the access platform or the geographical location of the user. As the intent is for data and its applications to be served from the cloud, availability should be universal for authorised users.
Capacity	The design of data transfer systems between Smart Campus systems must be built to consider their effect on network and electrical loading, and be considerate of storage costs and impact. The transfer of data should be reasonable in scope to ensure network congestion is kept to a minimum. The amount of storage should be accounted for in the design, including how data is maintained and removed or archived over time. For example, polling or sample rates of devices should be set to provide the minimum usable volume of meaningful data to save on bandwidth and in turn power consumption.
Catch-All	Where possible, all data from a Smart Campus system or sub-system should be aggregated into the TAFE NSW Data Platform for analysis (with respect to correct data entry requirements, including 'Sanitisation') even if there is no immediately obvious use for the data.
Connectivity	All network connectivity required to support data collection must be enterprise-scale ready and meet Systems Group security and operating requirements.
Consistency	Data gathered as part of Smart Campus systems throughout TAFE NSW must conform to the guidelines of Project Haystack, an open source set of general purpose data types to facilitate interoperability. TAFE NSW specific data types extensible to Project Haystack are nominated throughout this document.
Data	All acquired data must comply with Systems Group standards including encryption at transit and at rest and with agreed data retention policies. All data collected from Smart Campus systems servicing TAFE NSW is subject to NSW Government data sovereignty and must not leave Australian shores without permission. Data collected for AI purposes and the resultant information output remains the property of TAFE NSW and must not be used in entirety or partially without TAFE NSW permission.
Integrity	Data gathered as part of Smart Campus must maintain the academic integrity standards expected of TAFE NSW. For example, remote learning for assessment tasks must require learner identification and authentication.
Privacy	Collection of data throughout any Smart Campus system shall be considerate of human identification. Systems must not collect personally identifiable data unless expressly required for the system to operate (for example – access control, assessment systems). In those circumstances, digital safeguards must be applied in order to protect personally identifiable data from unauthorised access and usage. No Personal information is to be collected, used or shared without express permission of the TAFE NSW CISO.

2 Design Fundamentals

2.5 Data Collection and Use Strategy

Strategy	Outcomes
Real-Time	Data should be gathered from Smart Campus systems and processed into the TAFE NSW Data Platform in real-time, or as close to real-time as practicable for systems that require some level of processing time.
Sanitisation	All efforts must be taken to ensure that data gathered from installed devices is appropriately sanitised. Data should be considered meaningful, intelligible and useful prior to its incorporation into the TAFE NSW Data Platform. Devices incapable of sanitising their own data should have data processed through an interim device or system, such as a data broker, to ensure correct formatting and metadata association.
Security	Security of all gathered data must be at the forefront of importance to ensure trust in the systems is established amongst all users. In line with ICT best practises, a 'Zero-Trust' philosophy must be considered with the implementation of all Smart Campus technologies. Protocols must be included to ensure protection of online material to ensure the security of TAFE NSW intellectual property or internal data.

Applications

3 Applications

3.1 Roles and Responsibilities

Development of Smart Campus facilities is a multi-faceted effort requiring the application of all disciplines' inputs to achieve a high-performance building.

This section of the Standard is intended to guide the project's design and delivery teams to understand their roles and responsibilities for the delivery of Smart Campus.

3 Applications

3.1 Roles and Responsibilities

3.1.1 Consultants

Group	Key Roles
Specialist ICT/Smart Buildings Consultant	▪ Primary responsibility for overarching Smart Campus design strategy, research and implementation across the life of the project; ▪ For detailed role description, refer to Section 3.2.3 Specialist Consultants on page 38.
Specialist BIM Consultant	▪ Primary design responsibility for overarching Building Information Modelling strategy, across all disciplines; ▪ For detailed role description, refer to Section 3.2.3 Specialist Consultants on page 38.
Architects (including Interior Designers and Landscape Architects)	▪ Coordinate architectural design with Smart Campus design strategy and associated services layouts and specifications; ▪ Assist in the development of project smart campus solutions through close collaboration and engagement with services consultants and project stakeholders; ▪ In absence of a Specialist BIM Consultant, the architect's role will include the management of BIM delivery across all consultant disciplines.
Electrical Engineer	▪ Primary responsibility for design, research and development and specification of all electrical and data infrastructure required to support Smart Campus integrations, and specify electrical systems such as lighting controls that integrate with Smart Campus; ▪ In absence of a Specialist ICT/Smart Buildings Consultant, the electrical engineer's role will include the design and implementation of Smart Campus integrations in line with the project scope.
Mechanical Engineer	▪ Primary responsibility for design, research and development and specification of mechanical infrastructure and controls including building management systems.
Hydraulic Engineer	▪ Responsibility for design of hydraulic infrastructure that may connect to Smart Campus infrastructure, such as water meters. Coordinate with the design team to ensure requirements are captured.
Fire Services Engineer	▪ Responsibility for design of fire safety infrastructure that may connect to Smart Campus infrastructure, such as fire indicator panels and trips. Coordinate with the design team to ensure requirements are captured.
Sustainability Engineer	▪ Design reviews and input to ensure system captures and conveys the appropriate environmental metrics and establishes the system requirements to meet sustainable development and environmental targets.
Vertical Transportation Engineer	▪ Integrating Smart Campus requirements for lift movement, predictive planning, energy use and generation.
Security Consultant	▪ Primary responsibility for design and specification of physical and electronic security infrastructure, and coordination of electronic security infrastructure with Smart Campus principles.
Project Manager	▪ Ensure all project consultants and contractors are incorporating the requirements of this Standard in the project design and construction; ▪ Progressive review of project Smart Campus systems; ▪ Manage consultant coordination on Smart Campus across the project; ▪ Seek progressive client design feedback and endorsement for nominated project Smart Campus systems.
NSW Government Agencies	▪ Progressive design review of Smart Campus systems; ▪ Facilitating workshops with Data and Digital teams to confirm alignment with overall NSW Government strategy.
Universal Design Consultant	▪ Progressive design review of Smart Campus and related systems to ensure accessible and equitable design principles are observed.

3 Applications

3.1 Roles and Responsibilities

3.1.2 TAFE NSW Project Team

Group	Key Roles
Programme Managers	▪ Lead role in overseeing all stages of the design, with heavy involvement in the construction phases to manage liaisons between consultants/contractors and other TAFE NSW project stakeholders.
Design Managers	▪ Lead role in defining concept design and initial project engagement stages, to identify project needs, existing conditions and constraints; ▪ Ensure the design standard is referenced in all project consultant engagements and is provided to consultants upon their commencement on the project; ▪ Conduct design reviews of project documentation at each design gateway to ensure the requirements under the standard are met and any non-compliances are discussed and mitigated; ▪ Conduct post-implementation reviews of nominated projects to gauge success of the project.
Strategic Planners	▪ Project lead for major works projects with key involvement in defining the business case; ▪ Ensuring project and solution alignment with the TAFE NSW 20 Year Infrastructure Strategy; ▪ Ensuring key smart system design strategies are captured within the strategic business case.
Development Managers	▪ Responsible for large-scale large vision strategisation inclusive of precinct planning, industry partnerships and regional benefits; ▪ Seeks to use the information gleaned from Smart Campus installations to inform whole-of-state developmental processes.
Facilities Management	▪ Direct local asset register inclusions; ▪ Key stakeholder in commissioning local installation.
Systems Group	▪ Inclusive of Architecture Review Board, Security and Change Advisory; ▪ Key stakeholder to be consulted at every major IT hold point.
Customer & Stakeholder Relations	▪ Responsible for managing learner services and service delivery at a Sub-Regional or Campus level; ▪ Ensure site-specific functionality and operations are working properly; ▪ Act as liaison between Campus staff and faculty and ensure that requirements and concerns are addressed.

3 Applications

3.1 Roles and Responsibilities

3.1.3 TAFE NSW Operations and End-Users

Group	Key Roles
Product Team	▪ Utilise direct feedback from employer customers to influence the design and applications.
Data Analysts	▪ Provide guidance on TAFE NSW data management policies, procedures and use cases; ▪ Key stakeholder in handover of data gathering components.
Education Planning & Services Delivery	▪ Identify learning needs and advise on current developments or implementations with respect to technology-based learning; ▪ Key stakeholder in on-boarding and operational start-up of implementation.
Sustainability Specialists	▪ Overseeing and reviewing sustainability credits, initiatives and embodied design during all project design phases, and ensuring that initiatives are retained throughout construction.
Teaching & Learning Representatives	▪ Act as training delivery subject matter expert throughout concept, schematic and detailed design phases; ▪ Check alignment and offer sound-boarding for new ideas to be raised; ▪ Key stakeholder in commissioning and user acceptance testing.
Logistics	▪ Key involvement in the business case stage, tendering and construction as product procurement commences.
Physical Security Managers	▪ Responsible for progressive review and endorsement of any campus/building security systems integrated into the building/s design; ▪ Assist in the setup/commissioning of the security systems.
Work Health and Safety Group	▪ Provide input as TAFE NSW subject matter experts in project design working groups.
Physical Access Advisory Group	▪ Provide input as TAFE NSW physical access subject matter experts on project working groups during design phase; ▪ Disabilities teacher and/or consultants to be trained on use of components of Smart Campus systems that may be accessed by teachers or learners with a disability.
Technology Access Advisory Group	▪ Key involvement across all design phases and procurement/installation to ensure product selection and interface design embodies accessibility requirements.
Change Management Group	▪ Understand and provide pre-emptive feedback on educational and operational changes throughout the project scope.
Delivery Implementation & Performance	▪ Provide input from industry and community trends and feedback; ▪ Ensure applications meet Registered Training Organisation standards.
Learner Support Services	▪ Ensure applications meet the requirements of libraries, multicultural and skills teams.

3 Applications

3.1 Roles and Responsibilities

3.1.4 Contractors

Group	Key Roles
Specialist Master Systems Integrator	▪ Lead role in implementing the technical delivery of Smart Campus infrastructure, including documentation and trades coordination; ▪ For detailed role description, refer to 3.2.4 Specialist Installers on page 40.
Network Integrator	▪ Party engaged by TAFE NSW to undertake lead role in procuring, installing and integrating the active network; ▪ For detailed role description, refer to 3.2.4 Specialist Installers on page 40.
Software Developer	▪ Responsible for developing custom software integrations and application programming interfaces for new Smart Campus systems not part of the standard TAFE NSW software stack; ▪ For detailed role description, refer to 3.2.4 Specialist Installers on page 40.
Head Contractor	▪ Lead role in managing and undertaking construction of the overall project site.
Electrical Sub-Contractor	▪ Responsible for running and terminating all power and data services as required by the Master Systems Integrator and Network Integrator.
Mechanical Sub-Contractor	▪ Responsible for installing all mechanical services including building management systems, and coordinating terminations including of those of Electrical and Hydraulic sub-contractors. Responsible for coordinating final system delivery with Master Systems Integrator.
Hydraulic Sub-Contractor	▪ Responsible for running and terminating all hydraulics services as required by the Master Systems Integrator and Network Integrator.
Fire Services Sub-Contractor	▪ Responsible for running and terminating all wet and/or dry fire services as required by the Mechanical Sub-Contractor or other Integrators/Sub-Contractors.

3.1.5 Suppliers

Group	Key Roles
Technology platform suppliers	▪ Technical support and integration best-practises; ▪ Software stack including cybersecurity provisions, e.g. certificates; ▪ Provision of end-user training; ▪ Automated software updates and maintenance.
Sensor and device manufacturers	▪ Documentation of integration and ingest methodology; ▪ Ongoing maintenance, inclusive of firmware updates.
Electrical and mechanical system manufacturers	▪ Provision of standards-compliant infrastructure; ▪ Provision of hardware and software platforms for electrical and mechanical equipment, including cybersecurity provisions and software updates.
Human interface system suppliers	▪ Provision of devices, including integration documentation and knowledge base for end-users to program devices; ▪ Proof of conformity to ensure compliance with accessibility guidelines; ▪ Automatic software updates and maintenance.

3 Applications

3.2 Project Applications

3.2.1 Project Types

This Standard is intended to support the design and delivery of a variety of virtual and physical environments including but not limited to the project types below:

Major Capital Works & Special Projects

- All new building and major refurbishment projects must comply with this Design Standard;
- Such projects need to be positioned as a benchmark and best practise for realising nominated Smart Campus technologies;
- Such projects require the appointment of specialist consultants including an ICT/Smart Buildings Technology consultant and a BIM Consultant;
- A prescribed minimum subset of Smart Campus technology applications must be agreed upon with TAFE NSW stakeholders from the project's inception;
- All technologies implemented must be a fully realised TCP/IP and Cloud IoT native solution;
- A "Strong Implementation" of each technology application must be selected and delivered by the design and construction teams.

Minor Works

- All alterations and additions to buildings that include upgrades to systems that have the potential to integrate with smart campus infrastructure (e.g. lighting, HVAC, access control, etc.) must comply with this Design Standard and include a level of implementation of smart campus technology, except where doing so would trigger major upgrades to existing services infrastructure beyond the scope of the project.
- Space utilisation tracking systems must be installed in habitable internal learning environments and workspaces that are significantly changed and/or upgraded under a minor works project;
- Minor works projects which incorporate a teaching and learning upgrade must include a prescribed minimum subset of Smart Campus technology applications;
- If the application of Smart Campus technologies is significant, the appointment of specialist consultants including an ICT/Smart Buildings Technology consultant and a BIM Consultant should be considered;
- A feasibility study must be applied prior to selecting the implementation level of technology applications. A "Strong Implementation" of each technology application should be selected as much as practicable, with a "Reduced Implementation" acceptable if agreed upon as part of the feasibility study.

3 Applications

3.2 Project Applications

Minor Refits

- All minor refits should make every effort to comply with this Design Standard;
- Minor refits may necessitate the upgrades of ICT infrastructure to realise Smart Campus technology applications and should be appropriately considered/budgeted for at project planning phase;
- A "Reduced Implementation" of each technology application may be permitted, with justification;
- Minor refits typically do not require the appointment of specialist consultants or contractors.

Digital/Virtual Implementation

- All design approaches for TAFE NSW works, irrespective of size, must be undertaken using a Building Information Modelling (BIM) workflow;
- For works other than Minor Refits, a Digital Execution Plan (DEP) must be produced for each project, to reflect the strategy for producing digital deliverables throughout, including the approach to 3D modelling, asset data inclusion and eventual integration with real-world building monitoring and control systems;
- For works other than Minor Refits, all physical objects forming part of any Smart Campus technology application must be modelled in BIM to target a level of LOD 400 during the design stage;
- For Minor Refits, a reduced approach commensurate with project requirements is acceptable, culminating in a usable BIM model to target a level of LOD 300;
- BIM projects must be undertaken with reference to the TAFE NSW Data Platform, including allowance for BIM objects to be referenced to their real-world counterparts;
- For works other than Minor Refits, the completion of the construction stage must result in a usable BIM model. Target a level of LOD 400 complete with metadata to the requirements of TAFE NSW's asset management platform.

3 Applications

3.2 Project Applications

3.2.2 Project Stages

This Design Standard references the whole life cycle of any given project. Depending on the user and project type, the requirements in this Design Standard should be used in all or only select stages. The typical stages referenced in this Design Standard follow a typical Capital Works process. The following infographic details the typical design deliverables required to realise the design and construction of a Smart Campus.

Figure 1: Typical TAFE NSW Design and Construction Process

3.2.3 Specialist Consultants

Specialist consultants must be engaged to plan and coordinate the Smart Campus implementations for Major Capital Works and Special Projects. For Minor Works which incorporate significant technology upgrades or are architectually complex in nature, specialist consultants should be engaged in line with project requirements.

For works that do not meet these categories, the implementation of Smart Campus services needs to be ingrained in the project team's documentation to suit the project's immediate requirements. Typically, the Electrical Consultant should assume the responsibility of documenting Smart Campus infrastructure, and the Architect should assume the responsibility of BIM execution and coordination. In each case, the consultant shall demonstrate the assignment of suitably capable staff to the project who can deliver project requirements.

ICT/Smart Buildings Technology Consultant

The leading designer or consultant engaged to complete the detailed design of Smart Campus services integration must be an experienced and suitably qualified Information Communications Technology (ICT)/Smart Buildings consultant.

The consultant shall be covered by professional indemnity and public liability insurance in accordance with the TAFE NSW contract and relevant industry requirements.

At the completion of the briefing stage and at every design stage, the designer must obtain endorsement of the proposed design from the TAFE NSW project team to proceed to the next stage.

The ICT/Smart Buildings consultant must provide an overarching technology strategy for the contracted project and nominate the responsibilities and obligations of all other professional services design consultants to realise a coordinated design that is highly functional and further meets the requirements of specific technology applications. These include, but are not limited to:

- Architect;
- Electrical Engineer;
- Mechanical Engineer;
- Hydraulic Engineer;
- Fire Services Engineer;
- Audio Visual Consultant;
- Vertical Transportation Engineer;
- Sustainability Consultant.

In addition to the project deliverables, the designer has the following obligations:

- Presentation of proposed systems to the TAFE NSW IT Architecture Review Board or nominated project Systems Group representative to align OT/IT strategies for approval and onboarding;
- Review of all documents and specifications provided by the installer to maintain quality of the installation in accordance with the design;

- Undertake a risk and gap analysis during the design and construction phases of all building subsystems and infrastructure;
- Review of samples provided by the installer to maintain quality of the installation in accordance with the design.

BIM Consultant

The role of the Building Information Modelling (BIM) Consultant is to prepare, plan, coordinate and oversee the delivery of the Digital Building Representation (DBR). This commences with the publication of a Digital Execution Plan (DEP), a document that nominates the responsibilities and obligations of all professional services design consultants to produce a coherent, standards-based BIM model.

These include, but are not limited to:

- Architect (Head Designer);
- Interior Designer;
- Landscape Architect;
- Builder (Head Contractor);
- Structural Engineer;
- Civil Engineer;
- Electrical Engineer & Sub-Contractor;
- Mechanical Engineer & Sub-Contractor;
- Hydraulic Engineer & Sub-Contractor;
- Fire Services Engineer & Sub-Contractor;
- Audio Visual Consultant & Sub-Contractor;
- Vertical Transport Engineer & Supplier;
- Sustainability Consultant.

The BIM Consultant will outline the objectives of the design and construction team including protocols, detailed information on deliverables, technical software requirements, workflows and protocols. Critically, this will include defining data structures and variables to be consistent with the TAFE NSW Data Platform.

The BIM Consultant's main goal is to ensure that all parties can deliver a model that at the completion of the project, is integrated into the TAFE NSW Data Platform and usable as a visualisation tool, utilising live data from the project's on-site Smart Campus systems throughout the building's lifecycle.

3.2.4 Specialist Installers

Generally, if the scale of a project has determined that a specialist consultant has been engaged, similarly a specialist installer will be required to plan and implement the construction of the proposed Smart Campus services.

Where a project does not meet this scale, typically the implementation would be carried out by electrical sub-contractors in coordination with TAFE NSW Systems Group for data coordination and linking.

Master System Integrator

The role of the Master System Integrator (MSI) is to undertake the overall technical implementation of the Smart Campus throughout the later stage design and construction stages.

In an Early Contractor Involvement (ECI) Contract, it is useful for the MSI to be involved with the project to assist the ICT/Smart Buildings Consultant in producing a comprehensive design.

The MSI must develop an understanding of the proposed Smart Campus technology Systems incorporated in the project, and be familiar with the TAFE NSW Data Platform.

The MSI will take the Technology Strategy and design documentation from the ICT/Smart Buildings Consultant and develop the integration requirements for all Smart Campus Systems, designing and implementing the on-site components of the platform. The MSI will write connectors and integration scripts to ensure subsystems are connected to the TAFE NSW Data Platform, e.g. data lake, data warehouse, in a secure manner. The MSI will verify the transfer of live data to facilitate further development of the reporting and visualisation platforms by the software developer.

The MSI will be skilled in technical project management and hold formal PRINCE2, PMI or Agile training and current certification. The MSI will be responsible for scheduling of detailed design and delivery, cost management, and technical performance of the system. The MSI will undertake risk management and administration duties required to maintain an accurate record of works completed.

Network Integrator

An approved, pre-qualified Network Integrator must be engaged by TAFE NSW Systems Group to undertake the detailed design and implementation of the Integrated Communications Network (ICN), commissioning the network so it is ready for integration of Smart Campus System components.

This will include the detailed design and configuration of active network equipment, including but not limited to network hardware, servers, and IT client technologies.

Funding for Network integrator should be considered in all project budgets.

The network integrator will have relevant experience and hold formal CCNA, CCIE, RCDD and CISSP (or equivalent) certifications.

3 Applications

3.2 Project Applications

Software Developer

The MSI may be required to nominate or engage a software developer to undertake complex integrations that require a translation layer or similar platform in order to successfully transfer data between Smart Campus Systems and the TAFE NSW Data Platform. Engagement of a developer would typically be required for the introduction of a Smart Campus System that is new to the TAFE NSW Data Platform and is required to be integrated.

Engagement of a Software Developer must be completed at the commencement of the Construction Phase to allow for a sufficient development timeline, and to allow for all the requisite endorsements from the Systems Group. The Software Developer must work with TAFE NSW Systems Group to ensure the software development plan and proposed methodologies are consistent with Systems Group's standard operating procedures.

The Software Developer will be skilled in a typical software design workflow and hold formal PRINCE2, PMI or Agile/Waterfall training and current certification.

3.2.5 Systems Group Liaison

Throughout the course of the project, the Specialist Consultants and Installers must be continually engaged with the TAFE NSW Systems Group to ensure that integration of technologies into the TAFE NSW IT systems is achieved correctly, and meets the project delivery timelines. The project team is to access the Systems Group through the TAFE NSW Project Manager, and follow the Systems Group project process.

Throughout Section 3.3 Project Design Documents, a Systems Group review requirement is nominated and aligned with the project process stages below:

Stage	Systems Group Owner	Purpose
Discovery	Project Manager	To discover the path forward towards implementing a solution.
Heads Up	Architecture	Understand strategic alignment and assess rationale behind preferred options.
Solution Design	Architecture/Project Manager	Design a solution that incorporates strategic direction and architectural principles.
Design Review	Architecture	Seek endorsement on a proposed design and discuss risks/technical debt accrued.
Security Review	Security	Assess design against security controls and principles.
Build	Project Manager	Translate the design into a working solution and document deployment.
Change Board	Change Manager	Seek change to enable the solution to be deployed based off the deployment artefacts. Shall include operational and technical support staff training.
As-Built	Architecture	Understand whether what was built is aligned with the endorsed-design and remediate where necessary.

For smaller projects which primarily involve modifications to existing Smart Campus infrastructure and include no software development component, the above process is reduced to an Design Review and assessment of As-Built process by the Enterprise Architecture Team.

3 Applications

3.3 Project Design Documents

3.3.1 Designer Deliverables

The following deliverables must be provided as part of the standard scope of works for any project nominating the appointment of a member of the specialist consultant group identified in Section 3.2.3.

The consultant must prepare and submit all reports, design documents and certification as required to fully describe the design intent, suitable to the scale and complexity of the project, as indicated below:

Existing Site Audit Report

Responsibility	Scope
ICT/Smart Buildings Consultant	For existing sites (either refurbishments or new buildings on existing campuses), a detailed site investigation and audit must be undertaken for the entire existing building systems considered part of the Smart Campus scope, including but not limited to mechanical, electrical, communications and controls. The report should include: ▪ Identification of any existing Smart Campus systems or related systems not currently integrated into Smart Campus (e.g., legacy BMS). Where identified, the report should outline a strategy based on the system's compatibility and suitability for re-use; ▪ Identification of artefact examples of systems found, including existing point lists, wiring diagrams, photographs, etc; ▪ Assessment of the condition of existing building systems and their suitability to handle Smart Campus systems; ▪ A preliminary outline of proposed Smart Campus systems to inform the project, and an outline of any major capital upgrades required to support these; ▪ Any remaining site constraints, potential hazards or risks.
TAFE NSW	▪ Systems Group to provide the Consultant with report of vendor contract management affected systems; ▪ This deliverable must be endorsed by the TAFE NSW Strategic Planner(s).

Smart Campus Technology Brief

Responsibility	Scope
ICT/Smart Buildings Consultant	A Smart Campus Technology Brief must be prepared to outline the proposed Smart Campus technology inclusions, and to clearly define the roles and responsibilities of all other consultants. The brief should include: ▪ Identification and outline of technology design approach and methodology; ▪ A demarcation schedule or matrix clearly identifying the design and installation responsibilities of each consultant and trade to realise the development of Smart Campus; ▪ Demonstration that proposed technologies and their implementation meets accessibility requirements; ▪ A design brief separated by System in a format similar to Section 5.1.3 of this Standard. This must include a functional description of proposed technologies, including overarching descriptions of purpose, inputs, outputs and logic.
TAFE NSW	▪ This deliverable is aligned to Systems Group 'Discovery' Stage; ▪ This deliverable is a major hold point. This deliverable must be endorsed by all members of the TAFE NSW Project Team; ▪ This deliverable must be endorsed by the Physical Access Advisory Group and the Technology Access Advisory Group.

3 Applications

3.3 Project Design Documents

Digital Execution Plan

Responsibility	Scope
BIM Consultant	A digital execution plan (DEP) must be prepared to outline the overall lifecycle of the project's digital building representation (DBR). The DEP is crucial for outlining the documentation roles and responsibilities of all consultants and all trades. The report must include: ▪ Identification of all DBR objectives. The DEP should nominate the purposes and use-cases specific to the project of creating and maintaining a DBR from design through to construction to ongoing operations; ▪ Identification and nomination of Digital Dimensions (2D, 3D, 4D and beyond) applicable to the project's scope; ▪ Nomination of Level of Detail (LOD) requirements throughout the project lifecycle; ▪ Nomination of data storage, model naming and data structure requirements with respect to modelling the project's individual parts; ▪ Nomination of file backup and disaster prevention protocols; ▪ A detailed planning and execution guideline outlining roles and responsibilities, project stakeholders, information exchange protocol, auditing and quality control and milestone procedures; ▪ A guide on services coordination and clash detection consistent with industry best practises; ▪ A guide on model management and methodology, including detailed modelling requirements, phasing, templates, families and types, software platform, cloud-hosting and project collaboration tools.
TAFE NSW	▪ This deliverable must be endorsed by the TAFE NSW Design Manager(s).

Budget Cost Summary

Responsibility	Scope
ICT/Smart Buildings Consultant in collaboration with Mechanical Consultant and Electrical Consultant	A Budget Cost Summary must be prepared and submitted identifying costs for all proposed technology services systems and their implementation by the MSI in accordance with the Smart Campus Technology Brief. It is important to note that the costs for the services whose primary design responsibility is by others should have their costs estimated by those parties. Outline any assumptions and exclusions. Any proposed alternate innovative design solutions must undertake a cost/benefit analysis study. This must identify capital costs, ongoing energy, software, licensing and maintenance costs, along with a qualitative analysis illustrating the reliability, longevity, and maintenance regime for the alternative proposal. Offer a fair, comparative assessment of the capital and operational costs of this alternative solution when compared with the applicable specified provisions. For information technology inclusions, the Budget Cost Summary must be cognisant of operational expenditure (OpEx) understanding and operational management details factored in over a minimum 36-month term. The technology systems pricing needs to include single installation versus enterprise scale rollout costs. Identify any cost efficiencies that may come with implementation at scale.
TAFE NSW	▪ This deliverable is aligned to Systems Group ' Heads Up' Stage; ▪ This deliverable must be endorsed by the TAFE NSW Programme Manager(s) and Design Manager(s).

3 Applications

3.3 Project Design Documents

Risk Management Report

Responsibility	Scope
ICT/Smart Buildings Consultant	A risk management report must be prepared and submitted in conjunction with the facilitation of ongoing risk management workshops, identifying: ▪ Safety and design requirements for construction, operation and maintenance; ▪ The origin of all identified risks; ▪ Work to be carried out in hazardous and confined spaces; ▪ Asbestos retention and/or removal; ▪ Hazardous goods handling and storage areas; ▪ Any specific stakeholder insurance risk requirements; ▪ Client operational risks, i.e. downtime to building or campus systems during demolition and installation periods, and any other disruptions to BAU operations; ▪ Potential latent conditions including the process for early resolution to agree costs involved prior to proceeding with works and to avoid/mitigate construction delays.

Certification

Responsibility	Scope
ICT/Smart Buildings Consultant, Mechanical and Electrical Consultant	Certification must be submitted to the Principal Certifying Authority/person qualified to conduct a Certification of Crown Building Works in accordance with the NCC/BCA, statutory and regulatory authority requirements, this Design Standard any other relevant TAFE NSW standard.

Specification Documentation

Responsibility	Scope
ICT/Smart Buildings Consultant	The ICT & Smart Building Services Specification must incorporate and further develop the detail of the Smart Campus design and all the software and hardware integration requirements expected of the MSI, including requirements of all relevant report findings and outcomes, along with the inclusion of the following as a minimum: ▪ Nominate how the Design Fundamentals, Technology Requirements and Systems Definitions nominated in this Standard are addressed; ▪ Nominate in particular how the design addresses dignified design for accessibility; ▪ A comprehensive, project-specific scope of works detailing the requirements of the MSI, and all other trades in accordance with the roles and responsibilities set out in the Smart Campus Technology Brief; ▪ A responsibility delineation matrix clearly identifying each trade's scope of works and TAFE NSW Systems Group scope of works at all demarcation points; ▪ Nomination of compliance requirements including this Standard, all other relevant TAFE NSW Standards, and all statutory and regulatory requirements; ▪ Nomination of commissioning, testing and quality assurance frameworks throughout the construction phase, including review process monitoring and cycle; ▪ Description of TAFE NSW staff training and handover procedures; ▪ Detailed technical description of each Smart Campus System as nominated in the Smart Campus Technology Brief.

3.3 Project Design Documents

Responsibility	Scope
TAFE NSW	▪ This deliverable is partially aligned to Systems Group 'Solution Design' stage. As it does not constitute a fully realised design, it does not progress to Design Review until the installer team is engaged; ▪ This deliverable must be endorsed by the TAFE NSW Programme Manager(s) and Design Manager(s); ▪ This deliverable must be endorsed by the Physical Access Advisory Group and the Technology Access Advisory Group.

Design Drawings & Model

Responsibility	Scope
ICT/Smart Buildings Consultant	The requisite design drawings for Smart Campus systems should be completed in the BIM platform to the relevant LOD nominated in the Digital Execution Plan. Drawings should typically include: ▪ Cover Sheet, Legend and General Notes; ▪ Layout drawings nominating locations and installation requirements of Smart Campus technology subsystems; ▪ Layouts should be completed in full coordination with other consultants. It is noted that the ICT/Smart Buildings Consultant is not required to document other consultants' scope (e.g. lighting control should be detailed by the electrical consultant), but interfaces between systems should be made clear; ▪ Schematic drawings clearly displaying wired and wireless connections, and where Smart Campus Systems interface with the Integrated Communications Network. Each System should have a separate schematic drawing for clarity; ▪ Details as required, showing physical interfaces or mounting arrangements to embellish the design requirements; ▪ Strict revision control and supporting document transmittals to cover legal requirements. Hard copies printed and stored appropriately for efficient retrieval.
TAFE NSW	▪ This deliverable is partially aligned to Systems Group 'Solution Design' stage. As it does not constitute a fully realised design, it does not progress to Design Review until the installer team is engaged; ▪ This deliverable is a major hold point. This deliverable must be endorsed by all members of the TAFE NSW Project Team.

3.3 Project Design Documents

Gap & Risk Analysis

Responsibility	Scope
ICT/Smart Buildings Consultant	A Gap & Risk Analysis document is required to be produced by the ICT/Smart Buildings Consultant under the following circumstances at minimum: ▪ When the ICT/Smart Buildings Consultant is engaged during the progression of an existing project, at any stage; ▪ When a major design change occurs that affects the Smart Campus scope; ▪ When the responsibility of design is changed, e.g. when a Contractor takes over a design from a Consultant; ▪ Following a Value Management exercise. The Gap & Risk Analysis should be a comprehensive review of the project documentation (typically Electrical and Mechanical drawings, data sheets, briefs and specifications) to ensure the outcomes of the Smart Campus Technology Brief can still be met. The document should include the following as a minimum: ▪ An analysis of each relevant technology system nominating ‘No Uplift Required’, ‘Further Detail Required’, or ‘Uplift Required’; ▪ Where uplifts or further detail is required, nominate the information and actions required of the relevant parties; ▪ Detail the risks concerned with inaction of recommended or required uplifts.
TAFE NSW	▪ This deliverable is aligned to Systems Group 'Design Review' stage; ▪ This deliverable is a continuous hold point. All revisions of this deliverable must be endorsed by the TAFE NSW Programme Manager(s), Design Manager(s), Teaching and Learning Stakeholder(s) and the Systems Group.

3.3.2 Installer Deliverables

The specialist installer group must prepare and submit all reports, design documents and certification as required to suit the scale and complexity of the project. The minimum requirements for deliverables are as indicated below:

Technology Installation Brief

Responsibility	Scope
Master Systems Integrator	The Technology Installation Brief must demonstrate the MSI's understanding of the project and outline their project plan. The brief should include the following as a minimum: ▪ Nominate how the Design Fundamentals, Technology Requirements and Systems Definitions nominated in this Standard are addressed; ▪ Gantt Chart or similar project representation outlining the MSI's proposed project management plan, including management of other trades and sub-contractors; ▪ Quality Assurance framework; ▪ Nomination of responsible staff, stakeholders and sub-contractors; ▪ Indicative bill of materials for items procured under the MSI's scope.
TAFE NSW	▪ This deliverable is partially aligned to Systems Group 'Solution Design' stage. The Brief needs to demonstrate all strategic directions and overarching technical design parameters for approval by Systems Group, to progress to Security Review; ▪ This deliverable is a major hold point. This deliverable must be endorsed by all members of the TAFE NSW Project Team.

Alternative Design Verification

Responsibility	Scope
Master Systems Integrator, Head Contractor	Where alternatives to the ICT/Smart Building Consultant's documentation are proposed, provide an alternative design assessment report indicating compliance with the design intent and design criteria. Provide all supporting technical data, and associated installation methodology which must be compliant with the requirements of this Standard.

Risk Management Report

Responsibility	Scope
Master Systems Integrator	A risk management report must be prepared and submitted identifying: ▪ Safety and design requirements for construction and installation; ▪ The origin of all identified risks; ▪ Any potential electrical hazards; ▪ Work to be carried out at heights; ▪ Work to be carried out in hazardous and confined spaces; ▪ Asbestos retention and/or removal; ▪ Hazardous goods handling and storage areas.

3 Applications

3.3 Project Design Documents

Samples

Responsibility	Scope
Master Systems Integrator, Head Contractor	A sample register must be maintained in accordance with the MSI's proposed bill of materials. Submit all specified equipment, devices, human interface devices, software and wiring to the sample register, and provide a physical sample on site for testing and approval. The sample register must include the following: ▪ Manufacturer's technical data; ▪ Colour and finish of proposed sample; ▪ Standardised cover sheet nominating approval stakeholders and process.

Workshop Drawings and Model

Responsibility	Scope
Master Systems Integrator	The requisite workshop drawings for Smart Campus systems should be completed in the BIM platform to the relevant LOD nominated in the Digital Execution Plan. Drawings should exercise further detail in an iterative manner from the design drawings and address methods of installation, staging, alterations in construction methodology, fixings, and commitment of approved alternative designs. At this stage, drawings and schedules must include unique identifiers of each Smart Campus data source to prepare for ingest into the Asset Management platform.

Technical Design Reports and Schedules

Responsibility	Scope
Master Systems Integrator and associated Sub-Contractors	The MSI will submit technical design reports to detail the final technical details pertaining to installation, configuration and commissioning of Smart Campus. Reports are to be scaled in accordance with the project scope, generally the following reports and schedules should be provided prior to the commitment of installation: ▪ Network Design Report, demonstrating how the Smart Campus systems will integrate with the existing and proposed TAFE NSW networks. The report will cover topics such as subnetting and VLAN, methodology of connection, switch configuration settings and cybersecurity measures; ▪ Schedule of devices, nominating all Smart Campus devices supplied by the MSI and with inputs for other trades to contribute. The Schedule should also include cabling designs showing cable type, cable pathways, termination points, and any Wi-Fi RF surveys with Access Point placement; ▪ Data Structure and Integration report and schedule, nominating the data sources incorporated in the design and proposed level of access allowed for each data structure; ▪ Cybersecurity Design report, nominating cybersecurity measures in the design.
TAFE NSW	▪ These deliverables are aligned with the progression of Systems Group 'Solution Design', 'Design Review' and 'Security Review' stages.

Warranties

Responsibility	Scope
Master Systems Integrator	Submit all extended warranties for installation and equipment as listed in the Technical Requirements section.

3.3 Project Design Documents

Software Development Plan

Responsibility	Scope
Master Systems Integrator/ Executed by Software Developer	The MSI will submit a software development plan to detail the proposed software integration layers that may be required to expose or manipulate data for inclusion in the TAFE NSW Data Platform. The software development plan should include the following: ▪ Details outlining the requirements for custom software, and why an off-the-shelf solution is not appropriate for the application; ▪ Nomination of software framework including requisite APIs and device/hardware requirements for interfacing; ▪ Nomination of operating environment, e.g. database, operating system or standalone application, language, cloud or on-premises. This should be written in line with TAFE NSW's Service Management Plan template, available from Systems Group; ▪ Details of graphical user interfaces, with particular emphasis on accessible design principles; ▪ Cybersecurity framework and measures; ▪ Resilience strategy and measures; ▪ Detail of software functionality, including inputs and outputs, and test cases; ▪ Software update and maintenance strategy.
TAFE NSW	▪ This deliverable is aligned with the progression of Systems Group 'Solution Design', 'Design Review' and 'Security Review' stages.

Installation and Testing Plan

Responsibility	Scope
Master Systems Integrator	The MSI must develop and submit a project-specific Installation and Testing Plan (ITP) as per their quality assurance framework detailed in their Technology Installation Brief. This must be consistent with the Head Contractor’s construction plan, and include: ▪ Definition of handovers, including staged areas; ▪ All milestones; ▪ Cable test results for all copper and fibre cable plant; ▪ Notice for witness testing, commissioning testing and user acceptance testing; ▪ Detail of mandatory off-site and on-site tests and approvals in accordance with this Standard; ▪ Detail of testing procedures applied to each Smart Campus System and nomination of responsible parties in accordance with the trade delineation matrix; ▪ Detailed commissioning plan to ensure the data platform and sub-systems are commissioned as well as verification that metrics measured by each sub-system are accurately reflected in the TAFE NSW Data Platform; ▪ Submission of ITP test records in hard-copy form and synchronised into the DBR platform.

As-Built Drawings and Model

Responsibility	Scope
Master Systems Integrator, BIM Consultant	As-built drawings for Smart Campus systems should be completed in the BIM platform to the relevant LOD nominated in the Digital Execution Plan. Drawings should exercise further detail in an iterative manner from the workshop drawings. An As-Built model is required to incorporate all site design changes/updates. Modelling must be completed to a level of tolerance as nominated in the DEP.

3 Applications

3.3 Project Design Documents

Operations and Maintenance Manuals

Responsibility	Scope
Master Systems Integrator	The MSI will develop and submit an operations and maintenance manual with the inclusion of the following project-specific detailed requirements: ▪ Table of Contents: per contractual requirements; ▪ Directory: per contractual requirements; ▪ Format: per contractual requirements, and mirrored on the TAFE NSW Data Platform; ▪ Installation Description: description of how the installation meets the Technology Installation Brief; ▪ Smart Campus Systems Descriptions: Technical description of the systems installed, written to ensure that the stakeholders fully understand the scope and facilities provided. Identify function, normal operating characteristics, integration with data platform, cross-coordination with DBR, and limiting conditions; ▪ Certificates: · Product Certifications; · Calibration Certificates from ITP; · Design Certificates demonstrating compliance to TAFE NSW standards, all statutory & authority requirements and the NCC; · Inspection and Contractor rectification records. ▪ As-Built drawings in 2D and link to DBR view highlighting the installation of Smart Campus scope; ▪ Custom Software operations manual, API programming guide and dependencies, if applicable. Contract should include provision of source code licenced to TAFE NSW; ▪ As-Built bill of materials encompassing equipment descriptions: · Name, address, and telephone numbers of the manufacturer and supplier of items of equipment installed, together with catalogue list numbers; · Locations, metering and control settings, performance figures and dates of manufacture. Provide a unique code (asset) number; · ICN Configuration Settings, i.e. MAC Address, DHCP Access, Static IP, Security Certificate; · Cross-reference to the record and diagrammatic drawings and schedules, including easy to find spare parts schedule, for each item of equipment installed; · Manufacturers' technical literature for any devices or equipment assembled or programmed specifically for the project. (Generic Brochures are not acceptable. Provide project specific technical data of items installed.); · Mounting and fixing to product data to illustrate relations of component parts. Include typed text as necessary. ▪ Manufacturer's technical data sheets for proprietary equipment, including: · Technical specifications and drawings; · Verification reports; · Performance and rating tables; · Recommendations for installation and maintenance; · Schedule of proposed major products that are not specified as proprietary items; · Product certification. ▪ Operation Procedures; ▪ Maintenance Procedures; ▪ Records and Documents; ▪ Commissioning and Testing Records; ▪ Extended Warranties.

Technical Requirements

4 Technical Requirements

4.1 Smart Campus Structure

4.1.1 Overview

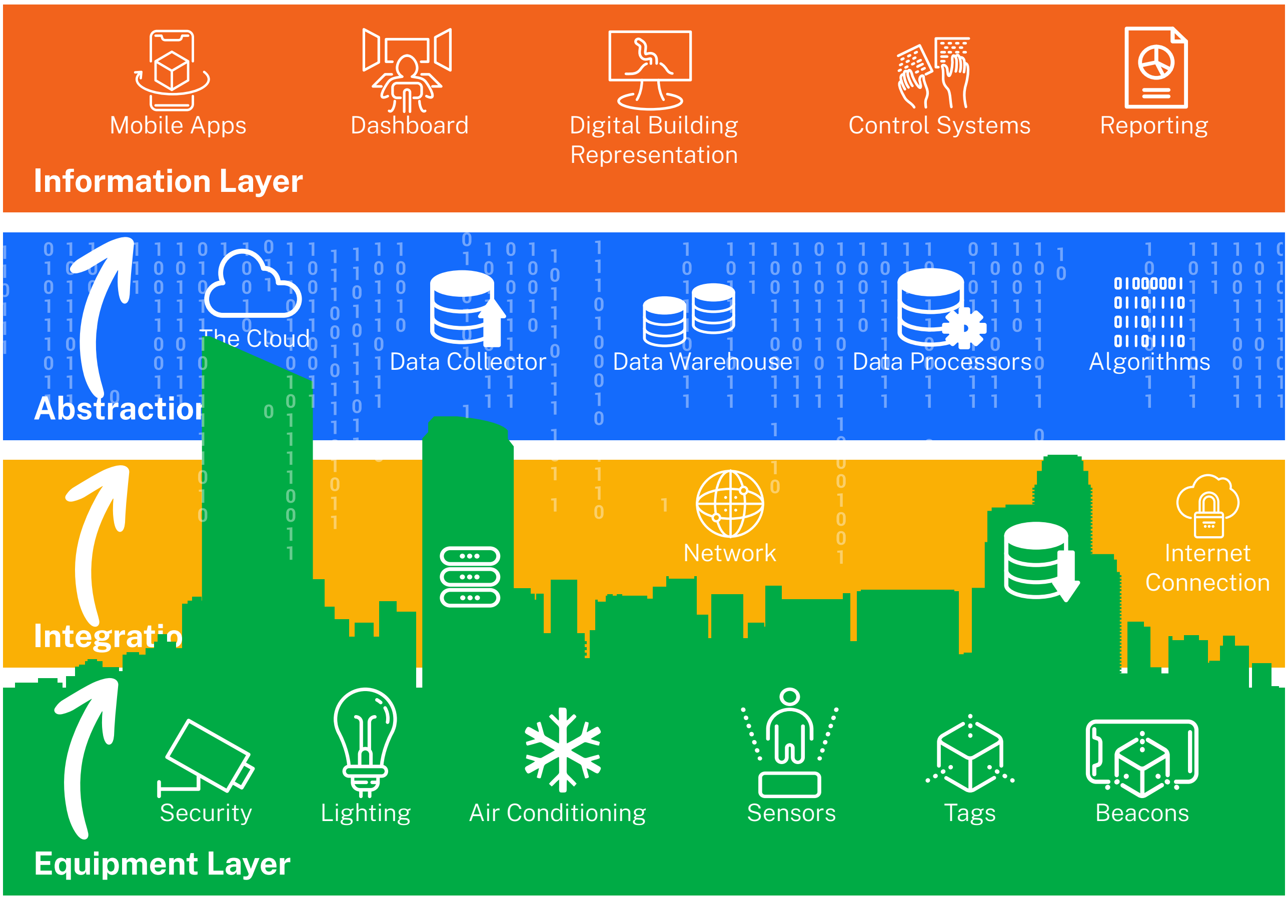


Figure 2: Diagram demonstrating Smart Campus structure.

The TAFE NSW Smart Campus structure comprises four distinct layers of infrastructure which aim to conceptualise the paradigm and explain the system's use cases.

The Equipment Layer comprises physical devices and equipment that sends and receives data through the Smart Campus ecosystem. Consider the Equipment Layer the 'things' in the Internet of Things. These devices may include sensors, building systems equipment, security equipment, computers, audio visual systems, and any device that through either a wired or wireless connection contributes to information flow throughout the system. Typically, devices on the Equipment Layer, being physical devices, are localised to a single physical area (i.e. a single TAFE NSW Campus).

The Integration Layer comprises computing equipment that processes data flow to and from devices in the Equipment Layer. This includes the active network equipment that connects the building's computer systems, data processing devices, head-ends and the like. The devices assist with transferring data between the 'local campus' environment, and the internet or 'cloud environment'. As with the Equipment Layer, these devices typically connect equipment throughout the Equipment Layer and thus are localised to the one physical area, generally in equipment racks located in telecommunications rooms.

4 Technical Requirements

4.1 Smart Campus Structure

The Abstraction Layer is a ‘virtual’ layer which comprises the cloud-based technologies that interpret, compute and process data. The layer is applicable to all members of the TAFE NSW Smart Campus ecosystem, as data from all campuses is aggregated in the Abstraction Layer. Some of the technologies in use are data brokers, data collectors and data processors, which manipulate TAFE NSW’s ‘big data’ environment and seeks to structure and scale the vast amount of data available to TAFE NSW.

The Information Layer is another ‘virtual’ layer which comprises the application and presentation of data in a human or device-readable format. Presentations created in the information layer are generally relayed back to devices on the Equipment Layer, e.g. displaying visualisations on PCs or mobile devices. Application software which drives items on the Equipment Layer will also be considered part of the Information Layer, e.g. a software program which controls lighting devices based on room occupancy data. The Information Layer is designed to scale across the entire TAFE NSW Smart Campus ecosystem to increase redundancy and consistency, and minimise unnecessary programming.

4 Technical Requirements

4.1 Smart Campus Structure

4.1.2 Equipment layer

Common Equipment Requirements

Items on the equipment layer constitute a large variety of devices. Specific instruction on device selection thus cannot wholly be encompassed in the scope of this Standard. The following guidelines are nominated to assist with device selection:

- Devices must conform to standards-compliant network stacks for data transport. For example, wired devices must follow the TCP/IP or UDP protocols, wireless devices must follow IEEE standards, encompassing all aspects of packet transfer. No proprietary communication protocols are permitted;
- Devices that connect to the integrated communications network must encompass SSL/TLS certificate-based security, issued by a recognised third-party authority. If the device has a web-based configuration interface, it must force the user to use HTTPS, and disallow HTTP connections;
- Devices with web-based configuration interfaces should use Active Directory for authentication. In the event a device only supports local authentication, ensure default usernames and passwords are changed, and stored in the Operations and Maintenance manual;
- Devices that do not conform to either of the above requirements are permitted to operate through a broker or gateway device only;
- Devices should not be installed at heights exceeding 2.6 metres. In the event that room architecture deems installation at heights necessary, control measures must be incorporated into the design to allow for safe installation and maintenance of devices.

Local Data Handling

All systems need to be designed to operate independently of an active wide-area network connection. Integration between devices must operate through the local-area network whilst transferring data to and from the TAFE NSW Data Platform. This is to ensure that the Azure platform is not completing unnecessary compute tasks, and to ensure that devices are operable in the event of a wide-area network outage.

Systems must be built with error handling considerate of wide-area network outages. This could include one or more of the following, dependent on application:

- Default 'fallback' settings allowing operation without data transfer. This is to ensure that a network or power outage does not reduce building safety and operability to an unacceptable level, causing undue impact on the building's occupants;
- Data cache to allow for the transmission of historical data following network re-establishment.

4 Technical Requirements

4.1 Smart Campus Structure

4.1.3 Integration layer

Common System Server Requirements

Some Smart Campus systems require the installation of an on-premises server to process and transmit data locally. The on-premises server could facilitate local data processing or management, or act as a Data Gateway to facilitate a connection back to the TAFE NSW Data Platform, in limited circumstances detailed in the sub-section below.

The on-premises server must adhere to the below requirements:

- The requirement for the server must be reviewed by TAFE NSW Systems Group;
- For optimisation of resources, it is preferred for the server to operate as a virtual server instance on Microsoft Hyper-V. A bare metal server may be permitted in limited circumstances, for example, a server that requires far greater processing power or storage than allowed by a virtual server cluster, or a single-purpose site where a virtual server cluster may not be required;
- Access to any graphical user interfaces served must be protected with encrypted username/password authentication at minimum. Integration with TAFE NSW's single sign-on procedure (Microsoft Active Directory) is preferred, and may be configured under the instruction of Systems Group;
- Under no circumstances should the server's operating system user interface be accessible through the use of internet-based remote desktop software. Any interaction with the server software must be through a native executable or web-based graphical user interface served to the client.

Data Gateway

The on-premises data gateway acts as a bridge, or translation layer, to provide quick and secure data transfer between on-premises data and the TAFE NSW Data Platform. It is strongly preferred that the data gateway is a virtualised software device. A hardware device may be permissible in limited circumstances, e.g. where security risks are too great.

There are generally two reasons that a data gateway would be required:

- The on-premises data source runs on a legacy system or protocol that may lack the cybersecurity requirements acceptable to the TAFE NSW Data Platform. In this instance, the data gateway must be a hardware solution as the legacy system shall not be permitted to connect to TAFE NSW's TCP/IP network;
- The on-premises data source transmits data in a proprietary format and requires the data gateway to transmit the data into a format readable by the TAFE NSW Data Platform. This is common with older BMCS equipment, which requires a data gateway to translate signals to the open MQTT standard.

Active Network Equipment

Refer to Section 4.2.3 for active network systems requirements applicable to Smart Campus.

4.1.4 Abstraction Layer

Data Platform

TAFE NSW operates a Data Platform through a Microsoft Azure data warehouse tenancy and supporting Azure applications. The TAFE NSW Data Platform aggregates information to gather intelligence throughout a large range of TAFE NSW business units, including enrolments, education delivery, building and asset performance, finance, amongst other disciplines.

Smart Campus technology systems are instrumental to providing inputs and controls to the TAFE NSW Data Platform, and furthermore utilising algorithms to automate and control their operation.

Data gathered and used by Smart Campus technology systems must be published and stored in a well-structured, normalised manner using standardised naming conventions and metadata. The nominated data structuring schema is Project Haystack, an industry standard, open source IoT data structuring paradigm.

Collection of data is to be accomplished by use of a time-series data warehouse, providing the ability to analyse data generated by a vast quantity of data sources across TAFE NSW campuses, generating data at regular intervals.

Data Structuring

Data must be easy to access, discover and interpret by software reporting and visualisation tools across the Information layer, thus a structure must be followed for establishing a device onto the TAFE NSW Data Platform. Data types, file types, HTTP API and ontology are to follow the internationally recognised Project Haystack taxonomy.

For asset management, data sources from physical assets, i.e. Smart Campus devices, must be assigned the below standardised device identification schema to register the asset and provide enrichment to measurements:

Schema	Example
RegionID	North Region: NorthR
CampusID	Ballina TAFE: BAL
BuildingID	Building A: A
SpaceID	Space G.17 Plant Room: G.17
DeviceID	Lighting Fixture: LFX001

Representation of asset schema is generally cumulative, excluding RegionID, so the above example lighting fixture would be referenced in a data visualisation platform as BAL.A.G.17.LFX001.

Data Abstraction Layer Requirements

The following general requirements apply to data gathered from the Smart Campus ecosystem:

- Data operations are to run on an application purpose-built for gathering IoT data, using the following components:
  - Data Ingestion Engine
  - Pre-Processed Measurement Cache
  - Data Pre-Processor (typically on premises)

4 Technical Requirements

4.1 Smart Campus Structure

  - Data Warehouse (recent measurements)
  - Data Historian (historical measurements)
  - Data Query Handler
- The application must be capable of gathering data sources from as wide a variety of interfaces as possible, in real-time, including REST APIs, MQTT, raw TCP/IP, or trickle feeding of data from standards-based serialisations, including CSV, JSON and XML.
- For the purposes of historical curation, all data is to be extracted as a time-series measurement unless a specific requirement for static data is established. A measurement by this definition is a single value from a single source (e.g. a sensor), at a single timestamp. Timestamps are to be measured from the site's local NTP server.
- Data sources from an application can be scaled from a very high sample rate (i.e. millions of measurements per second) to a very low sample rate, dependent on application.
- Measurements must be visible to user queries instantaneously, 30 seconds since the measurement took place or less.

Data Types

Smart Campus devices must be capable of gathering data in one or more of the following standard data types:

Data Type	Description
Text	Text string. Generally, should be avoided due to processing overhead and overuse of size on disk. Use to store meta-data or strings, e.g. fault descriptions.
Boolean	Binary value. Generally, could be used for 'True' or 'False', 'On' or 'Off' type logic applications.
Integer	Numeric value allowing approximately up to 4 billion metrics.
Float (or Double)	4-byte or 8-byte data type allowing for complex metrics required for high range or precision values, e.g. accurate temperature sensing
Structure	A data structure allowing multiple data types with separate fields linked to a single record.

Data Ownership

All data transferred throughout the Smart Campus ecosystem must be transmitted and secured through the TAFE NSW Data Platform. TAFE NSW must have exclusive ownership of all data produced, gathered and operated on.

Some Smart Campus technology systems may require the installation of on-premises hardware or proprietary cloud services in order to undertake data processing, noting that the implementation of a proprietary cloud system separate from TAFE NSW's Azure based data platform is discouraged. In the event the implementation of a proprietary data processing system is unavoidable, the system must:

- Facilitate the duplication of all such data to the TAFE NSW Data Platform with the use of APIs (REST, MQTT or the like);
- Meet all TAFE NSW and NSW Government data security and governance requirements. The installation shall be subject to a third-party security audit.

4 Technical Requirements

4.1 Smart Campus Structure

4.1.5 Information Layer

Dashboards and Reporting

TAFE NSW operates an intelligence platform using internal and external data to derive trends to inform business and education planning decisions.

Smart Campus information primarily feeds data into the asset management, learner engagement and environmental management fields of the data warehouse. Per the guidelines set in Section 4.1.4 Abstraction Layer, data that enters the TAFE NSW Data Platform should be structured and follow approved asset management schema.

The Smart Campus platform is to allow a consistent dashboard and reporting template across all campuses. TAFE NSW may utilise in-house templates for dashboards and reporting where it is suitable for the application.

For specialised Smart Campus applications, some vendors may publish first-party dashboard and reporting tools. These may be deemed acceptable following the Systems Group review process. Such tools should:

- Be built on Microsoft Azure, natively using visualisation technologies such as Dynamics 365 or Power BI;
- Access data from the data platform natively, and not complete any internal transformation or transposition of data.

Artificial Intelligence

Artificial Intelligence (AI) and Machine Learning (ML) are likely to be used throughout the development of Smart Campus software, models or reporting. AI and ML may also be used to manifest physical responses, such as programmatic control of lighting and air conditioning devices through observation of the natural environment.

AI programmes must be verifiable, built on mature technology and be guided by clear requirements established by a case study. AI programmes are computationally expensive and must be written with key optimisations to avoid server saturation.

Responsible implementation of AI must thus follow the following Microsoft fundamentals:

- Fairness: AI implementation should not be affected by inherent bias in the algorithm, or the data used to train the model;
- Reliability and Safety: AI implementation should not cause harm, and include appropriate error checking mechanisms;
- Privacy and Security: Data storage for AI implementation must be subject to rigorous governance standards;
- Inclusiveness: AI implementation must consider all users. For example, an AI derived application must be accessible;
- Transparency: AI implementation should be trustworthy, and data used to train the AI should be known;
- Accountability: Liability for AI-driven decisions must be established.

4 Technical Requirements

4.1 Smart Campus Structure

Care must be taken when implementing computer vision (image classification, object detection, semantic segmentation, image analysis, face detection and optical character recognition) applications. Data collected on building occupants must consider NSW privacy legislation. Generally, image processing outputs must not retain images of faces, only metadata may be stored.

3D Visualisation (Digital Building Representation)

Per the Digital Execution Plan, major projects should be finalised by way of a Digital Building Representation programmed to retrieve information from the data warehouse. The Digital Building Representation must be live, and conducive to changes across the life of the building. The Digital Building Representation may operate on a vendor's proprietary software stack, however the software must operate from within TAFE NSW's Microsoft Azure tenancy.

Model State

The BIM model to be used in the Digital Building Representation must be both sufficiently detailed, and well optimised for repurposing into the Digital Building Representation. The strategy for model optimisation is variable depending on the outcomes of the Digital Execution Plan, however the following guidelines apply:

- Elements/Families/Types must be free of superflous Properties that are not relevant to the asset register. Examples of such properties include manufacturer data and marketing material, photographs, URLs, and proprietary Properties that are not conformant to TAFE NSW asset register fields or BIM software default fields;
- The model must be federated, incorporating all architecture and engineering services into a single file. The federated model shall include no duplicate items;
- The model must be cleaned and purged of all unused assets;
- The model must be free of two-dimensional annotations and typed text elements;
- The model must be high-performance, as it is required to be viewable through web browsers. Models are expected to be detailed in alignment with the warranted level of detail, however it is inappropriate to use ultra high-polygon elements extracted from 3D modelling software.

Asset Tagging and Linking

The Data Structuring requirements nominated in Section 4.1.4 Abstraction Layer determine the schema of how items in the final federated BIM model should appear, prior to import into the Digital Building Representation platform. This must be undertaken natively in the BIM software used to create the model (e.g. Autodesk Revit), and carry through to the exported model:

- All Rooms and Spaces to be tagged with TAFE NSW compliant space codes, space types, space names and area (in square metres);
- All Plant and Equipment to be located within a space in the BIM model. This requires room calculation points to be modelled accurately to prevent incorrect attribution;
- Loose Plant and Equipment is typically exempt from modelling in the Digital Building Representation, however must be included in the asset register. Semi-loose equipment that is typically localised to a specific room or space however should be included in the model;

4 Technical Requirements

4.1 Smart Campus Structure

- All Plant and Equipment to be provided a DeviceID. The DeviceID may be manually entered, or computationally produced by the BIM software. No duplicate DeviceIDs shall be permitted.

Application or Module Development

TAFE NSW has a preference for software to be based on established codebases, whether in-house, Microsoft-developed, or established by an approved third party. It is understandable however that introduction of new Smart Campus technologies will necessitate the development of additional software applications, plug-ins, modules or procedures.

The proposal to develop new software as part of a project scope must follow the directives of Section 3.2.5 Systems Group Liaison. The Discovery Phase should be used to explore opportunities to initially avoid new software development, such as utilising existing Microsoft Azure tools to undertake the requisite functionality.

The blueprints for the proposed software would generally be directed by the Smart Buildings/ICT Consultant. It is the responsibility of the Master System Integrator and software developer to produce a comprehensive Software Development Plan encompassing the purpose, scheme, security measures and inputs/outputs of the proposed software.

The new software is required to be supported by TAFE NSW ICT services infrastructure, therefore a Service Management Plan must be produced by the developer as part of the Software Development Plan. Templates are available from TAFE NSW Systems Group.

TAFE NSW operates four service environments which provide the software developer with suitable facilities for staging, which include:

- Development;
- Test;
- Pre-Production;
- Production.

Approval of the Software Development Plan will enable TAFE NSW Systems Group to set up a development environment.

During software development, liaise frequently with the Security and Operations groups within Systems Group to undertake security scans of the test development environments. When the software development reaches Pre-Production stage, the Project Manager shall issue a full penetration testing request in order to allow final sign-off and graduation to Production.

4 Technical Requirements

4.2 Supporting Infrastructure

4.2.1 Structured Cabling System

Overview

Horizontal cabling to support Smart Campus and general purpose communications applications is to be deployed as part of the electrical engineering design. Smart Campus structured cabling design and installation must be in accordance with the TAFE NSW Structured Cabling System Specification and any related amendments.

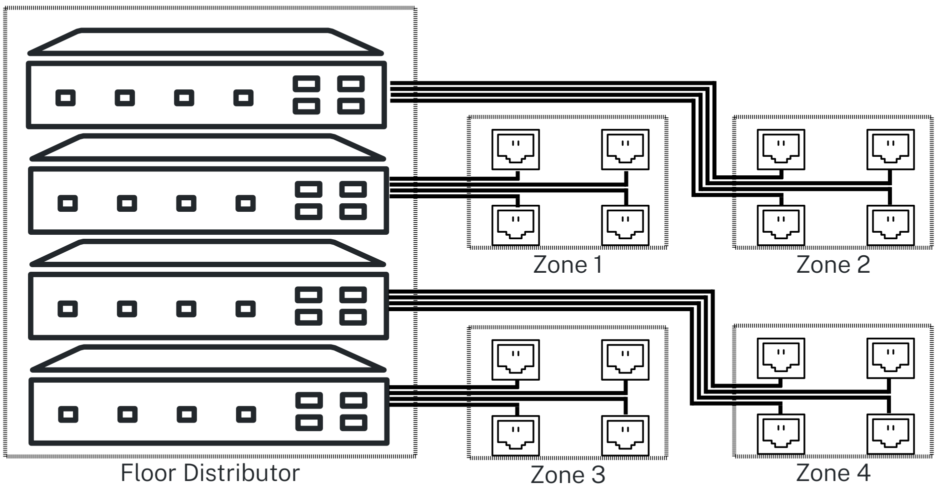
Outlets can be defined into the following two categories:

- Telecommunications outlet - used primarily in locations where the end device is administered by the user (e.g. computer, phone);
- Service outlet - connects a “non-telecommunications” device (e.g., door controller, security camera), and its location, media and topology is dependent on the application and location of the service. Typically, a service outlet becomes part of the building system and is used for permanently connected Smart Campus equipment.

The use of a star topology is a common method for deploying horizontal cabling to connected elements (e.g., devices, sensors, inputs). The use of a star topology minimises the numbers of connections in the transmission channel and is considered the easiest to troubleshoot, given that issues will be limited to the equipment, device, or individual link. Horizontal cabling must be designed to service one device per cable to provide maximum flexibility to facilitate future changes.

Figure 3: Typical example of groups of service outlets for IoT infrastructure through horizontal cabling in a 'zoned' star topology.

4.2.2 Digital Ceiling



4 Technical Requirements

4.2 Supporting Infrastructure

Digital Ceiling is the concept of pre-planning structured cabling infrastructure for service outlets throughout the ceiling of a given space, either concealed within a ceiling cavity, or run on a cable tray or cable basket in spaces without a ceiling. The purpose of running a Digital Ceiling is to provide the infrastructure for current and future unknown Smart Campus services to be operating over Ethernet. As the standard and foreseeable future for cabling infrastructure is Ethernet-based, this provides a safety net for future additions.

Typically, digital ceiling outlets are 8P8C female service outlets with an additional 5m of slack to support the relocation of outlets and eventual endpoints, for flexible use of the space.

For initial planning purposes, a sufficient quantity of cabling links are to be provided in the initial schematic designs for Smart Campus systems, distributed throughout the ceiling space. Refer to the TAFE NSW Structured Cabling System specification for cabling design, selection and reticulation requirements.

Refer to the below table for the expected minimum quantity of Service Outlets required to service potential devices throughout usable floor space, as well as the recommended quantity to accommodate current and future requirements based on a 25% spare capacity. When calculating spare capacity, round up to the next highest number.

Use of Floor Space	Coverage Area per Device	Minimum outlets required per 500m^2	Recommended outlets required per 500m^2
General Teaching Space	25m^2	20	25
Office	35m^2	14	18
Workshop	50m^2	10	13
Laboratory	30m^2	17	22

4.2.3 Active Network Systems

Integrated Communications Network (ICN)

All Smart Campus technologies must operate through a shared Integrated Communications Network (ICN) and not operate standalone 'engineering services' networks.

An ICN is a purpose-built, secure and resilient TCP/IP network, operating as a campus' sole IP network, facilitating the exchange of data between end devices and relevant systems or platforms. The ICN will be designed and built with security at its forefront, using network security devices throughout and virtual LANs (VLAN) to isolate networks between disparate services.

The network shall adhere to the Australasian Signals Directorate's 'Essential Eight' criteria for network hardening, with the MSI assuming responsibility for integrating other services contractors' equipment onto the network.

Active Equipment

Specification and selection of active network hardware will be as directed by TAFE NSW's Systems Group, from the current hardware purchasing catalogue.

Wi-Fi and Wireless Access Technologies

Specification and selection of wireless network hardware will be as directed by TAFE NSW's Systems Group, from the current hardware purchasing catalogue. It shall be noted that wireless access technologies should be built with Smart Campus in mind, and specific hardware selections should adhere to the following guidelines:

- Wi-Fi access points should use the latest 802.11 connection standards available at the time of installation;
- Wi-Fi access points should support native connection of wireless IoT devices using a minimum of two low-power, non-802.11 protocols – e.g. Bluetooth Low-Energy, ZigBee, LoRaWAN;
- Wi-Fi access points should support in-device VLAN handling to segregate network traffic from Smart Campus devices and general usage devices.

Quality of Service

Quality of Service (QoS) shall be implemented in the ICN as required to enable traffic prioritisation for Smart Campus devices and differentiated treatment of network traffic based on traffic type and application requirements. QoS shall be configured using the differentiated services model where a number of mechanisms are employed to manage the traffic. Classification and marking tools shall be used to categorise and identify network traffic for QoS treatment by the network.

Traffic shall be classified according to the application or use type so that it can be properly marked for appropriate performance control using policing and queuing policies.

Following classification, the contractor may make network prioritisation recommendations to TAFE NSW. TAFE NSW Systems Group perform and are responsible for traffic engineering and will prioritise data traffic accordingly.

Power over Ethernet (PoE) Requirements

Power over Ethernet (PoE) is a system allowing the practise of distributing DC power and telecommunications signals over the same twisted-pair copper cabling infrastructure.

The design team should complete a full PoE power budget calculation prior to selection of active equipment. Active equipment must thus be selected to cover the full PoE power budget plus 30% spare electrical capacity.

4 Technical Requirements

4.3 Cybersecurity

4.3.1 Framework

Cybersecurity risks in an Internet of Things (IoT) environment must be considered front of mind. The constant connectivity, data sharing and different levels of protections applied to devices open new opportunities for information and infrastructure to be compromised.

TAFE NSW operates a zero-trust network, encompassing the perimeter, datacentre, cloud and interfaces between campuses. All network, hardware or software installations must follow the controls and procedures established by the latest available edition of the TAFE NSW Information Security Management System (ISMS) Controls Manual.

The framework must be followed whenever a new site is established, or when IT or OT infrastructure is modified on an existing site.

Risk Handling Approach

Implementation of systems must be commensurate with an integrated risk management approach. The relevant vendor(s), e.g. Master System Integrator, Software Developer, must implement a cyber security management system or cyber security framework, and ensure requirements from this framework are built into procurement and the system development and commissioning life cycle.

Penetration testing must be organised with TAFE NSW Systems Group - Security, a minimum of six weeks before practical completion.

The onboarding of any new Smart Campus solution, or the installation of an established Smart Campus solution involving a system or vendor new to TAFE NSW, must undergo a thorough security assessment.

Risk Standards

Systems implemented are to align with the objectives of Australian Standard AS ISO/IEC 27001 as relevant to manage cybersecurity risks.

Legacy System Risks

For system upgrade solutions, care must be taken to review security gaps introduced by legacy systems. Some systems are typically designed to be standalone or unconnected, and can be easily compromised if connected to an unsecured network.

The preferred approach is for as much of the design as possible, to utilise purpose-built IoT devices and systems from a reputable vendor with a clear security update policy.

Another approach is to utilise an agentless device security platform, which provides an inventory of all IoT devices connected to the network and uses a database to discover and classify device status, including active global security threats. Each IoT device is assigned a device profile, which is continually updated in response to risk assessments and known attacks.

4 Technical Requirements

4.3 Cybersecurity

Known Vulnerability Management

It may be necessary to incorporate products, protocols or systems with limited cybersecurity resources or known vulnerabilities to realise a project. Following review and subsequent acceptance by TAFE NSW Systems Group, the details of the system's vulnerabilities must:

- Be mitigated to best practises by either a hardware or software solution;
- Be fully documented in the Asset Management platform.

4.3.2 Network Access

TAFE NSW operates a secured network standardised on IEEE 802.1X. Authentication with a RADIUS server is required, which determines the assignment of a network port based on the connected client.

TAFE NSW Systems Group is required to provide the necessary network access controls for all candidate devices in a Smart Campus installation. Smart Campus devices should have native support for IEEE 802.1X -devices that do not comply may require alternative access methodologies at the discretion of TAFE NSW Systems Group.

All parties requiring network access must provide at minimum:

- MAC Address;
- Port numbers and routing (including source/destination);
- Physical item location;
- Connectivity type and requirements (e.g. PoE);
- Proposed IP address ranges;
- Level of internet access required;
- Requirement for access to local servers, e.g. Active Directory;
- Special protocol support requirements (e.g. MRP);
- Proof of valid SSL/TLS certificate for HTTPS access.

4.3.3 Threat Mitigation & Prevention

The network design supporting Smart Campus needs to ensure measures are in place to identify and mitigate a variety of malicious or accidental threats, including unauthorised access or disruption to any system or data. This will be achieved using security measures such as firewalls, denial of service mitigation, anti-virus and intrusion prevention mechanisms, encryption, password protection, and password policies.

The details of the Network Cyber Security mitigation should be developed by the MSI and approved by the TAFE NSW Systems Group.

Security measures overall shall be provided to mitigate against impacts arising from:

- Unauthorised network access;
- Malicious activity, hacking or other intrusions;
- Targeted or distributed cyber-attacks;
- Data theft or integrity issues;
- Privacy breaches;
- Unintended network impacts from external sources;
- Denial of Service Attacks.

Systems

5 Systems

5.1 General

5.1.1 Standard Inclusions

This section of the Design Standard nominates a selection of established Smart Campus System inclusions. These are standard practice and must be incorporated in all TAFE NSW developments:

- 5.2 Building Management & Control System on page 76;
- 5.3 Lighting Control System on page 79;
- 5.4 Emergency Lighting System on page 82;
- 5.5 Multi-Functional Poles on page 86;
- 5.6 Irrigation Management System on page 89;
- 5.7 Space Utilisation Tracking on page 93;
- 5.8 Digital Wayfinding System on page 97;
- 5.9 Access Control System on page 100;
- 5.10 Parking Management System on page 103;
- 5.11 Digital Art & Signage System on page 107.

5.1.2 Innovation

The implementation of Systems other than those nominated in this section may be appropriate. This Design Standard supports innovation and development of Systems that meet the Design Fundamentals and provide TAFE NSW with technologies that benefit the key tenets of educational and operational outcomes.

To propose a new Smart Campus technology for inclusion into a project, the project team must:

- Consider the usage cases and the ongoing benefits of the new Smart Campus system to TAFE NSW as a whole. The system needs to meet the Design Fundamentals. Consider if the system may be better served as a standalone prototype or concept;
- Should the proposed system still be deemed to meet the criteria for a Smart Campus installation, complete the Form for Submission of New Smart Campus System, located in Appendix A of this Standard;
- Provide supporting literature structured in accordance with Section 5.1.3 Structure for New Technology Submissions;
- Submit the form and supporting literature to the TAFE NSW Project Team for review by the TAFE NSW Systems Group. This is aligned with the Discovery phase in the ICT procurement process.

5 Systems

5.1 General

5.1.3 Structure for New Technology Submissions

Version: Provide a Version Number and Date | Provide review timing

Concept

Provide a short explanation of the concept behind the technology system.

References

If the technology system references other TAFE NSW Standards, list them here.

Data Gathered

A text description of the data gathered by the technology system and how it will be used, followed by a short table nominating data structures and schema as relevant to the system.

If the system's data types are covered under Project Haystack, these must be used first, over creating new types.

Highly complex systems comprising a lot of data structures do not require the submission of a data gathering table, as the data structures will be individually defined in the TAFE NSW Data Platform. Instead, provide a high-level overview of the quantum of data expected to be gathered as a result of the technology implementation.

Data Reference	Data Type	Data Use
A reference at the DeviceID level denoting the intended data reference’s nomenclature. Data references are equal to a Project Haystack data type, unless prefaced with an asterisk (*)	Boolean, Integer, Float, Structure	Description of the data gathered.

Implementation

Strong Implementation

Guidelines to how the technology would be implemented ‘strongly’ i.e. in a Major Capital Works project.

Reduced Implementation

Guidelines on how the technology could be implemented in a reduced fashion such as in Minor Works or Refits. This scenario might achieve similar objectives or gather slightly reduced data.

Upgrade Path

Guidelines on how the technology could be implemented in future in brownfields campuses with no immediate capital works planned, such as future-proofing.

Connection

Guidelines on how the system and its sub-systems connect back to the TAFE NSW network or data platform.

5 Systems

5.1 General

Coordination Requirements

Guidelines on expanded design/construction responsibility requirements, part of the following table.

Stakeholder	Responsibility
TAFE NSW	[Detail responsibilities here. Refer section 3 Applications for examples]
Architect	[Detail responsibilities here. Refer section 3 Applications for examples]
Electrical	[Detail responsibilities here. Refer section 3 Applications for examples]
Mechanical	[Detail responsibilities here. Refer section 3 Applications for examples]
Hydraulic	[Detail responsibilities here. Refer section 3 Applications for examples]
Fire	[Detail responsibilities here. Refer section 3 Applications for examples]
Audio Visual	[Detail responsibilities here. Refer section 3 Applications for examples]
Sustainability	[Detail responsibilities here. Refer section 3 Applications for examples]
ICT Consultant	[Detail responsibilities here. Refer section 3 Applications for examples]
MSI	[Detail responsibilities here. Refer section 3 Applications for examples]
Networks	[Detail responsibilities here. Refer section 3 Applications for examples]
Others	[Detail responsibilities here. Refer section 3 Applications for examples]

Commissioning & Operation Requirements

This section needs to provide guidelines on commissioning requirements specific to the operation of the system and its integration with other components of the TAFE NSW Smart Campus ecosystem, including the TAFE NSW Data Platform.

This section is also required to include specific end-user training and capability development requirements to form part of the Change Management plan initiated by provision of a new System.Sensors typically connect to the TCP/IP network via copper Ethernet cabling utilising PoE;

5.2 Building Management & Control System

5.2.1 System Description

Concept

A building management & control system (BMCS) is a complex structure of devices providing control and monitoring services across a wide variety of building services systems. Historically, BMCS is used to automate mechanical air handling systems, however has expanded to monitoring electrical, security, fire, hydraulics and vertical transportation systems. BMCS is to be included in all TAFE NSW campuses, and must transmit all data to the TAFE NSW Data Platform to incorporate a whole-of-portfolio reporting solution.

BMCS integration with Smart Campus systems is intended to provide monitoring and reporting capability, as well as the ability to run automation programmes to optimise energy usage based on data trends, local conditions or other algorithms. Manual remote management of BMCS is beyond the scope of Smart Campus.

A BMCS hierarchy typically includes the following components:

- Input Devices - a device that measures the value of a variable and relays the information to the associated controller (e.g. a field sensor);
- Output Devices - a device that receives a control signal and causes a mechanical response (e.g. a switch actuator);
- Controllers - a network-connected device that provides wholesale control and monitoring for a system (e.g. air handling unit controller);
- Head-End - a computer system that aggregates all input devices, output devices and controllers and provides control, monitoring, and analytical functions.

A Smart Campus installation requires the BMCS to be connected to the TAFE NSW Data Platform via the internet. This could occur at any of the above device levels (e.g. a BMCS could operate all field devices on a proprietary interface, and the head-end could connect to the data platform; alternatively, all field devices could connect to the data platform directly, negating the requirement for a head-end).

References

Refer to TAFE NSW Mechanical Services Design Standard, Section 4.11, for Mechanical Engineering requirements pertaining to the supply, installation and configuration of a BMCS.

Refer to TAFE NSW Vertical Transportation Design Standard, Section 4.5.4 for Vertical Transportation Engineering requirements pertaining to the requirements for all lifts to be connected to the BMCS for the purpose of gathering data.

5.2 Building Management & Control System

Data Gathered

As a BMCS gathers a significant quantity of data, it is beyond the scope of this Design Standard to nominate all possible data structures. The following references act as a guide to the minimum level of data that must be captured through the use of a BMCS where the relevant system has been installed.

Refer to Project Haystack for specific BMCS schema for each data type.

Data Reference	Data Gathered
Electrical Metering	Monitor kW, kVA, kWh, voltage, current, power factor, harmonics at all electrical and mechanical distribution boards.
Electrical Faults	Monitor for faults at all main switchboards, electrical and mechanical distribution boards.
Generator Status	Where any generator is installed, monitor status, fuel capacity, run-time, faults and alarms.
Computer Room Monitoring	Monitor for high temperature, water leak, A/C unit failure and the like.
Uninterruptible Power System	Monitor for on-line, by-pass, overload, normal operation and fault status.
Fire Controls	Provide a high-level interface nomination fire and smoke alarm monitoring throughout the BMCS and in turn the TAFE NSW Data Platform.
Hydrant Status	Monitor for pressure, leaks, faults and the like.
Hydraulic Plant Status	Monitor for pressure, leaks, faults and the like.
Gas Metering	Monitor gas usage and leaks at the floor level.
Potable Water Metering	Monitor water usage at the floor level.
Lift Monitoring	Monitor lift failure, fire service, alarm button, independent service, normal service, maintenance mode and hazardous goods operation.
Plant Speed	Refer TAFE NSW Mechanical Design Standards
Valve Positioning	Refer TAFE NSW Mechanical Design Standards
Multi-Zone AHU	Refer TAFE NSW Mechanical Design Standards
VAV AHU	Refer TAFE NSW Mechanical Design Standards
Chilled Water System	Refer TAFE NSW Mechanical Design Standards
Heating Water System	Refer TAFE NSW Mechanical Design Standards
Condensing Water System	Refer TAFE NSW Mechanical Design Standards
Vertical Transportation System	Monitor for lift alarms - lift failed, fire services, alarm button pressed, independent service, normal services, maintenance, hazardous goods operation. Monitor the total number of times, with timestamp, that the lift is called, in order to gauge lift user traffic patterns.

5 Systems

5.2 Building Management & Control System

Implementation

Strong Implementation

A Strong Implementation will comprise the installation of a new BMCS fully conformant to the TAFE NSW Mechanical Design Standard. The BMCS will utilise a standardised, open protocol running on TCP/IP and not a proprietary system. A majority of BMCS components will operate over the site's ICN and be capable of transmitting data to the TAFE NSW Data Platform without the use of a translation layer.

The Strong Implementation will use data gathered to undertake a number of automated energy management programmes. These are to be adjusted to local conditions, and at minimum will include:

- Mechanical Operation Time Management - e.g. minimising mechanical systems' operating hours through delayed start, or maintaining operating temperature at the end of day;
- Night Cycle - e.g. maintaining temperature throughout unoccupied periods through air-handling unit cycling, or using cooler night air to pre-cool the building prior to activating mechanical cooling in the day;
- Intelligent Heat Transfer - e.g. automatically switching to natural ventilation modes when conditions are suitable;
- Distributed Power Demand - e.g. undertaking load shedding and demand sharing between air conditioned spaces based on data gathered by human presence detectors and the like;
- Optimised Start and Stop Strategies - e.g. a basis on historical building performance (temperatures, occupancy, etc), system capacity, predicted weather conditions, current indoor and outdoor conditions, and time scheduling.

Reduced Implementation

A Reduced Implementation may leverage an existing BMCS that may not necessarily be fully conformant to the TAFE NSW Mechanical Design Standards. The BMCS may comprise a monitoring system with a reduced function set, or it may utilise proprietary, non-TCP/IP protocols. The Reduced Implementation will comprise a design allowing a legacy BMCS to be able to communicate with the TAFE NSW Data Platform, which may include:

- Upgrading a head-end to a modern system with native TCP/IP connectivity to interface with the TAFE NSW Data Platform;
- Provision of translation layers, such as platform edge gateways, which attach to a traditional BMCS network and convert the data to a protocol readable by the TAFE NSW Data Platform;
- Provision of new network devices or segregated local area networks in the case of unsecure transmissions, to prevent legacy BMCS equipment being used as a cyber attack vector.

The Reduced Implementation must use the TAFE NSW Data Platform to undertake as many of the energy management controls, as described in the Strong Implementation, as possible.

Upgrade Path

An upgrade path in existing campuses is to undertake an audit of any legacy BMCS equipment, and make the determination to undertake a Strong Implementation and Reduced Implementation based on the age and workability of the system. Sites that do not have an existing BMCS may benefit from the installation of small scale control and monitoring systems, for example, standalone TCP/IP-connected energy meters installed at local electrical switchboards. The components are to be configured to record the same type of data as a full-scale BMCS would.

Connection

Typically, Controllers and Head-Ends are TCP/IP-native devices and thus connect to the TCP/IP network via copper Ethernet cabling. Some devices may require PoE.

Typically, Input and Output devices (field devices) utilise 'traditional' copper BMCS wiring using conductors of between 0.35 mm^2 and 1.35mm^2 to operate extended channel lengths over what is possible with copper Ethernet. Devices may alternatively use media conversion devices to operate longer distances via fibre-optic cabling. Traditional BMCS wiring is generally terminated on field devices and controllers using terminal blocks or terminal strips.

5 Systems

5.2 Building Management & Control System

Coordination Requirements

Guidelines on expanded design/construction responsibility requirements, part of the following table.

Stakeholder	Responsibility
TAFE NSW	Oversee and approve BMCS strategy. TAFE NSW regional BMCS operators must endorse proposed BMCS design and advise on integration requirements with existing systems.
Architect	Oversee and approve locations of field devices, provide adequate spatial provisions to mount controllers and associated mechanical panels.
Electrical	Undertake design and construction of electrical monitoring, metering and controls equipment. Determine the backbone and horizontal cabling pathways and delivery methods to support BMCS installation. Provide a points list to the BMCS installer to ensure all electrical data points are captured.
Mechanical	Undertake design and construction of mechanical equipment and their associated BMCS connectivity/devices; nominate locations of field devices and controllers; nominate mechanical control systems cabling topology. Provide specification and commissioning plan requirements. Nominate data capture requirements and work with the MSI to undertake synchronisation of data with the TAFE NSW Data Platform.
Hydraulic	Provide a points list to the BMCS installer to ensure all hydraulics data points are captured.
Fire	Provide a points list to the BMCS installer to ensure all fire data points are captured. Integrate high-level interface between Fire Indicator Panel and BMCS.
Audio Visual	Provide a points list to the BMCS installer to ensure all audio-visual systems data points are captured.
Sustainability	Oversee and approve BMCS strategy. Verify that all control and monitoring procedures are consistent with the sustainability framework applicable to the project.
ICT Consultant	Nominate network connections, software integration requirements and other parties' obligations to ensure that all systems and endpoints are registered in the Smart Campus design.
MSI	Undertake programming and inclusion of data structures into the TAFE NSW Data Platform. Instruct the BMCS installer on site on configuration and network connectivity requirements, and assist them in informing existing data structures and topologies. Undertake testing and commissioning of BMCS data transfer and verify correct operation.
Networks	Provide BMCS specific VLANs and address space for BMCS, metering and mechanical devices and advise the BMCS installer and MSI on network connectivity requirements.
Others	Vertical Transportation - Provide a points list to the BMCS installer to ensure all lifts and escalators' data points are captured.

5 Systems

5.2 Building Management & Control System

Commissioning & Operation Requirements

Commissioning and testing data and results must be provided for BMCS integration, including but not limited to the following:

- Functionality and operation of BMCS field devices within each room and area. Record the result in the Asset Management platform as a pass or a fail;
- Validate the operation against known set-points of mechanical equipment, and ensure all devices react as required;
- Creation of a temporary ‘staging’ visualisation on the Information Layer in accordance with TAFE NSW Systems Group procedures to test the working integration of data structures prior to integration into the production Data Platform;
- Upon a successful staging process, integrate data structures into the production Data Platform.

The following final completion and operations actions must be undertaken:

- Measure data over time to train artificial intelligence/machine learning algorithms to optimise mechanical system operation;
- Conduct comprehensive user training to facilities management representatives on the operation of graphical user interfaces and data dashboards implemented as part of BMCS integration;
- Conduct comprehensive user training to relevant faculty members on the data collection and display methodology to aid in learning delivery.

5 Systems

5.3 Lighting Control System

5.3.1 System Description

Concept

Traditionally, lighting control systems only provided illumination and used stand-alone or independent controls. With the integration of occupancy and light sensors, a lighting system can be integrated with other building systems to provide enhanced occupant comfort and optimise energy use.

References

Refer to TAFE NSW Lighting Services Design Standard, Section 4.2, for Electrical Engineering requirements pertaining to lighting control system design, specification and installation.

Data Gathered

Lighting control systems typically follow a hybrid TCP/IP and traditional cabling (e.g. DALI, KNX, Dynalite) topology, as fully TCP/IP-controlled lighting devices are not commonly installed.

In this topology, up to 64 addressable elements (e.g., lights, sensors) can be interfaced with a controller. This controller communicates with the driver within each fixture to switch or dim the light according to inputs from sensors or external sources.

Thus, data structures are generally operated on a per-controller basis, and not typically on a per-device level.

Data Reference	Data Type	Data Use
occupied	Boolean	Reported by sensors, either as part of the lighting control system, or alternative non-lighting control TCP/IP sensors. Continually monitors whether the room is occupied. (If the signal comes from a human presence detector, the data broker is to simplify the recorded number of people to a Boolean "Occupied" response).
light-level sensor	Integer (0...100)	Reported by sensors, either as part of the lighting control system, or alternative non-lighting control TCP/IP sensors. Continually monitors the ambient light in the room to provide daylight harvesting functionality.
*TimedAction	Structure {Time, Action }	A data structure nominating actions (on, off, dim etc) to occur to a certain lighting control group at a certain time.
*LoadShedTrigger	Boolean	Certain lighting groups can be programmed to load shed in the event of generator switchover.
light-level sp	Integer (0...100)	Reported by lighting drivers. DimmingStatus is controlled by other local or global settings and is reported back to the platform every 30 seconds.

5.3 Lighting Control System

Implementation

Strong Implementation

A Strong Implementation will comprise the installation of a new lighting control system fully conformant to the TAFE NSW Lighting Services Design Standard.

It is expected that all spaces in the project will be controlled by a smart lighting control system. All spaces are to utilise new TCP/IP lighting controllers capable of transmitting and receiving the data structures as described above for comprehensive lighting system monitoring and control. A Strong Implementation in the future could include dedicated TCP/IP devices (luminaires, sensors) which negate the requirement for an TCP/IP lighting controller.

Reduced Implementation

A Reduced Implementation may leverage an existing lighting control system that may not necessarily be fully conformant to the TAFE NSW Lighting Services Design Standard.

- If the implementation includes an existing lighting control system that does not necessarily include all data structure features above (e.g. the system doesn't include dimmable lights), incorporate as many features as possible;
- If the implementation does not include an existing lighting control system (e.g. 230V switching only), consider a wholesale capital upgrade or a minor technology re-fit depending on the project's scale. A minor technology re-fit could be the implementation of a combination of inexpensive 230V smart switching devices with a wholesale implementation of Human Presence Detectors offering data gathering benefits over and above lighting control.

Upgrade Path

An upgrade path in existing campuses is to undertake an audit of lighting control systems across the TAFE NSW network and determine the capability/gaps for implementation of TCP/IP connectivity and data structures. Those with compatible systems should be included in a long-term plan to integrate controllers with the data platform via data brokers or similar.

Existing campuses with no existing lighting control systems should be nominated for future re-fit works per the Reduced Implementation guideline.

Connection

- Luminaires, sensors and button panels/touch screens typically connect to a hard-wired electrical power bus with driver-based control, typically DALI;
- Some, newer models of the above may natively connect to the TCP/IP network via copper Ethernet cabling utilising PoE;
- Controllers typically connect to the TCP/IP network via copper Ethernet cabling.

5 Systems

5.3 Lighting Control System

Coordination Requirements

Guidelines on expanded design/construction responsibility requirements, part of the following table.

Stakeholder	Responsibility
TAFE NSW	Oversee and approve lighting strategy.
Architect	Oversee and approve positioning of all lighting devices in conjunction with architectural intent.
Electrical	Undertake design and construction of the overall lighting layouts, lighting control systems and nomination of human interface devices. Undertake modelling in design and as-built models of lighting systems throughout. Provide specification and commissioning plan requirements.
Mechanical	If lighting control system is nominated to use a BMS-based interface, e.g. BACnet, ensure compatibility with BMS and enrol common data structures within the BMS.
Hydraulic	Nil
Fire	Nil
Audio Visual	If lighting control system is nominated to be controlled via AV system, ensure compatibility with AV system and enrol common data structures within the AV control system.
Sustainability	Oversee and approve lighting strategy and control devices with respect to energy efficiency strategy.
ICT Consultant	Nominate network connections and requirements for lighting control system ensuring that all devices are registered in the Smart Campus design.
MSI	Undertake programming and inclusion of data structures into the TAFE NSW Data Platform. Instruct the lighting controls installer on site on configuration and network connectivity requirements. Undertake testing and commissioning of lighting control system data transfer and verify correct operation.
Networks	Provide lighting specific VLANs and address space for lighting control systems and advise the lighting controls installer and MSI on network connectivity requirements.
Others	Nil

Commissioning & Operation Requirements

Commissioning and testing data and results must be provided for lighting control system integration, including but not limited to the following:

- Validation of lighting control sensors must be undertaken to ensure that appropriate thresholds are allowed for visual comfort. Calibration of sensors (lighting-native or otherwise) needs to be sensible and ensure that control of luminaires does not result in abrupt or haphazard switching or dimming;
- Functionality and operation of lighting control devices and luminaires are to be recorded in the Asset Management system and verified against a commissioning date;
- User testing to ensure that lighting meets comfort and controllability requirements;
- Comprehensive user training on any lighting control integrations, particularly any systems that involve connection of user devices;
- Upon a successful staging process, integrate data structures into the production Data Platform.

5 Systems

5.4 Emergency Lighting System

5.4.1 System Description

Concept

Emergency lighting systems are fundamental to safety, navigability and visibility in the event of an emergency. Failure of such systems introduces a high degree of risk to TAFE NSW's staff and learners. With the integration of Emergency Lighting Control Systems into the Smart Campus, preventative maintenance of emergency lights across all installations can be made possible.

References

Refer to TAFE NSW Lighting Services Design Standard, Section 4.3, for Electrical Engineering requirements pertaining to emergency lighting control system design, specification and installation.

Data Gathered

Emergency lighting control systems typically use a proprietary control cabling or wireless RF or mesh topology, feeding data to either a local, central head-end unit. The head-end unit should be TCP/IP-native and connected to the Smart Campus network.

Individual lights must be addressable, however data structures can be managed by the central head-end unit.

Data Reference	Data Type	Data Use
*FittingType	Text	Nominates the type of fitting, e.g. single-point luminaire, twin-head luminaire, exit sign, etc.
*LastDischarge	Structure { Date, Result, Duration }	Nominates the last time the battery was discharged and provides a diagnostic test result based on the discharge time.
*NextScheduledTest	Date	Calculated result based on the results of the last test and the required maintenance schedule.
*Status	Boolean	Fitting Status, 1=OK, 0=Fault
*BatteryState	Integer	Percentage of Battery Discharge
*LampState	Boolean	Lamp Status, 1=On, 0=Off
*FaultReason	Text	Description of the reason the device in question last faulted.

5 Systems

5.4 Emergency Lighting System

Implementation

Strong Implementation

A Strong Implementation will comprise the installation of a new emergency lighting system fully conformant to the TAFE NSW Lighting Services Design Standard. It is expected that all spaces in the project will be covered by this wholesale lighting control system and it will be consistent across the campus. A central head-end will be installed supporting the data structures as described above for comprehensive system monitoring and control.

Reduced Implementation

A Reduced Implementation may leverage an existing lighting control system that may not necessarily be fully conformant to the TAFE NSW Lighting Services Design Standard.

- If the implementation includes an existing lighting control system that does not necessarily include all data structure features above, incorporate as many features as possible;
- If the implementation does not include an existing lighting control system (e.g. 230V switching only), consider a wholesale capital upgrade or a minor technology re-fit in the local areas concerned depending on the project's scale. A minor technology re-fit could be the implementation of a wireless mesh network system with a localised TCP/IP-based controller in the electrical distribution board.

Upgrade Path

An upgrade path in existing campuses is to undertake an audit of emergency lighting systems in the project and determine the capability/ gaps for implementation of a compatible emergency lighting control system.

Existing campuses with no existing lighting control systems should continue the practise of incorporating fixed 230V emergency lighting units into the asset register.

Connection

- Emergency lighting units typically connect over an RF mesh network, using proprietary protocols over shared RF spectrum. The mesh network eventually connects back to a head-end unit;
- Emergency lighting units may also connect over hard-wired systems or proprietary wireless connections to intermediary units before the final distribution is made to the head-end;
- Intermediary units are typically located in electrical riser cupboards and connect to the TCP/IP network via copper Ethernet cabling;
- Head-end units are typically located in main communications rooms and connect to the TCP/IP network via copper Ethernet cabling.

5 Systems

5.4 Emergency Lighting System

Coordination Requirements

Guidelines on expanded design/construction responsibility requirements, part of the following table.

Stakeholder	Responsibility
TAFE NSW	Oversee and approve lighting strategy.
Architect	Oversee and approve positioning of all emergency lights in conjunction with architectural intent.
Electrical	Undertake design and construction of the overall emergency lighting layouts, lighting control systems and nomination of a platform that complies with this Standard. Undertake modelling in design and as-built models of emergency lighting throughout. Provide specification and commissioning plan requirements.
Mechanical	If emergency lighting systems are nominated to use a BMS-based interface, e.g. BACnet, ensure compatibility with BMS and enrol common data structures within the BMS. (It is noted that a direct database connection to the TAFE NSW Data Platform is preferred)
Hydraulic	Nil
Fire	Nil
Audio Visual	Nil
Sustainability	Nil
ICT Consultant	Nominate network connections and requirements for emergency lighting system ensuring that all devices are registered in the Smart Campus design.
MSI	Undertake programming and inclusion of data structures into the TAFE NSW Data Platform. Instruct the emergency lighting installer on site on configuration and network connectivity requirements. Undertake testing and commissioning of emergency lighting data transfer and verify correct operation.
Networks	Provide emergency lighting specific VLANs and address space for nominated systems and advise the installer and MSI on network connectivity requirements.
Others	Nil

Commissioning & Operation Requirements

Commissioning and testing data and results must be provided for emergency lighting system integration, including but not limited to the following:

- Completion of a full AS 2293 compliant log-book nominating asset identifiers, testing results and testing schedule;
- Integrate the log-book into the Asset Management platform including correct assignment of fields;
- Apply programming in the Asset Management platform and Digital Building Representation to synchronise maintenance issues. This includes, but is not limited to, providing notifications to certain user groups of errors, testing reminders, records of automated test results and the like.

The installer is required to provide comprehensive user training to the facilities management, in conjunction with UI/UX developers if required, on the operation of the Digital Building Representation and how emergency lighting units are represented. TAFE NSW Systems Group is required to ensure that correct access levels are assigned to facilities management representatives.

5 Systems

5.5 Multi-Functional Poles

5.5.1 System Description

Concept

Multi-functional poles can house or support devices such as public lighting, traffic signals, dynamic signage, 4G/5G small cells, public Wi-Fi, CCTV, electric vehicle chargers and a wide variety of smart city sensors in an integrated and often modular approach. By integrating so may devices, multi-functional poles result is less street clutter, greatly improved visual amenity, enhanced capabilities and potentially, lower overall costs due to the need for fewer poles.

The concept for incorporating multi-functional poles into Smart Campus includes:

- Multi-functional poles to include lighting intelligence;
- Inclusion of external lighting intelligence outside of lighting poles, to facilitate other external lights, e.g. bollards, inground luminaires and the like;
- Provisions to allow for the modular inclusion of additional services to multi-functional poles in the future.

External lighting systems can use sensors within multi-functional poles to incorporate data-driven automation to enhance safety and security at night, and optimise their outputs to minimise the effects on the environment when the area is unoccupied. Some of the integrations with Smart Campus subsystems are to include:

- Presence detectors must be able to detect approaching vehicles and pedestrians. For a group of lights, the next light in a string should increase in intensity as a person or vehicle approaches it.
- The system should be considerate of ecosystems. For example, presence detectors, where installed, must be able to detect animals and not activate lights in their presence.
- Presence detectors should operate flexible colour temperature lighting systems when installed so that 'warm' lighting is output during normal operation, and adjusts to 'cool' upon the detection of a vehicle or pedestrian.
- Lighting schedules must consider predicted sunrise and sunset data as published into the Data Platform by the Bureau of Meteorology.
- Lighting poles or pedestals should incorporate a level of TCP/IP system expandability to allow for the attachment of other Smart Campus data gathering devices.

References

Refer to TAFE NSW Lighting Services Design Standard, Section 4.1, for base Electrical Engineering requirements pertaining to lighting system installation, inclusive of external lighting.

Data Gathered

Intelligent external lighting systems will make use of data published by other sources to control the luminaires. It is intended that the luminaires will contain some level of internal memory to operate in a fail-safe manner in the event of network loss.

Data Reference	Data Type	Data Use
occupied	Boolean	Reported by sensors, either as part of the lighting control system, or alternative non-lighting control TCP/IP sensors. Continually monitors whether the immediate area is occupied and adjusts linked and adjacent lighting levels/temperatures to suit. (If the signal comes from a human presence detector, the data broker is to simplify the recorded number of people to a Boolean “Occupied” response).
light-level sensor	Integer (0…100)	Reported by sensors, either as part of the lighting control system, or alternative non-lighting control TCP/IP sensors. Continually monitors the ambient light in the area to provide daylight harvesting functionality.
*LightOnTime	Date	Calculated in the Data Platform to determine a dynamic time based on time zone and sunrise/sunset factors and requisite lighting levels for switching on baseline outdoor lighting.
*LightOffTime	Date	As per LightOnTime

Implementation

Strong Implementation

A Strong Implementation will comprise the installation of new outdoor lighting systems including luminaires, structures (e.g. poles) and data gathering devices (e.g. sensors) consistent with the landscape architecture and immediate campus requirements.

Two general categories of multi-functional pole exist, and may be considered for installation in the project, commensurate of landscape architecture considerations. The selection of pole type must be consistent across the project and the wider campus.

- External-Device Poles: mounting tracks to allow for the quick and secure attachment of external devices, such as cameras, lights and sensors;
- Internal-Modular Poles: aesthetically cleaner poles where proprietary devices are stacked internally.

Multi-function poles are to be produced with a standardised footing, with a diameter of 460mm. Poles are to be affixed to the pier with six rag-bolts. The concrete footing and associated assembly must be based on site-specific calculations carried out by a suitably qualified and experienced structural engineer.

Installation of supporting infrastructure to the poles must follow the guidelines shown under 'Upgrade Path'.

5 Systems

5.5 Multi-Functional Poles

Reduced Implementation

There is no Reduced Implementation applicable to this System.

Upgrade Path

An upgrade path will incorporate the distribution of power and communications conduits complete with draw wire or filled with copper or fibre-optic cabling, parallel with power cabling/conduits, to facilitate the future connection of intelligent outdoor poles.

Each pole location must be provided with a minimum of two 50mm communications conduits per pole, to facilitate a TAFE NSW network connection, and a separate alternative network connection, such as a telecommunications provider to support a future 5G deployment.

Pole locations on paths with foot traffic only must be provided with a minimum of one 50mm power conduit per pole. Pole locations on paths accessible to vehicle traffic and potentially acting as electric vehicle charging stations must be provided with a minimum of two 50mm power conduits to allow for additional sub-mains cabling.

Connection

- Multi-function poles may host a wide variety of devices. Typically, low-power devices are to be TCP/IP compliant, powered by Power over Ethernet and connect back to the TAFE NSW network via structured cabling.
  - Where the pole top is less than 90 metres from its originating communications room (or external enclosure), the device(s) must be supplied with underground-rated copper Ethernet cable as recommended by the TAFE NSW Structured Cabling Standards. Each device is to have its own dedicated cable;
  - Where the pole top exceeds 90 metres distance from its originating communications room, the device(s) must be supplied with a fibre-optic cable as recommended by the TAFE NSW Structured Cabling Standards. Where the pole (and adjacent poles) service fewer than three devices, a fibre media conversion device is to be applied at both ends, allowing the device to connect to a standard copper switch. Where the pole (and adjacent poles) services three devices or greater, the pole must be supplied with a ruggedised PoE network switch approved by TAFE NSW Systems Group, with devices in the pole connected directly.
- For lighting, luminaires typically connect to each other a hard-wired electrical power bus with driver-based control, typically DALI;
- Alternatively, luminaires may connect to each other over an RF mesh network, using proprietary protocols over shared RF spectrum. The luminaires will be powered by a direct 230V supply to the pole;
- Lighting control devices including data-gathering sensors typically connect to the TCP/IP network via DALI or copper Ethernet cabling.
- All network infrastructure connected into exterior multi-function poles or the like must incorporate lightning arrestors to prevent damage to upstream network infrastructure.

5 Systems

5.5 Multi-Functional Poles

Coordination Requirements

Guidelines on expanded design/construction responsibility requirements, part of the following table.

Stakeholder	Responsibility
TAFE NSW	Oversee and approve lighting strategy.
Architect	Oversee and approve positioning of all external lighting devices in conjunction with landscape architecture and façade architecture intent.
Electrical	Undertake design and construction of the overall external lighting layouts, lighting control systems and nomination of human interface devices. Undertake modelling in design and as-built models of lighting systems throughout. Provide specification and commissioning plan requirements.
Mechanical	If lighting control system is nominated to use a BMS-based interface, e.g. BACnet, ensure compatibility with BMS and enrol common data structures within the BMS.
Hydraulic	Nil
Fire	Nil
Audio Visual	Nil
Sustainability	Oversee and approve lighting strategy and control devices with respect to energy efficiency strategy and obtrusive effects of outdoor lighting.
ICT Consultant	Nominate network connections and requirements for lighting control system ensuring that all devices are registered in the Smart Campus design.
MSI	Undertake programming and inclusion of data structures into the TAFE NSW Data Platform. Instruct the lighting controls installer on site on configuration and network connectivity requirements. Undertake testing and commissioning of lighting control system data transfer and verify correct operation.
Networks	Provide lighting specific VLANs and address space for lighting control systems and advise the lighting controls installer and MSI on network connectivity requirements.
Others	Nil

Commissioning & Operation Requirements

Commissioning and testing data and results must be provided for integration of external lighting control within multi-functional poles, including but not limited to the following:

- Work with the electrical contractor to ensure the assets (e.g. lights and sensors) are given correct hostnames and IP addresses in line with the TAFE NSW Asset Management platform requirements;
- Complete parametric testing must be undertaken to ensure behaviour is as expected. Ensure that sensors are capable of operating stand-alone and in groups;
- Ensure that data collection functionality including presence detection is reporting data back to the network. Complete staging process and integrate data structures into the production Data Platform;
- User training requirements for the outdoor lighting system are minimal, however ensure that appropriate fallback measures are included and appropriate facilities management to allow manual control of lighting as required.

5 Systems

5.6 Irrigation Management System

5.6.1 System Description

Concept

To optimise the irrigation, planting, mulching and garden maintenance strategies for gardens, lawns, agricultural or horticultural spaces specific to local condition/s and the future outlook. Ultimately, management of irrigation systems with Smart Campus data sets will reduce and more efficiently use water and labour for horticultural maintenance.

As the TAFE NSW Data Platform gathers meteorological data from the Bureau of Meteorology, data from predictive rain forecasts will be incorporated into the irrigation management system to better manage water use.

References

Not applicable.

Data Gathered

Irrigation Management systems typically follow a hybrid of TCP/IP and traditional cabling (e.g. BACnet, HiLo) topology fed back to a central controller/management system.

The specific cable and data collection topology is flexible; however, the data transport should allow the following per a space:

Data Reference	Data Type	Data Use
*IrrigationStatus	Boolean	Reported by sensors , continually monitors whether the system is operating. (If the signal provides more detail, the data broker is to simplify the recorded number/ percentage to a Boolean “On” response).
flow	Integer (0…100)	Reported by sensors, the current flow level of the irrigation system.
humidity	Integer (0…100)	Reported by sensors, the current humidity level of the external area to predict potential evaporation.
temp	Integer (0…100)	Reported by sensors, the current temperature level of the local garden area to predict potential evaporation.
*RainLevel	Integer (0…100)	Reported by sensors, the current rain level of the local garden area to predict potential moisture level change.

5 Systems

5.6 Irrigation Management System

Implementation

Strong Implementation

A Strong Implementation will comprise the installation of new TCP/IP based sensors that would communicate real time data to the irrigation management system, whilst also collection of the data to analyse usage and improve maintenance strategies over time.

It is expected that all agricultural or garden spaces will have an irrigation management system. A Strong Implementation in the future could include a single multi-sensor not only capable of soil moisture, but of detecting weather (temperature, humidity, rain, wind, etc.)

Reduced Implementation

A Reduced Implementation may be deployed in specific highly visible or difficult to maintain agricultural or garden spaces. These specific cases may have a small "standalone" system that may not necessarily be fully conformant to the data structure above.

- If the implementation includes an existing control system that does not necessarily include all data structure features above (e.g. the system doesn't include humidity), incorporate as many features as possible;
- If the implementation does not include an existing control system, consider a wholesale capital upgrade or a minor technology re-fit depending on the project's scale. A minor technology re-fit could be the implementation of weather station and/or soil moisture sensors offering data gathering on the health/status of the space to allow irrigation system "tuning" and optimisation.

Upgrade Path

An upgrade path in existing campuses is to undertake an audit of irrigation and garden maintenance systems across the TAFE NSW network and determine the capability/gaps for implementation of TCP/IP connectivity and data structures. Those with compatible systems should be included in a long-term plan to integrate controllers with the data platform via data brokers or similar.

Existing campuses with no existing systems should be nominated for future re-fit works per the Reduced Implementation guideline.

Connection

- Sensors typically connect to a hard-wired centralised controller;
- Flow meters and/or control valves connect to a hard-wired centralised controller;
- Newer sensors and flow control may natively connect to the TCP/IP network via copper Ethernet cabling utilising PoE;
- Controllers typically connect to the TCP/IP network via copper Ethernet cabling.

5 Systems

5.6 Irrigation Management System

Coordination Requirements

Guidelines on expanded design/construction responsibility requirements, part of the following table.

Stakeholder	Responsibility
TAFE NSW	Oversee and approve irrigation management system/s strategy.
Architect	Oversee and approve positioning of all sensor devices in conjunction with architectural/landscape intent.
Electrical	Undertake design and construction of the communications cabling topology, reticulation, location and quantity.
Mechanical	Nil
Hydraulic	Undertake design and construction of the irrigation management system topology, reticulation, location and device quantity.
Fire	Nil
Audio Visual	Nil
Sustainability	Oversee and approve water use/irrigation strategy and control devices with respect to resource efficiency strategy.
ICT Consultant	Nominate network connections and requirements for irrigation system strategy ensuring that all devices are registered in the Smart Campus design.
MSI	Undertake programming and inclusion of data structures into the TAFE NSW Data Platform. Instruct the irrigation controls installer on site on configuration and network connectivity requirements. Undertake testing and commissioning of irrigation control system data transfer and verify correct operation.
Networks	Provide project specific VLANs and address space for sensors and controllers and advise the Installer and MSI on network connectivity requirements.
Others	Nil

Commissioning & Operation Requirements

Commissioning and testing data and results must be provided for integration of the irrigation management system controllers with the water supply and other physical elements, including but not limited to the following:

- Weather data must be validated and benchmarked over time to ensure that the automation of irrigation is consistent with the horticultural expectations, and vegetation is not being over-or under-watered;
- The irrigation management system must be thoroughly benchmarked against a 'default' set-point of water usage expectations throughout its operational life to validate the water savings data and gauge the success of the implementation;
- For installations where the irrigation management system is used for teaching and learning settings, for example, agricultural installations, comprehensive user training is required. The TAFE NSW Change Management advisory in associated with the Customer and Stakeholder Relations group must work to incorporate the new system's features into classwork.

5 Systems

5.7 Space Utilisation Tracking

5.7.1 System Description

Concept

Space utilisation tracking is the science of gathering data on the effectiveness of a room or a space. The key purpose of incorporating utilisation tracking is to understand the occupancy (quantity and duration) statistics associated with a person's inhabitance of a space or room.

Space utilisation tracking is commonly achieved through the use of optical or thermal multi-sensor devices. Such devices generally operate by scanning a room for human presence by way of image analysis or heat signatures. Devices commonly include additional sensors such as temperature or humidity to provide metadata regarding the environment of the room at a certain point in time, which can be correlated with human presence data.

Occupancy and occupant duration provide data to indicate the effectiveness of a space/room, finishes, furnishings, equipment and utilities to meet the requirements of those occupants.

Space utilisation is important for building design and planning, understanding facility effectiveness, and making data-backed decisions about facility management and investment.

References

Not applicable.

Data Gathered

The deployment of a space utilisation sensor must be capable of detecting the quantity of people in a space, not simply if it is occupied. Traditional Lighting and Access Control systems typically provide a very limited level of detail of occupancy and as such are insufficient for this application.

The specific cable and data collection topology is flexible; however, the data transport should allow the minimum of the following per a space/ room. Multiple sensors may be required in larger rooms - the designer is to ensure that the sensors do not overlap. This can be achieved through design - sensors typically feature detection zones and can be programmed to avoid certain zones.

Data Reference	Data Type	Data Use
occupied	Boolean	Reported by sensors, either as part of a space utilisation detection or integrated within other systems such as Security or Audio Visual cameras. Continually monitors whether the room is occupied. (If the signal comes from a human presence detector, the data broker is to simplify the recorded number of people to a Boolean “Occupied” response).
occupancy	Integer (0…100)	Reported by sensors. Continually monitors the number of people in the space.

5.7 Space Utilisation Tracking

Implementation

Strong Implementation

A Strong Implementation will comprise the installation of new space utilisation sensors that optimally would pass real time data to other building systems, as required, but importantly can connect to TAFE NSW Timetabling, Room Calendar and similar Software or Cloud based systems.

It is expected that all teaching spaces in the project will have TCP/IP based human presence detectors (HPD) using optical, thermal (InfraRed) or similar technology sensors to identify the quantity of occupants within a space in addition to the duration of their dwell. HPDs must be self-contained, comprising a sensor, processor and all in-built algorithms to provide a resultant calculation, with data passed to the TAFE NSW Data Platform in a native format. No system that sends image data to external hardware to perform optical image analysis will be permitted.

HPDs are not to function as cameras, thus should not allow viewing of raw sensor data. As a benchmark, devices should be conformant to the requirements of the European Privacy Seal, or greater.

A Strong Implementation may include a single multi-function sensor not only capable of detecting occupant numbers but also temperature, humidity, sound level and/or light level.

The designer must consider the following to inform the placement of HPDs:

- Consider the viewing angle of an optical sensor, and ensure that the sensor's field of vision is not obstructed by objects, or crosses over into the field of vision of another sensor, potentially corrupting data;
- Consider the sensor's range for installations in large rooms. It is advised to be conservative with the manufacturer's suggested limits;
- Consider the effects of brightness changes if using an optical sensor. A sensor's effectiveness may be diminished by highly contrasting environments;
- Consider the height limitations of sensor mounting for access, and ability for the sensor to gather data from an extended range;
- Consider environmental limitations on sensor placement. For example, food preparation areas, high-humidity areas or outdoor workshops may require IP-rated or HACCP compliant devices. For edge cases where strict requirements are in place that cannot be managed by design controls, a substitution with a less capable device meeting the restrictions may be permitted.

Reduced Implementation

A Reduced Implementation may leverage or add to an existing building control system that may not necessarily be fully conformant to the data structure above.

- If the implementation includes an existing control system that does not necessarily include all data structure or topology features above (e.g. the system doesn’t include people counting, or is not TCP/IP based), incorporate as many features as possible;
- If the implementation does not include any existing system or sensors, consider the upgrade path detailed below and/or a minor technology re-fit depending on the project’s scale. A minor technology re-fit could be the implementation of HPDs in a sample of teaching space (e.g.. 25%) to enable data extrapolation about space utilisation for the building/campus.

5.7 Space Utilisation Tracking

Upgrade Path

An upgrade path in existing campuses is to provide an additional structured cabling Service Outlet in every teaching space. This would allow for the future connection of HPDs as the funding and capability is rolled out.

Existing campuses with no or limited TCP/IP network capacity could should be nominated for future re-fit works per the Reduced Implementation guideline.

Connection

- Sensors typically connect to the TCP/IP network via copper Ethernet cabling utilising PoE for power;
- Sensors typically publish data in a structured format via a REST API, MQTT or BACnet;
- Some sensors may be capable of integrating with existing BMCS or lighting control systems via proprietary cabling. Generally, this practise is discouraged except in retro-fit applications.

Coordination Requirements

Guidelines on expanded design/construction responsibility requirements, part of the following table.

Stakeholder	Responsibility
TAFE NSW	Oversee and approve space utilisation strategy.
Architect	Oversee and approve positioning of all sensor devices in conjunction with architectural intent.
Electrical	Undertake design and construction of the communications cabling topology, reticulation, location and quantity.
Mechanical	If Space utilisation system is nominated to use a BMCS-based interface, e.g. BACnet, ensure compatibility with BMCS and enrol common data structures within the BMCS.
Hydraulic	Nil
Fire	Nil
Audio Visual	Nil
Sustainability	Nil.
ICT Consultant	Nominate network connections and requirements for space utilisation strategy ensuring that all devices are registered in the Smart Campus design.
MSI	Undertake programming and inclusion of data structures into the TAFE NSW Data Platform. Instruct the space utlilisation installer on site on configuration and network connectivity requirements. Undertake testing and commissioning of sensors and system data transfer and verify correct operation.
Networks	Provide project specific VLANs and address space for sensors and controllers and advise the Installer and MSI on network connectivity requirements.
Others	Nil

Commissioning & Operation Requirements

Physical installation of the sensor must be undertaken in strict accordance with the design documentation to ensure that a correct field of vision is achieved. An incorrect field of vision will result in inaccurate data.

Commissioning and testing data and results must be provided for space utilisation tracking system integration, including but not limited to the following:

- Sensors are to be commissioned on a staging environment prior to entering the production network;
- Procure, supply and install a valid SSL/TLS certificate;
- Undertake controlled testing in an unfurnished environment and final furnished environment. Compare the results and scan for false readings;
- Undertake controlled testing in different lighting settings. Record ambient light levels with a lux-meter;
- Adjust function threshold values to compensate for false positive or negative readings.

5 Systems

5.8 Digital Wayfinding System

5.8.1 System Description

Concept

Digital wayfinding systems provide guidance for learners, visitors and workers to navigate TAFE NSW sites. Systems may also incorporate integrations with web platforms, including desk allocation, room bookings and management of events. A key objective for the design is to provide clear and efficient navigation of sites.

The structure of a Digital Wayfinding System includes the following components:

- Existence of an accurate model of the site, and its rooms and spaces;
- A software platform utilising the aforementioned model via the TAFE NSW Data Platform to deliver an immersive, accessible smartphone or web application;
- Coordination with physical wayfinding design to promote user interaction with real-life signage and waypoints;
- Physical 'augmented reality' objects acting as wayfinding beacons capable of communicating with the aforementioned application. An example concept includes tracking of subjects throughout the site through the use of fixed location Bluetooth Low-Energy (BLE) beacons or gateways.

Successful implementation of digital wayfinding requires continual close coordination between the Smart Campus systems designer and the architect.

Digital wayfinding application software must be procured through a partner approved by TAFE NSW Systems Group to ensure that the implementation is consistent across campuses. Thus, this Design Standard does not embellish the requirements of application software and sets out the infrastructure considerations only.

References

Not applicable.

5.8 Digital Wayfinding System

Data Gathered

Digital Wayfinding Systems are typically TCP/IP microcomputer systems feeding data back to the Data Platform for real-time navigation, feedback and visualisations supplied to end-user devices, such as smartphones.

Tracking devices generally operate through technologies such as BLE and provide geolocation beacons for bidirectional tracking and guidance of subjects throughout the site. Unique identifiers per user Bluetooth device handshake to fixed location beacons.

Data Reference	Data Type	Data Use
*deviceProximity	Structure {time, uniqueIdentifier}	Reported by sensors, as an independent system. Data shall provide a unique Identifier of users within proximity to the sensor.
occupied	Boolean	Reported by sensors, either as part of a digital wayfinding, space utilisation or independent system. Continually monitors whether the room, desk or space is occupied.
occupancy	Integer	Reported by sensors, either as part of a digital wayfinding system, space utilisation detection or integrated within other systems. Continually monitors the number of people in corridors and access routes.

Implementation

Strong Implementation

A Strong Implementation will comprise of the installation of new infrastructure supporting an architecturally designed digital wayfinding system.

The system may incorporate accessible wayfinding totems complete with printed area maps, and a 'pebble' allowing the user to launch the interactive wayfinding software platform via smartphone. The pebble should be passive, industrially designed, complete with Braille instructions, and provide two or more methods to access a localised link, including:

- Near-field communication (NFC);
- Bluetooth Low-Energy (BLE);
- QR Code.

The software application in a Strong Implementation would be capable of providing turn-by-turn navigation on a user's smartphone. A Strong Implementation would leverage individually TCP/IP addressable beacons which communicate to the smartphone using BLE. The software facilitates navigation algorithmically through a combination of algorithmically determining distance between beacons, and the smartphone's internal capabilities such as compass and magnetic field strength meters.

Beacons may be stand-alone devices, or be converged into other network devices such as compatible wireless access points. In all cases, beacons are to be connected to the TCP/IP network through Ethernet cabling.

5 Systems

5.8 Digital Wayfinding System

Reduced Implementation

A Reduced Implementation may facilitate a level of digital wayfinding without the implementation of beacons. The software platform remains consistent, and the architectural direction will still require the addition of 'pebbles' strategically located at wayfinding totems.

Without beacons, the turn-by-turn navigation will not operate, and the software platform will rely on the user to understand their surroundings.

A Reduced Implementation may also manifest if the project is not provided with an appropriate Digital Building Representation. In this instance, the software partner developing the digital wayfinding solution must take responsibility for coordinating an appropriate 2D environment interlinked with correct room and space data.

Upgrade Path

An upgrade path in existing campuses is to undertake a general wayfinding upgrade in line with the TAFE NSW Signage Standards. In conjunction, engage the software partner developing the digital wayfinding solution and undertake a site audit and review, with the view to incorporate either a Strong Implementation or Reduced Implementation depending on viability, navigability of the existing site, and ability to include the requisite cabling and electronic infrastructure.

Connection

- Digital Wayfinding Beacons are typically wall or ceiling mounted, and connect to user devices such as smartphones via Bluetooth Low Energy (BLE). Mounting of devices is to be considerate of height and range limitations;
- Beacons typically connect via Ethernet cabling to the TCP/IP Network. Sensors are to communicate directly to the TAFE NSW Data Platform or via a data broker;
- Beacons may alternatively be incorporated in existing appliances, such as wireless access points and enabled via software;
- Beacons may alternatively be wireless and communicate via BLE, Wi-Fi or alternative low-power networks, however, it is to be ensured that beacons are connected to AC mains power and not battery operated;
- Digital Wayfinding Pebbles, mounted on wayfinding totems, are typically unpowered passive devices containing pre-programmed links accessible via QR code or RFID (NFC) tagging;
- Controllers and servers, if any, connect to the TCP/IP network via copper Ethernet cabling.

5 Systems

5.8 Digital Wayfinding System

Coordination Requirements

Guidelines on expanded design/construction responsibility requirements, part of the following table.

Stakeholder	Responsibility
TAFE NSW	Oversee and approve Digital Wayfinding strategy.
Architect	Oversee and approve positioning of all sensor and beacon devices in conjunction with architectural intent.
Electrical	Undertake the design and construction of the power and communications cabling topology, reticulation and quantity.
Mechanical	Nil.
Hydraulic	Nil.
Fire	Nil.
Audio Visual	Nil.
Sustainability	Nil.
ICT Consultant	Nominate network connections and requirements for the Digital Wayfinding System ensuring that all devices are registered in the Smart Campus design.
MSI	Undertake programming and inclusion of data structures into the TAFE NSW Data Platform. Instruct the Digital Wayfinding System integrator on configuration and network connectivity requirements. Undertake testing and commissioning of the Digital Wayfinding System ensuring data transfer and verify correct operation.
Networks	Provide specific VLANs and address space for the Digital Wayfinding System and advise integrator and MSI on network connectivity requirements.
Others	Nil.

Commissioning & Operation Requirements

Commissioning and testing data and results must be provided for the Digital Wayfinding System, including but not limited to the following:

- Ensuring that all QR codes and NFC links are tagged, tested and resolve to valid URLs on a production server;
- Ensuring that the mapping platform is correctly linked to the as-built architectural documentation and all room names and numbers are synchronised with the Asset Management platform;
- Coordinate with the software partner that accessibility options are correctly incorporated into the web or smartphone application. For example, ensuring that a wheelchair option is correctly implemented to navigate users towards lifts instead of stairs;
- If the Digital Wayfinding System is new to a particular campus, run a comprehensive training session with Customer & Stakeholder Relations group members to build confidence in the system's usage.

5 Systems

5.9 Access Control System

5.9.1 System Description

Concept

The TAFE Infrastructure NSW Security team is in the process of creating an access management strategy that has the ability to integrate access control, intruder alarm, lighting, remote assistance, printers, EOT, learner cards, locker and CCTV system, using existing and emerging technologies.

Smart Campus integrations are designed to leverage the wealth of data available to the access control system platform and use sub-sets of this data for building, business and operational enhancements. For example, the access control database is intended to be linked to the HR and learner enrolment platform to undertake seamless onboarding, reducing manual data entry.

All new TAFE NSW building projects are to be provided with a new Inner Range Integriti access control platform. The security sub-contractor is responsible for integrating new Integriti installations with the overall TAFE NSW Integriti cloud-hosted platform, which will automatically enable data transfer into the TAFE NSW Data Platform, enabling Smart Campus integrations. This section of the Design Standard is intended to be informative only, to outline the proposed Smart Campus integrations with current and future Integriti installations.

References

Not applicable.

Data Gathered

Integriti is a large-scale platform that encompasses all TAFE NSW sites. Integriti operates its own SQL data platform hosted on TAFE NSW's Azure data platform, separate from the TAFE NSW Data Platform, for security isolation reasons.

Data may be transferred to and from the Integriti database through Inner Range published API calls only.

5 Systems

5.9 Access Control System

As Integriti gathers a significant quantity of data, and its API is privately accessibly by approved security personnel only, it is beyond the scope of this Design Standard to nominate all possible data structures. The following references act as a guide to the minimum level of data that must be captured through the use of Integriti.

Refer to the Integriti documentation and Project Haystack for specific schema for each data type.

Data Reference	Data Use
Alerts	Unauthorised Entry, Card Read Error, Invalid Card, Power/Data Communications Failure, Forced Door, Door Open Too Long, Intrusion Detection, Tampering, etc.
Access	Date and timestamp of entrance/egress, User Identification
Analytics	Camera vision tampering, person/vehicle silhouette detection, fence line detection, mask and social distancing

Implementation

Strong Implementation

All projects are to be provided with an Inner Range Integriti instance for managing security and access control. The Security Sub-Contractor is responsible for integrating the site onto the greater TAFE NSW Integriti installation.

Additional items over and above standard access control requirements may need to be flagged by the ICT/Smart Buildings Consultant during the design stage and included into the Integriti site design. These may include:

- Access control systems requiring card/keyfob access other than entrance/egress, such as for lockers, printers, etc;
- Any video analytics software or systems;
- Analytics for vertical transportation systems;
- Specialised or hazardous area perimeter security systems;

Reduced Implementation

There should be no Reduced Implementation for Access Control System integration. No legacy non-Integriti access control system may be integrated into the Smart Campus platform.

Connection

- Access control and perimeter security end-points, such as card readers and intrusion detection devices, are typically connected via traditional methods, such as RS-485 or Figure-8 cable, to a Security Expander or a Door Controller panel;
- Security Expanders and Door Controllers are connected to the TCP/IP network via copper Ethernet cabling;
- Video surveillance cameras typically operate over a controller hierarchy, with cameras connected to the TCP/IP network via copper Ethernet cabling, and managed by an on-premises Network Video Recorder, also on the TCP/IP network.

5.9 Access Control System

Coordination Requirements

Guidelines on expanded design/construction responsibility requirements, part of the following table.

Stakeholder	Responsibility
TAFE NSW	Security Group to oversee and approve overall security and access control strategies, including endorsement of any items over and above default.
Architect	Review placement of security devices. Production of door schedule incorporating security systems.
Electrical	Design and documentation of electronic security systems, including all power and data requirements, in line with the TAFE NSW Electronic Security Systems Specification.
Mechanical	Nil.
Hydraulic	Nil.
Fire	Detail of fire trip integrations with security system.
Audio Visual	Nil.
Sustainability	Nil.
ICT Consultant	Design and documentation of expansions to security system and additional software/hardware integrations.
MSI	Undertaking software and hardware expansions as required, providing support to networks and security sub-contractor.
Networks	Supply, install and configure network hardware supporting security hardware. Provide specific VLANs and address space for Access Control Systems and advise integrator and MSI on network connectivity requirements.
Others	Security sub-contractor to supply, install and integrate security systems onto the TAFE NSW Security Platform. Vertical transport supplier to coordinate with MSI and Security sub-contractor and ensure all access control and usage tracking systems are integrated with TAFE NSW Security Platform.

Commissioning & Operation Requirements

Commissioning and testing data and results must be provided for the Access Control Systems, including but not limited to the following:

- Validate the correct operation of all security hardware and software in a staging environment and correct all errors;
- Ensuring that all access systems including door identifiers are correctly linked to the as-built architectural documentation and all room names and numbers are synchronised between the TAFE NSW Security System on Integriti with the Asset Management platform;
- If there are additional software and hardware systems that are new to a particular campus, such as a smart locker management system, run a comprehensive training session with Customer & Stakeholder Relations group members to build confidence in the system's usage.

5 Systems

5.10 Parking Management System

5.10.1 System Description

Concept

Parking Management Systems incorporate several technologies which assist with access control, guided parking, space utilisation, automated billing, enforcement processes and integration into security systems. A key objective for the design is to converge datasets which provide a seamless user experience of the technologies.

References

Not applicable.

Data Gathered

Parking Management Systems typically follow a hybrid TCP/IP and traditional cabling (e.g. typically RS-485 or proprietary) topology. Advancements in wireless and low energy Bluetooth technologies has enabled fully TCP/IP-controlled systems aggregating to a server or gateway.

Automatic Number Plate Recognition systems may be incorporated into the camera technology or through the use of an analysis server. Parking Guidance Systems may control the traffic flow and allocation of parking spaces to visitors. These may show the direction of flow and current capacity.

Individual Parking Space allocation sensors may utilise wireless technologies and shall track the direct area's occupancy status.

Data Reference	Data Type	Data Use
*numberPlate	Structure {time, numberPlate}	Identified through recognition cameras the Data identifying the time of day and asset ID through its licence plate. Data may be used for access control, time billing and location services.
*vehicleHeight	Integer	Reported by sensors, either as part of the Parking Management System or independent TCP/IP sensors. Collects the vehicles height data which may be used for signalling warnings and access authorisation.
*capacityStatus	Integer	Reported as part of the management system, this details the current capacity of the facility.
*spaceOccupancy	Boolean	Reported by sensor per space, details if the observed space is occupied or available. Each sensor shall be assigned a 'type' which can associated with normal parking bays, electric charging, bike parking etc.
*laneTraffic	Integer	Reported by sensors, either as part of the Parking Management System or independent TCP/IP sensor, identifying the quantity of vehicles within the field of view. Data shall be utilised to manage traffic flow.

5 Systems

5.10 Parking Management System

Implementation

Strong Implementation

A Strong Implementation will comprise of a new Parking Management System (PMS). It is expected all remote sensor data shall be aggregated into a central management server or cloud technology stack. The PMS shall be integrated with the facilities Integrated Security Management System (ISMS) to follow the structure of the ISMS for tenancy, building management and user authorisation. A Strong Implementation would leverage individually TCP/IP addressable sensors and an open standard Application Programming Interface (API). Sensors shall be hard cabled to provide resilience, reliability and low maintenance when compared to wireless technologies.

Reduced Implementation

A Reduced Implementation may utilise individual technologies which provide specific but reduced data excluding more advanced technologies.

- If the implementation includes an existing PMS with Automatic Number Plate Recognition, the system shall be integrated with the Security Management System to provide automated access control. The Automatic Number Plate Recognition system shall provide the data structure for the fields above;
- If the implementation includes an existing PMS with Parking Occupancy Detection, the system shall integrate with a data broker or gateway to access the data structure for the fields above;
- If the implementation does not include an existing PMS, consider a minor technology project to install Automatic Licence Plate Recognition systems and retro-fit wireless occupancy detection. All sensors shall provide individually identifiable ID's through a gateway or PMS.

Upgrade Path

An upgrade path in existing campuses is to undertake an audit of any existing car parking lots across the TAFE NSW network and determine the capability/gaps for implementation of TCP/IP connectivity and data structures. Those with compatible systems should be included in a long-term plan to integrate controllers with the data platform via data brokers or similar.

Connection

- Automatic Number Plate Recognition Cameras typically connect through an TCP/IP network over copper Ethernet cabling utilising PoE;
- Parking Occupancy Sensors typically connect to a hard-wired electrical power bus with driver-based control, such as RS-485;
- Newer versions of the above may enable the use of wireless technologies and connect through gateways to the TCP/IP network;
- Parking Management System Servers typically connect to the TCP/IP network via copper Ethernet cabling.

5 Systems

5.10 Parking Management System

Coordination Requirements

Guidelines on expanded design/construction responsibility requirements, part of the following table.

Stakeholder	Responsibility
TAFE NSW	Oversee and approve Parking Management System Strategy.
Architect	Oversee and approve positioning and integration of sensors with architectural detail.
Electrical	Undertake the design and construction of the Parking Management System integrating remote sensors, access gateways, ticketing systems and detection cameras.
Mechanical	Nil.
Hydraulic	Nil.
Fire	Nil.
Audio Visual	Nil.
Sustainability	Oversee and approve the Parking Management Strategy and control devices with respect to energy efficiency strategy.
ICT Consultant	Nominate network connections and requirements for the Parking Management System ensuring that all devices are registered in the Smart Campus design.
MSI	Undertake programming and inclusion of data structures into the TAFE NSW Data Platform. Instruct the Parking Management System integrator on configuration and network connectivity requirements. Undertake testing and commissioning of the Parking Management System data transfer and verify correct operation.
Networks	Provide specific VLANs and address space for Parking Management Systems and advise integrator and MSI on network connectivity requirements.
Others	Security Integrators shall undertake the configuration of the Integrated Security Management System to provide access control with the Parking Management System.

Commissioning & Operation Requirements

Commissioning and testing data and results must be provided for Parking Management System, including but not limited to the following:

- Functionality and operation of all field sensors including; Automatic Number Plate Recognition systems, vehicle sensors, occupancy sensors and traffic monitors. Record the result in the DBR as a pass or a fail, stress test and adjust to ensure the highest of accuracy of data;
- Creation of a temporary ‘staging’ visualisation on the Information Layer to test the working integration of data structures prior to integration into the production Data Platform;
- Acceptance Testing of systems integration between the ISMS and PMS for access control and monitoring.
- Upon a successful staging process, integrate data structures into the production Data Platform.

5.11 Digital Art & Signage System

5.11.1 System Description

Concept

Digital Art & Signage Systems provide a canvas to showcase visual content and provide a platform to communicate with occupants of the area. Systems and equipment are often implemented on converged networks and utilise a proprietary platform for content creation and content management.

A key objective of this design standard shall be to guide the integration requirements of the TAFE NSW Smart Campus to provide an evergreen and inclusive implementation, and aim to centralise content management.

Technologies to be implemented may include but not limited to:

- Large format LED walls, LCD walls and projection systems;
- Display totems, signboards and kiosks;
- Networked digital content players;
- Assistive listening and audio description system;
- Zone motion detection for content triggering and interaction;
- Digital connection to provide users related information.

References

Not applicable.

Data Gathered

Digital Art & Signage Systems are typically TCP/IP network connected systems. Digital content is delivered via the network to content and signage players, however do not often integrate with wider data gathering and connected systems.

For large scale installations where TAFE NSW wishes to gather user engagement data, space utilisation systems (refer Section 5.7 Space Utilisation Tracking) may be used to collect engagement data when near or interacting with digital art and/or signage systems.

Additional methods can be employed to measure interaction, such as Bluetooth beaconing, NFC or QR codes or zone motion detection within the vicinity of the showcase.

Digital signage players will form the basis of delivering content to audio-visual installations. Standardised operational data will be gathered from this equipment such as operational uptime, efficiency, source content and any other data accessible through the system's API, as follows:

5.11 Digital Art & Signage System

Data Reference	Data Type	Data Use
*playerPowerIsOn	Boolean	Reported by content players, as part of the integrated system. Data shall provide the current power status of the device.
*playerConnected	Boolean	Reported by content players, as part of the integrated system. Data shall provide the current connection status of the device.
*dynamicArtURL	String	Each piece of art content must be supplanted with a text description describing the artwork, and metadata such as artist and year. Art content may also be supplanted with a print/purchase link. The URL shall be dynamically associated with the art on display at a moment in time, and be accessible to any smartphone user.
*dynamicSignURL	String	Each piece of signage content must be supplanted with a text description. The URL shall be dynamically associated with the sign on display at a moment in time, and be accessible to any smartphone user.
occupancy	Integer	Reported by people counting sensors, either as part of the Digital Artwork & Signage or independent system. Continually monitors the quantity of persons within zoned areas.
*nfcScan	Structure {time, uniqueIdentifier}	Digital art installations may be flanked with a beacon or 'pebble' encouraging the user to interact with the artwork, or allow the delivery of audio description/assisted listening content. Reports a scan action through time and the unique identifier of the device.
*displayStatus	Boolean	Reported by display devices such as LCD or LED screens (not the content player), as part of the integrated audio visual system. Data shall provide the current power status of the device.

Implementation

Strong Implementation

A Strong Implementation will comprise of the installation of a new TCP/IP based Digital Artwork & Signage System which shall aggregate the data from sensors related to the system.

People counting shall be implemented to provide the current count of people within the vicinity of the system, this shall report via the TCP/IP network always up to date information.

Dedicated content players will be required to provide an accessible API to allow monitoring and data gathering of status and runtime. The content creation system shall be capable of managed access and single sign on features through Active Directory. Only authorised users shall be capable of publishing content to players.

5.11 Digital Art & Signage System

Near field communications transmitters shall have a strong integration with the visible digital content to provide seamless information to users. NFC shall provide information regarding time and each scans unique identifier of the user, data may be utilised to trigger personalised content. TAFE NSW shall be capable of updating the NFC’s data through the TCP/IP network.

Additional implementations shall provide key accessibility features to the TAFE NSW Smart Campus’s. These shall include audio description of content through an assisted listening system, operating on the user's personal device. The audio description may be generated procedurally within the cloud to provide accurate and relevant content.

Reduced Implementation

A reduced implementation may provide data aggregation as an on-premise service only through a gateway. This implementation may not utilise cloud compute services, but provide controllable but local compute power on premises.

A minor re-fit of Digital Artworks & Signage Systems may provide the ability to select data sensors which provide the most value such as NFC and device monitoring.

Upgrade Path

An upgrade path in existing campuses is to undertake an audit of any existing digital art and signage systems across the TAFE NSW network and determine the capability/gaps for implementation of TCP/IP connectivity and data structures. Those with compatible systems should be included in a long-term plan to integrate and update controllers to track usage and add accessibility features in line with a Strong Implementation.

Connection

- Digital signage players and associated LED/LCD displays are to be connected via copper Ethernet cabling to the TCP/IP network;
- BLE Beacons or NFC transmitters shall connect via Ethernet cabling to the TCP/IP Network. Sensors are to communicate directly to the data platform or via a data broker;
- Assistive listening systems are generally based on audio description engines produced by user devices, e.g. built into Apple and Android smartphones;
- Alternative assistive listening technologies for static installations may include hearing loops built as part of the audio-visual design;
- Controllers and servers connect to the TCP/IP network via copper Ethernet cabling.

Coordination Requirements

Guidelines on expanded design/construction responsibility requirements, part of the following table.

5 Systems

5.11 Digital Art & Signage System

Stakeholder	Responsibility
TAFE NSW	Oversee and approve Digital Art & Signage strategy.
Architect	Oversee and approve positioning of all display equipment, artwork and sensor devices in conjunction with architectural intent.
Electrical	Undertake the design and construction of power and data requirements to need the requirements of the Digital Art & Signage strategy.
Mechanical	Nil.
Hydraulic	Nil.
Fire	Nil.
Audio Visual	Undertake the design and construction of any digital art and signage systems, including specification of all audio-visual equipment, platforms and appropriate assistive listening devices to meet the design standards.
Sustainability	Nil.
ICT Consultant	Nominate network connections and requirements for the Digital Art & Signage System ensuring that all devices are registered in the Smart Campus design.
MSI	Undertake programming and inclusion of Digital Art & Signage systems into the TAFE NSW Data Platform. Instruct the audio-visual integrator on configuration and network connectivity ensuring data transfer and verify correct operation. requirements. Undertake testing and commissioning of the human interfaces, such as BLE beacons and pebbles.
Networks	Provide specific VLANs and address space for the Digital Art & Signage System and advise integrator and MSI on network connectivity requirements.
Others	Nil.

Commissioning & Operation Requirements

Commissioning and testing data and results must be provided for Digital Art & Signage System, including but not limited to the following:

- Functionality and operation of all field devices including correct video reproduction settings, audio and assistive listening;
- Integration of assistive description and listening URLs onto the digital signage player platform and link to TAFE NSW Data Platform;
- Creation of a temporary 'staging' visualisation on the Information Layer to test the working integration of data structures prior to integration into the production Data Platform;
- Acceptance testing of systems integration for users;
- Comprehensive training with all relevant stakeholders for the management of artwork and signage, content creation guidelines, TAFE NSW Brand Standards (for digital signage), and links to associated services such as e-commerce systems for artwork purchases;
- Upon a successful staging process, integrate data structures into the production Data Platform.

Regulatory

6 Regulatory

6.1 Work Health & Safety

6.1.1 General Requirements

The ''Common Work Health & Safety Concerns'' table identifies common Work Health & Safety concerns arising from events that have been identified from past TAFE NSW projects. Each project team must demonstrate that all safety concerns raised have been addressed as part of their involvement with any project to which this Design Standard applies. The safety concerns listed in the table must be included in project-specific Safety-in-Design Registers to ensure that project teams demonstrate how they have been addressed through all phases of any project.

Please note the information in the table is:

- For guidance only;
- Not exhaustive and does not take into account specific circumstances and should not be relied on in that way, and;
- Does not alleviate the respective TAFE NSW team, designer, supplier or contractor from their own Work Health and Safety obligations and duties.

Legend	Level of Risk	Action Required
H	High	Implement cost effective risk control measures, and formalise procedures or management responsibility for reducing risk. Amend design to reduce risk, or seek alternative option. Only accept option if justifiable on other grounds.
M	Moderate	Incorporate cost effective risk control measures within the scope of long-term planning. Management responsibility must be specified. Check that risks cannot be further reduced by simple design changes.
L	Low	Manage by routine procedures. Check that risks cannot be further reduced by simple design changes.

6 Regulatory

6.1 Work Health & Safety

6.1.2 Common Work Health & Safety Concerns

Safety concern raised	Potential Control or Treatment measure	Reference to Design Standards/ Statutory Requirements	Level of Risk	Phase: Project Delivery	Phase: Design	Phase: Construct, Supply, Install	Phase: Operation and End use
Battery Storage Systems discharge causing injury	Battery storage systems to be located in locked communications rooms or dedicated rooms.	NCC/BCA	H	-	Y	Y	-
Excessive heat and noise from communications rooms	Ensure adequate air-conditioning and noise insulation installed to meet comms room operating requirements	Section 2.3	M	-	-	-	Y
Exposure to live power causing electric shock	Connectivity to power systems is to be outside of public access areas. Extra-low voltage equipment is preferred over mains equipment.	Section 4.2	H	-	Y	-	Y
Working at heights	Height constraints to be applied to sensors and devices. A control strategy to be applied for installations exceeding 2.6m.	Section 4.1.2	H	Y	Y	Y	Y
Injury caused by user distraction	User interfaces to be designed to best practises, avoiding unnecessary visual or aural elements.	Section 2.2.3	M	-	-	-	Y
Malfunction or hacking causing unwanted or unsafe operation of systems	Devices are to be cybersecured to prevent malicious damage, and controls in place to separate data collection from operational controls.	Section 4.3	M	-	Y	-	Y
Outage complaints	Design to consider portable generator option where historically network outages are common.	TAFE NSW Electrical Services Design Standard	H	-	Y	Y	-
Water leaks into rooms	Design of rooms to be water tight so that no leaks occur within room. No water services to be provided in switchboard residing in rooms, cupboard areas.	NCC/BCA	H	-	Y	-	-
Lack of power outlets means that excessive power boards used outlets within room	The TAFE NSW Electrical Services Design Standard provides the minimum quantity of outlets. Project design team to ensure adherence.	AS/NZS 3000	M	-	Y	-	Y
Damaged power outlets	Power outlet locations to be positioned to minimise damage.	AS/NZS 3000	M	-	Y	Y	-
Tag testing not provided to equipment	Statutory inspections to be carried out.	AS/NZS 3000	M	-	Y	-	Y
Floor boxes use	Floor boxes to include cable protecting flap to protect wiring. When surface mounted locate to avoid tripping hazard. When recessed provide fire rating cover to maintain fire rating integrity of slab. Locate only where necessary.	AS/NZS 3000	M	-	Y	-	-
EDB access	EDB access to be readily accessible by maintenance staff in accordance with AS. EDB to be provided in lockable cupboard. Do not locate EDB cupboard on fire rated wall.	NCC/BCA	M	-	Y	-	-
Damage to Overhead cabling	All communications cabling to be trenched underground within campus serving buildings and no permanent overhead cabling will be permitted.	TAFE NSW Structured Cabling Standards	M	Y	Y	-	-

Appendix

A Appendix

A.1 Appendix A - Form for Submission of a New Smart Campus System

Instructions	
Purpose	This form is to submit and assess the proposal for a new System for inclusion as part of the TAFE NSW Smart Campus platform.
Intended Audience	TAFE NSW Design Manager responsible for the project. The form will be distributed to all relevant TAFE NSW project and operations stakeholders. The form and all supporting documentation will be processed for endorsement.
User Input	The designer of the proposed System is required to complete: ▪ Part A - System Background ▪ Part B - Reasoning and Supporting Information ▪ Part C - System Description The TAFE NSW Design Manager is required to complete: ▪ Part D - Endorsement

Part A - System Background
Describe the research and motivation for proposing the new Smart Campus System.

Part B - Reasoning and Supporting Information
Nominate how the new Smart Campus system meets the Design Fundamentals, and supporting operational and educational objectives realised.

A Appendix

A.1 Appendix A - Form for Submission of a New Smart Campus System

Part C - System Description
Attach a System Description in Word (.DOCX) format, following the Structure for New Technology Submissions in the TAFE NSW Smart Campus Design Standard.

Part D - Endorsement
FOR INTERNAL USE ONLY
The TAFE NSW representative by signing this form has sought endorsement from all relevant TAFE NSW Stakeholders for inclusion into the design.
Project:
TAFE NSW Campus:
Design Authority Name:
Approved/Not Approved:
Signatory:
Position:
Date:
Review Date:

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