SECTION 10: BAS & CONTROLS

CONTENTS

10.1 INTRODUCTION

This section of the Design Standards provides details of the University's minimum requirements for the design, installation and operation of Building Automation System (BAS) services. The BAS contractor (or for larger building projects, the project consultant) is required to produce their own detailed BAS specification incorporating the requirements of all sections of the Design Standards. documentation.

10.2 GENERAL SYSTEMS AND STRATEGY

10.2.1 Future Direction: The BAS Strategy

The University's BAS Strategy aims to consolidate all existing and future BAS sub-systems into a central building management system to provide a single point of access for monitoring and control of all buildings across the Parkville campus. This centralised structure will provide the following operational benefits:

- A single point of access for monitoring and control of all buildings throughout the campus;

- More efficient servicing and system diagnosis;

- Remote access support for monitoring and control of any building from any location throughout the Parkville campus and from off-site locations; and,

- Access to all BAS systems via portable devices

The strategy is underpinned by a commitment that all systems / devices must comply with the open protocol of either the LON or BACnet communications standard. All DDC controllers must support open programming using software programming tools available to a number of local based Melbourne BAS contractors for ongoing support purposes. Where buildings have existing LON based BAS systems, it is required for new projects to install compatible LON controllers. However, for a significant building upgrade project, it may be considered a better solution to install BACnet controllers and to interface them with the existing LON based BAS network.

Furthermore, the University is committed to developing a centralised BAS management and support facility that allows technicians and operators to access any of the University's BAS systems from a central location or remotely via secure Internet access.

The following key outcomes are sought from implementing the BAS Strategy:

- Centralised BAS management tools, interface, reporting, trending, event and alarm logs;

- Remote web-access to all BAS systems;

- LON or BACnet based controller communication protocol;

- A single point of access for control and monitoring of all buildings throughout the campus;

- Use of a common set of BAS / DDC products that support the LON or BACnet protocol and can be integrated onto the centralised BAS by our preferred BAS Services Contractor or selected BAS contractors;

- The capability to integrate other building sub-systems (i.e. lighting, fire, security, energy and water metering, etc.);

- The ability to implement energy efficient control strategies and functions such as time scheduling, load shedding, optimum start/stop, morning warm-up and night-purge, etc.);

- High level communication interfaces to VRV systems, chillers, VSD's, electrical metering and lighting control systems;

- Standardised alarm functionality integrated throughout the BAS with automatic alarm SMS paging and/or email notification to designated responsible persons for each area / system, as advised by the University;

- No obsolete products, devices, protocols or systems are to be installed; and,

- No proprietary systems are to be installed that would result in the University being dependent on a single organisation for ongoing support and maintenance.

To achieve these outcomes, the University has developed a three tier BAS Architecture to achieve the key outcomes identified above, as follows:

- Tier 1: Centralised BAS Management;

- Tier 2: Building Specific BAS Systems;

- Tier 3: Localised BAS / DDC controller devices that support LON or BACnet.

10.2.2 *BAS Migration Plans*

The following table summarises the range and extent of the different BAS systems currently in place at the University's Parkville Campus, together with comments regarding the future migration plans for each system type.

SYSTEM TYPE	MIGRATION STRATEGY
Tridium Niagara N4 using DGLux 5 graphical interface	Current controller products support the BAS strategy and includes the use of the Tridium expansion modules. DGlux 5 is the graphical interface tool used throughout The University of Melbourne.
Schneider Electric Structureware	Current controller products support the BAS strategy and the LON standard in specific buildings
Tridium Niagara AX	The University is phasing out this product range. All of these systems should be migrated over time to Tridium Niagara N4 current technology systems with a web interface.
Schneider Electric 'IA' Series	Current controller products support the BAS strategy and the LON standard.
Distech	Current controller products support the BAS strategy and the LON standard.
Stand Alone Controls	These products should be replaced with Tridium Niagara N4 current technology products during any repairs / upgrade / refurbishment works.

It is essential that any proposed refurbishment / upgrade project which is likely to impact on a current BAS installation must be discussed with and approved by the Engineering and Infrastructure Services team prior to any tender submission to ensure that the proposed works will comply with the University's BAS Strategy and will not compromise / conflict with an existing BAS installation and the relevant building's BAS migration / upgrade plan. The same applies to the design and construction of any new building.

10.3 AUSTRALIAN STANDARDS AND CODES

All BAS installations shall be designed, installed, tested and maintained in strict accordance with the most recent publication of the following Australian Standards and Codes:

AS/NZS 3087.1	Telecommunications Installations – Specification for the testing of balanced communications cabling
AS/NZS 3087.2	Telecommunications Installations – Specification for the testing of patch cords
AS/NZS 3000	SAA Wiring Rules
AS/NZS 3080	Telecommunications Installations – Generic cabling for commercial premises
AS/NZS 3084.	Telecommunications Installations – Pathways and spaces in commercial buildings
AS 60529	Specification for degrees of protection provided by enclosures (IP code)
AS 1668.1	Fire and smoke control in multi-compartment buildings
AS 1668.2	Ventilation design for indoor air contaminant control
AS 1668	The use of ventilation and air conditioning in buildings
ANSI/ASHRAE 135-2016 and 135.1-2013	BACnet data communications protocol (ISO 16484-5:2017) and Method of Test for Conformance
ISO/IEC 14908-1B & related standards	LonWorks data communications protocol
ANSI/ASHRAE 134-2005	Graphic symbols for HVAC and refrigeration systems
ANSI/ASHRAE GUIDELINE 1.1 2007	HVAC technical requirements for commissioning process
Modbus-IDA	**Modbus Application Protocol Specification V1.1b3**

10.4 GENERAL REQUIREMENTS

10.4.1 *Point Schedules*

For any BAS design, consultants shall provide comprehensive hardware point schedules detailing point descriptions, functions, types and any special requirements.

A copy of the 'As Built' revision points schedule shall be included in the BAS Operation & Maintenance manual for any BAS upgrade or new installation works and a hard-copy left in each field control panel.

Points schedules shall include, as a minimum, the point tag name, point description, point type (AI, DI, AO or DO), cable label, field device part number, field device description and comments columns.

10.4.2 BAS Ethernet Networks

Any new BAS installation shall be connected to the University IT department's Ethernet TCP/IP networks. The University has developed a three-tier BAS architecture, as follows:

- Tier 1:   Centralised BAS management tools for campus-wide monitoring and control with remote web access capability via remote access to the University's Ethernet TCP/IP network;

- Tier 2:   Local IP-based controller communication protocol between devices within individual buildings;

- Tier 3:   Localised BAS / DDC controller devices that support LON or BACnet.

The Consulting Engineer shall liaise with the University's Engineering & Infrastructure team (Campus Management) on BAS design and requirements, and obtain information on the existing BAS systems before commencing the initial project design phase.

10.4.3 LON & BACnet Open Communication Protocols

The University intends to maintain and support existing LON based BAS controllers where installed. For refurbishment and building upgrade projects where there are existing LON based BAS controllers, it is desirable to install new compatible LON based controllers. However, for a significant building refurbishment project, it may be more cost effective to install BACnet controllers interfaced to the existing building BAS system. Any new installation must be capable of a full and transparent interface. All configuration files, bindings, graphics, etc. must be non-proprietary and able to be edited or amended by the University or its appointed BAS Installation Contractors / preferred BAS Services Contractor.

Proprietary type controller device communication protocols will not be accepted for any University project.

For further details, refer to the appropriate current LonMark or BACnet standards documentation.

10.4.4 DDC Network Controllers

All field network controllers are to support LON or BACnet network communications, as appropriate for the project. Most of the existing installed network controllers are Tridium Niagara AX or N4 LON type controller or Distech; for which the University holds a licenced copy of the software or has plug-ins for tunnelling to freely program and alter the existing programs. The Niagara AX network controllers are no longer to be installed at the University.

Proprietary type controllers with locked programming tools that are not available to any other Melbourne based BAS contractor or provided to the University as part of the project are not accepted for any University project.

The preference for new installations or replacement is:

- Tridium Niagara 8000 N4

  The protocols at field level that are acceptable are;

  - Non-propriety open licence Tridium Niagara N4 JACE 8 or greater
  - A minimum of one unit per building.
  - Either one JACE 8 be utilised per each floor of a building or a maximum of 120 field devices be connected to a single JACE.

- It is a requirement that each MSTP network is to serve a maximum of one floor.
- Additionally, all new JACE controllers must be licensed with LON MSTP as a minimum.
- All JACE controllers must be licensed with Message Queuing Telemetry Transport (MQTT) support.

In making modifications or additions to an existing JACE(s) the vendor is to ascertain whether the existing JACE(s) have the capacity to accommodate for new works. In the event that the existing JACE(s) are inadequate in handling the additional project works, the vendor must provide additional JACE(s) for new works unless otherwise specified or instructed. In the event of the overloading and causing of instability of the network controllers, the vendor is to bear the costs of rectification the problem.

The vendor will be responsible for connecting the new project works onto the BMS network, arranging IP addresses, and all other related works. Under no circumstance will JACE(s) from other buildings be used in performing control functions, store trends, store graphics, and other related processes.

The vendor will be responsible for also ensuring that all new JACE(s) are configured to communicate with the University's Smart Campus platform using the MQTT protocol. The Consulting Engineer shall liaise with the University's Smart Campus team in relation to the specific communications requirements.

Any additional LON system controllers or routers, to be installed, are acceptable but must communicate to the JACE(s) controlling the building.

The only software accepted for modification, setting up, commissioning, programming, editing, backing up or servicing any controllers is Tridium Niagara N4 Workbench.

All Workbench PC tools and software installed on JACEs to be compatible with the above version of Tridium Niagara N4.

Any project works carried out involving existing JACEs that do not meet the minimum version requirements are to be upgraded to the latest version at the cost of the vendor. Each vendor must provide the required modules for modification, setting up, commissioning, programming, editing, backing up or servicing the field controllers and install the modules into Tridium Niagara N4 Workbench.

The vendor working on the Tridium software must all be fully Tridium licenced and must be an authorised Tridium System Integrator.

Controls that require 3rd party tools outside of Tridium Niagara N4 workbench to modify, setup, commission, program, edit, backup or service shall not be deemed acceptable without prior approval from the Manager Engineering and Infrastructure. This specifically includes all 3rd party software that requires dongle.

10.4.5 DDC Field Controllers

All field DDC controllers are to support LON or BACnet network communications as appropriate for the project. Most of the existing installed controllers are Schneider I/A Series LON or Distech LON type controllers; for which the University holds a licenced copy of software to freely program and alter the existing DDC programs.

Any new LON or BACnet field controllers must support and have open programming tools allowing multiple Melbourne based other BAS contractors to be able to modify and install new programs. Programming tools are to be supplied and licensed to the University for any new controllers installed.

Proprietary type controllers with locked programming tools that are not available to any other Melbourne based BAS contractor or provided to the University as part of the project are not accepted for any University project.

The preference for new installations or replacement is:

- LON or BACnet Schneider I/A Series
- Distech range of controllers

The protocols at field level that are acceptable is LonMark TP/FT-10

It is not acceptable to install proprietary communications protocols or gateways to proprietary protocols without prior approval from the Manager, Engineering and Infrastructure.

Standard off the shelf, non-propriety and openly programmable controllers that require individual licensing are not accepted without prior approval from the Manager Engineering and Infrastructure.

New systems will be capable of future expansion with spare capacity in memory and processing power and 20% spare Input / Output capacity. All firmware updates and bugs to be upgraded throughout defect liability period at no additional cost. The field controller's system shall be compatible with future software and hardware updates.

10.4.6   High Level Interfaces (HLI's)

Any VRV or proprietary type air conditioning system or sub-system planned to be installed or upgraded as part of the BAS or any other building service, should be fitted with a LON or BACnet interface network device to support communication with the BAS system.

Chillers, VSD's, electrical metering and lighting controls are expected to have HLI's to the BAS.

Wherever possible, installation of native open LON or BACnet protocol devices is preferred.

10.4.7   BAS Spare Capacity

The network controllers and main plant DDC controllers are to be installed with both 20% minimum spare hardware and software capacity at the time of project practical completion.

Spare hardware capacity is defined as 20% minimum spare of each point type being analogue input, analogue output, digital input, digital output and totaliser type points, without adding any additional hardware modules.

Spare software capacity is defined as 20% spare for additional programming control loops and graphics from the accepted installed system, as at practical completion, to match future hardware points or further software strategies.

The front-end BAS software is to be licensed and capable to provide 20% spare point capacity, including trend and event logging from the installed system, as at practical completion, to allow for future system expansion.

10.4.8   BAS Product Support

All new BAS products and devices installed on projects must have a minimum of 10 years remaining product support from the manufacturer. The University may request written information from the manufacturer to confirm this support.

Products deemed to be within 2 years of the end of their product lifecycle are not to be installed.

10.4.9 Criteria for Connection to BAS

The following equipment is to be connected to the BAS, as a minimum (unless Modification Request Form has been approved by the University)

- Mechanical Equipment (chillers, boilers, fans, pumps, VSD's, AHU's, FCU's, VAV's, VRV's, etc.);
- Electrical Equipment (meters, power factor correction, UPS, etc). The University's preference for high level communication interfacing, and not low level pulse signals;
- Lighting Controls: The preference is for high level communication interfacing;
- Hydraulic Systems, including water metering;
- Access Control, as necessary;
- Fire System point monitoring, as necessary;
- Solar Equipment / Panels; and,
- Air Quality.

10.4.10 Safety

No combination or sequence of operations of the BAS control shall cause a condition which is unsafe, unhealthy or liable to cause damage to equipment.

Functionality which is essential for safe operation shall be mechanically interlocked. For example, the enabling of electric re-heat units via the BAS controller output shall be overridden by a hardwired interlock in the mechanical panel to prevent the electric re-heat from operating unless the hardwired interlock to that unit's air flow switch and / or other air-flow proving device is satisfied.

Appropriate delay times and run-on timers shall be incorporated, wherever required, to ensure dampers are open prior to fans starting, fans run-on following electric re-heat no longer required, etc.

10.4.11 Energy & Water Conservation

The BAS shall be capable of implementing sustainability energy management programs including:

- Time programmed start / stop;
- Optimum start / stops;
- Supply air temperature reset;
- Economy cycle;
- Lighting control where appropriate;
- Occupancy sensing, control and scheduling;
- Wide temperature band / load reset;
- CO and CO_2 sensing control for air quality;
- Variable pressure control strategies for air and water systems;
- Thermal energy calculation;
- Virtual energy/water meter calculation;

- Optimum plant operation. For example, ventilation to lecture theatres being controlled on air quality level. Occupancy sensors should be used where appropriate;

- Load shedding of gas and electricity consumption;

- Any other monitored points which may assist in producing energy saving or energy consumption statistics;

- Water, gas and energy consumption, demand and totalisation by day / week / month / year and associated reporting;

- Tenant billing ability;

- Advanced water, gas and energy automated reports, custom reports, forecasting, unusual event detection and alarming, historical data record and back-up, comparison between individual meters, buildings and/or historical records (e.g. last month versus same month of previous year, etc.);

- Calculation of CO_2 emissions based on user-adjustable emission factors, definable for each component of the energy used (i.e. ensure the consumption of zero carbon energy from alternate sources is not included in the calculation of total CO_2 emissions).

10.4.12 Motion Detector Equipment

Motion detectors should be connected to the building's BAS system to control lighting and air conditioning in the affected areas. Wider temperature dead band control and reduced air flow shall be incorporated into a standby mode function.

10.4.13 Temperature Monitoring

Space temperature sensors shall be installed in each air-conditioning zone as independently controlled by the heating / cooling system. In the case where a zone covers several rooms, sensors shall be installed in each room and the average temperature shall be used for temperature control.

A supply air temperature sensor shall be fitted to any heating / cooling coil including VAV boxes with reheats to provide the BAS with a status of the plant and equipment.

10.4.14 Status Monitoring

Equipment status shall be a means of accurate verification of actual air/water flow. For example, the status of fans and pumps shall be provided by differential pressure transmitters/switches rather than contactor auxiliary contact points or other voltage free contacts that may not be reliable in all scenarios. Should a fan belt break on belt driven equipment, the contactor status is not to be affected.

Sufficient statuses shall be provided to the controller to allow the behaviour of the system to be monitored and diagnosed. If the BAS controls a pump or a fan, it shall monitor the pump or fan status. If the BAS controls a chiller or a boiler, all other associated parameters (i.e. status, alarm, water flow and return temperatures, pump status, etc.) shall be monitored. The BAS shall provide a mismatch alarm from control and status points for "fail to start" and "running in manual".

Should the fire system override plant for emergency shutdown due to a fire alarm condition, this alarm shall be provided to the BAS controller as a status digital input, an alarm shall be raised on the BAS head-end and all associated alarms arising due to the fire override of plant shall be disabled to prevent nuisance alarms arising from the fire override condition.

10.4.15 Set Point Adjustments

Where appropriate for the design, safe and efficient operation of the plant, the BAS front-end graphics shall provide the ability to override the control setpoints of mechanical plant provided all necessary conditions for setpoint reset are satisfied, as detailed in the BAS specification by the design consultant.

The BAS control shall prevent the override of set points beyond a reasonable range, as defined by the design consultant and/or plant manufacturer.

A temporary setpoint adjust needs to be provided for the mechanical contractors to temporarily override set points for a maximum of 1 hour.

Occupants of a space shall not be provided with the facility to vary the zone temperature set point locally.

10.4.16 Liaison

The Consulting Engineer shall liaise with the University's Engineering & Infrastructure team (Campus Management) on BAS design and requirements and obtain information on the existing BAS systems before commencing the initial project design phase.

10.4.17 Labelling

All items of equipment associated with the BAS shall be suitably identified with traffolyte or equivalent plastic labels. Front End, field controllers, VAV boxes, valves, dampers, and field sensors shall be labelled with identification that matches the relevant item programmed in the Front End.

All works shall be adequately documented so that every wire can be subsequently identified by wire number, colour code or termination frame location. All wires shall be numbered individually, and multi-core cables shall be terminated according to the standard colour code.

10.4.18 Commissioning

The BAS installation shall be fully commissioned and operational at the time of practical completion stage of the project. Commissioning procedures shall conform to Section 9: Mechanical Services and shall be carried out at the end / field equipment device to verify correct operation of equipment. All field sensors are to be calibrated against verified test instruments.

All sensors are to be calibrated and checked for correct operation. Dampers and valves are to be correctly stroked for 0%, 50% and 100% open positions.

Commissioning documentation is expected to be supplied to demonstrate that all BAS hardware and software has been fully commissioned including interfaces to other systems and devices.

All control loops must be fine-tuned to avoid valve actuators, damper motors and VSD speeds hunting for stable plant operation.

Commissioning of floor mixing boxes in conjunction with the mechanical contractor to calibrate airflow readings and implement commissioning airflow setpoints.

Undertake an air-conditioning system fire test in conjunction with mechanical contractor to ensure dampers and any VSD installation operates correctly for fire mode.

Fully configured graphical trend logs shall be required to be implemented for all equipment by the project BAS contractor to enable effective operational performance analysis and fine tuning during the commissioning phase.

All commissioning / test reports are to be provided to the University's Engineering and Infrastructure team (Campus Management) and design consultants for review.

10.4.19 *Training, As-Built Drawings, Operating & Maintenance Manuals*

The specification shall require the BAS Contractor to instruct and provide training to relevant University personnel and its nominated Contractors in the operation of the system prior to practical completion or project hand over.

As-built drawings, operating and maintenance manuals are to be provided as described in the CAD Standards Section of the University's Design Standards. The following BAS documentation is to be provided as a minimum:

a) Communication network and controller architectural drawings;
b) High level interface details;
c) Description of Operation including all control strategies;
d) Controller I/O hardware schedules including field device details;
e) Configured IP addresses;
f) Product data sheets for field sensors/devices; and,
g) Maintenance schedules.

One electronic set is to be supplied to the University's nominated Project Manager in PDF format (via email) and on a USB memory stick.

Manuals also need to be accessible via a link on the BAS building home page.

10.5   HARDWARE REQUIREMENTS

10.5.1 *Input / Output*

All interfacing with control devices shall conform to the following standards:

- Binary input:
  - o Voltage-free contact;
  - o Pulse input.
- Binary output: voltage-free contact;
- Analogue input:
  - o 0–10V, 0–5V;
  - o 4–20 ma;
  - o Current device sensor;
  - o Resistance device sensor;
  - o Voltage device sensor.
- Analogue output:
  - o 0–10V, 2-10V;
  - o 4–20 Ma.
- Service meters (gas, water, electricity): smart meter for electricity, gas and water consumption. HLI connection for electricity metering and pulse input connection for gas and water metering;
- Control relays shall operate at 12-24V AC/DC; and,

- Other interfacing standards are only acceptable in unusual circumstances, where sensors and devices conforming to the above standards are not available.

10.5.2 *Direct Digital Control (DDC) Controller*

The Direct Digital Control (DDC) Controllers shall support LON or BACnet communications and be a completely independent stand-alone unit, with all firmware and software programs to maintain control on an independent basis in event of a network communications failure. The controllers shall have full open software programming capability that at least three Melbourne based BAS contractors can access and perform DDC program modifications.

The main AHU, chiller and boiler Plant Controllers shall be enclosed in metal powder coated IP54 rated panels or within dedicated spaces within mechanical switchboards.

The system shall allow various main controllers and sub-controllers to be networked and have the flexibility to readily permit software modifications and additions of the control functions. Should one controller in a network fail, it shall not affect the performance of any others.

10.5.3 *Temperature Sensors*

Temperature sensors shall be resistance, voltage or current device types with ranges selected to suit specific applications and have a repeatable accuracy of +/-0.3°C. Sensors shall be protected in a neat plastic or metal casing so that access to terminal strips and cabling can easily be achieved by removal of a cover. Sensors mounted on external walls shall be insulated with cable entry holes effectively sealed. Sensors shall be professionally labelled to indicate air-conditioning zone or sensor number.

Sensors shall not be locally adjustable. Where two or more sensors are provided for one zone, an average signal shall be used for temperature control.

Sensors shall be mounted such that effects of direct radiation from heating / cooling sources (e.g. direct sunlight, heat generating equipment, supply air duct discharge grilles, draughts, etc.) are minimised.

10.5.4 *Pressure Switches*

Pressure switches shall have adjustable ranges and adjustable differentials to suit the application.

Pressure switches shall be sensitive enough (as low as 20 Pa if necessary) to ensure correct monitoring of small fans and shall have a switching differential of not more than 10% of the scale range;

Substitute the use of a pressure switch in favour of a current transformer with voltage free contact for status monitoring of very small fans where the duct pressure is unlikely to exceed the minimum sensible pressure.

10.5.5 *Pressure Sensors*

- Shall be suitable for the sensing medium, operating temperatures and pressures;
- Shall be capable of withstanding a hydraulic test pressure of 1.5 times the normal working pressure;
- Connections shall be suitable for 8mm (¼") o.d. copper tube or poly tube for air connections;
- Ductwork versions shall be supplied with air connections permitting their use as static or differential pressure sensors; and,

- The setpoint shall fall within 30%-70% of the sensing range of the sensor.

10.5.6   Damper Actuators

- Control voltage shall be 0–10V DC and power supply shall be 24V AC;

- Shall have sufficient drive torque to open and close valves against the maximum out of balance pressure across them;

- Dampers shall incorporate spring return facility, wherever necessary, for fail-safe operation during fire mode or in the event of power failure;

- Mounting shall be rigid without distortion during operation. Linkages shall be fixed to shafts with grub-screws set in drilled recesses;

- Dampers shall be supplied complete with the necessary universal joints, cranks, linkages and mountings for the specified motorised damper; and,

- Dampers shall have position indicators unless fitted to terminal units. The fully open and closed positions shall be unambiguously marked.

10.5.7   Valve Actuators

- Control voltage shall be 0–10V DC or 24 volt AC floating and power supply shall be 24V AC;

- Valve actuators shall be linear in operation fitted with a manual override such that, in the event of a power failure, manual operation can be achieved;

- Valve actuators shall have sufficient drive torque to open and close control valves against the maximum system pressure;

- Valve actuators shall be supplied complete with the necessary universal joints, cranks, linkages and mountings for the specified motorised valve; and,

- Valve actuators shall have position indicators unless fitted to terminal units. The fully open and closed positions shall be unambiguously marked.

10.5.8   Wiring

The wiring for data communication between sensors, controllers, valve / damper actuators and any other BAS analogue or digital signals shall be shielded so as to not be susceptible to any electromagnetic interference such as electrostatic, magnetic, mode and cross talk noise. Cabling is to have suitable sized conductors to minimise voltage drop at devices.

All cabling shall be routed at least 500mm away from any low or high voltage power wiring and cross-over at right angles where required (no parallel runs).

Orange CAT5e communications cabling shall be used for all BAS communications wiring.

Orange CAT5e patch leads are preferred by the University's IT Section.

All other wiring shall conform to the requirements of Section 7: Electrical Services.

10.5.9   Flow Measurement

Flow measurement devices shall include differential pressure transmitter / orifice plates, turbines, electromagnetic flow meters, ultrasonic flow meters, probe air velocity sensors or grid matrix air velocity sensors.

All flow measurement devices shall be calibrated during commissioning by calibrated independent equipment and appropriate scaling, offsets and/or K-factors applied to the measured values accordingly.

All calibration data including K-factors and offsets shall be documented and incorporated in the Operation & Maintenance Manual for the BAS.

10.5.10 Connection at the Mechanical Services Switchboard

Controls shall be designed so that the equipment will work safely and without risk to University staff or property in the event of loss of power from a BAS controller.

Control cabling shall be wired to mechanical switchboards in conduits, cable trays or enclosed ducts and be terminated to control interface terminal strips provided in each board.

Control Auto-Off-Manual switches are to be front panel mounted on all Mechanical Services switchboards. These switches shall conform to the University's standard, and shall be provided with LED indicator lamps as follows:

- RED: ALARM, or equipment in FAULT

- GREEN: equipment switched ON (either manually or remotely)

In general, controllers shall be segregated, but close to a mechanical services switchboard which shall supply the necessary power to the controller. Note: all cabling passing through a mechanical services switchboard shall conform to appropriate standards (e.g. 500V insulation), but the controller shall be limited to extra low voltages (less than 35V), and data cable shall be rated accordingly.

10.5.11 Uninterruptible Power Supply (UPS)

For critical building operation, as per the consultants' design, the BAS is to be supported with an uninterruptible power supply (UPS) which must be capable of sustaining power to the controllers and associated devices for a minimum period of thirty (30) minutes.

The BAS shall be of the type that in the event of mains failure the equipment supported shall not power down and reboot.

The system shall incorporate sealed batteries and include alarm volt free contacts for connection to the BAS for monitoring of "UPS fault", "low battery" and "charger fault".

10.6   SOFTWARE REQUIREMENTS

10.6.1 Capabilities

The BAS controller software shall perform the following functions:

- Time schedule start / stop;

- Optimum start / stop;

- Duty / standby cycling;

- Lead / Lag staging;

- Automatic temperature control;

- Maximum demand control;

- Control mode selection (i.e. P, PI or PID);

- Calculation points;

- Run hours totalisation;

- Lighting control;

- Integration with scheduling programs (where applicable);

- Integration with metering devices;

- Scanning and alarm processing;

- Alarm functions (via SMS and email);

- Load shedding;

- Temperature set point reset algorithm;

- Night purge, warm-up mode, etc.;

- Graphics reporting;

- Trend logging (graphical);

- Global communication (including web functionality and remote access);

- OPC server compliance;

- Tenant billing;

- Energy reporting; and,

- Auto controller restart in event of power failure.

10.6.2   User Friendliness

The BAS front-end software shall be easy to operate and program. Operators should be able to perform the following operations after minimal training:

- View building parameters;

- Select relevant graphical pages, building systems and points;

- Acknowledge alarms;

- Turn on and off controlled points manually;

- Modify setpoints;

- Log trend data;

- Generate custom reports;

- Understand system performance;

- Understand device communication failures/alarms.

10.6.3   Graphics

The University of Melbourne standard graphics package is DGLux5.

DGLux5 is a multiple-deployment, drag-and-drop interface application accessible in browsers with HTML5. Using DGLux5 enables the following features to input the University's graphics standard:

- Animated widgets, background themes, patterns, effects, 3D equipment images and assorted icons
- Customisable charts & gauge components
- Tables with data formatting, calculations and transformation
- Create custom interactions by adding behaviours to any object
- Set mouse and touch screen gestures and behaviours for desktop, tablet and mobile smart devices using Intelligent scaling with responsive layout to create once for all devices.

  The Graphics pages reside on the Tridium Niagara N4 Supervisor for the building. Standard status effect colours are:

- Communications Error   Yellow
- Fault   Orange
- Alarm   Red
- Manual   Purple
- Enabled   Green

As part of the standards the graphics shall include:

- Building graphics with selectable floor buttons that highlight red when building has an alarm.
- Floor plan graphics with room that highlight red when building has an alarm.

Two levels of plant graphics with the first graphic showing BMS information about the plant to easily identify problems and a more detailed view accessible or popup to show more detailed information about specific plant.

No Vendor branding is to appear on any graphics pages.

Provide a link from the main graphic page to access the functional description related to that building.

10.6.4 *Software Versions*

The latest BAS software shall be installed at time of project practical completion.

10.6.5 *BAS Communications*

Any BAS system installed on University properties shall provide reliable user interface functions to responsible staff via the University's IT computer network. This will allow the relevant staff to:

- Access buildings from the central BAS front-end or via secure internet connection;
- Receive SMS alarm messages for critical alarm conditions; and,

View building live and historical trend data from the central BAS front-end or via secure internet connection. Within each of the particular networks, controllers shall have the ability to broadcast data, transmit input/output points as global points onto the network for use by other controllers to capture data for internal processing. If one controller fails, it shall not affect the other controller's performance.

Any device communication failures shall raise a critical alarm on the BAS head-end.

10.6.6 *Reporting*

The BAS shall be capable and configured to produce the following reports to be viewed on the BMS screen, printed or exported to Microsoft *Excel* format. These configured reports are easily accessed from the main menu with selectable time/date start and end report durations and single point or multiple group point type or label selections.

A standard suite of reports is to be configured and provided for operator access including:

- Points in manual or override report:
  - o Detail of points that have been operator overridden.
- Operator changes report:
  - o Detail of what operator changes have been made. Single operator or all operator selectable.
- Point disabled or off scan report:

- o Detail of which points are not communicating or have been disabled from updates values to the front-end.
  - Alarm event report:
    - o Detail of alarms or point state change for a single point, group of points or all points.
  - BMS controller or communications report:
    - o Detail of communications alarms and controller diagnostic alarms.
  - After Hours A/C report:
    - o Detail of floor afterhours air-conditioning usage on a floor by floor basis with date and time stamping.

Reports are to include advanced water, gas and energy automated reports, custom reports, forecasting, unusual event detection and alarming, historical data record and back-up, comparison between individual meters, buildings and/or historical records (e.g. last month versus same month of previous year, etc.).

10.6.7 Trend Logging

The BAS shall have the ability to store logged data, including all input/output points, for a minimum period of two years online without manual data handling. Trend data must be easily retrievable for export to Excel spreadsheet.

Each point shall have individual time scales for system reporting. The time scale shall be adjustable in one minute increments.

The BAS software shall display live and historical trend data on demand.

The software shall allow the operator to select points, groups of points, and mechanical systems through user friendly graphics functionality.

It shall also be possible to register the start / stop sequence of any selected plant using the trend log, such as: main plant, floor / zone manager, services settings, water temperatures, etc.

Trend logging functions should be easy to query, manipulate trend periods, and adjust from the same graphics page.

The system shall have the facility for printing any display trend log.

All logs are to be stored for a minimum of 12 months.

10.6.8 BAS Alarms

Whenever abnormal conditions arise, alarms shall be generated and the alarm messages shall be displayed on the BAS head-end alarm log and simultaneously generate SMS and email messages, as appropriate to the application.

When an alarm condition is generated, the relevant head-end terminals on the system shall beep continuously until the alarm is acknowledged at any terminal.

The BAS shall prioritise alarm groups. Critical alarms shall be sent to nominated Campus Management staff members for immediate action via SMS and email.

All devices and third party equipment shall be configured such that the BAS 'alarm' or 'fault' contact is in the alarm condition upon loss of power at the device/equipment.

A minimum of 3 levels of alarming is to be configured, as being "Urgent", "High" and "Low" priority or similar.

All alarms are to be event logged within the front-end database where applicable where a BAS database front-end is installed or the main network controllers where a front-end is not installed.

Change of state monitoring events for equipment on / off status are to be event logged within the front-end database.

Access for operator event report data retrieval is required for reporting.

The following alarms are to be configured as a minimum:

Urgent Priority Alarms

- AHU fan fail to start
- Return air fan fail to start
- Controller communications fail
- Fire GFA alarm
- UPS alarm
- Chiller common fault
- Boiler common fault
- High CHW flow temp
- Low HHW flow temp
- Hydraulic fault
- Pump fault
- Cooling tower fan fault

High Priority Alarms

- VSD common fault
- Low static pressure
- High CO
- High CO_2
- FCU fan fail

Low Priority Alarms

- Temperature alarms if 3 degrees above or below setpoint when associated plant is operating. Time delay of 30 minutes to be configured for temperature alarms.
- Filter alarms

Alarm conditions are to be clearly indicated on associated front-end graphic pages.

10.7   BAS HARDWARE POINT REQUIREMENTS

The University has a standard template of BAS monitoring and control points required for any typical new plant for consistency in building operations and control.

The University or design consultants may choose additional points beyond the standard template requirements depending on the type of project.

10.7.1 General AHU

Inputs

Description	Device	Point Type
Room zone temperature (may have multiple zone temperatures depending on project requirements)	Room temperature sensor	AI
AHU supply air temperature	Duct temperature sensor	AI
AHU return air temperature	Duct combination temperature	AI
AHU return air CO$_2$	Duct probe CO$_2$ sensor	AI
AHU supply air static pressure	Duct probe air pressure sensor	AI
AHU return air static pressure	Duct probe air pressure sensor	AI
AHU supply air fan status	Air differential pressure switch	DI
AHU filter pressure	Air differential pressure sensor	AI
AHU return air fan status	Air differential pressure switch or current switch for direct drive fans	DI
After Hours push buttons (project specified)	Room pushbuttons	DI
AHU supply air fan VSD fault	From VSD	HLI
AHU return air fan VSD fault	From VSD	HLI
AHU supply air fan VSD kW	From VSD	HLI
AHU return air fan VSD kW	From VSD	HLI
AHU supply air fan VSD kWh	From VSD	HLI
AHU return air fan VSD kWh	From VSD	HLI
Outside air temperature	Typically from building common sensors	Controller software transfer
Outside air humidity	Typically from building common sensors	Controller software transfer

Outputs

Description	Device	Point Type
AHU supply air fan start/stop	Low level wired to mech board	DO
AHU return air fan start/stop	Low level wired to mech board	DO

AHU supply air fan VSD speed	Low level wired to VSD	AO
AHU return air fan VSD speed	Low level wired to VSD	AO
AHU chilled water valve	Control actuator and matched valve	AO
AHU heating water valve	Control actuator and matched valve	AO
AHU outside air damper	Damper actuator	AO
AHU return air damper	Damper actuator	AO
AHU spill air damper	Damper actuator	AO
AHU bypass damper (If fitted)	Damper actuator	AO

10.7.2 General FCU

Inputs

Description	Device	Point Type
Room zone temperature (may have second zone temperature depending on project requirements)	Room temperature sensor	AI
AHU / FCU supply air temperature	Duct temperature sensor	AI
AHU / FCU return air temperature	Duct combination temperature	AI
AHU supply air static pressure	Duct probe air pressure sensor	AI
AHU return air static pressure (if R/A fan fitted)	Duct probe air pressure sensor	AI
AHU supply air fan status	Air differential pressure switch	DI
AHU filter pressure	Air differential pressure sensor	AI
AHU return air fan status (if R/A fan fitted)	Air differential pressure switch or current switch for direct drive fans	DI
AHU supply air fan VSD fault	From VSD	HLI
AHU return air fan VSD fault (if R/A fan fitted)	From VSD	HLI
AHU supply air fan VSD kW	From VSD	HLI

AHU return air fan VSD kW (If R/A fan fitted)	From VSD	HLI
AHU supply air fan VSD kWh	From VSD	HLI
AHU return air fan VSD kWh (if R/A fan fitted)	From VSD	HLI
Outside air temperature	Typically from building common sensors	Controller software transfer
Outside air humidity	Typically from building common sensors	Controller software transfer

Outputs

Description	Device	Point Type
AHU supply air fan start / stop	Low level wired to mech board	DO
AHU return air fan start / stop (if R/A fan fitted)	Low level wired to mech board	DO
AHU supply air fan VSD speed	Low level wired to VSD	AO
AHU return air fan VSD speed (if R/A fan fitted)	Low level wired to VSD	AO
AHU chilled water valve	Control actuator and matched valve	AO
AHU heating water valve	Control actuator and matched valve	AO
AHU outside air damper	Damper actuator	AO
AHU return air damper (if fitted)	Damper actuator	AO
AHU spill air damper (if fitted)	Damper actuator	AO

10.7.3   *General VAV*

Inputs

Description	Device	Point Type
Room zone temperature (may have second zone temperature depending on project requirements)	Room temperature sensor	AI
VAV supply air temperature (if reheat coil is fitted)	Duct temperature sensor	AI

| VAV velocity sensor | Duct probe air pressure sensor | AI |

Outputs

Description	Device	Point Type
VAV damper	Damper actuator	AO
VAV heating water valve (if fitted)	Control actuator and matched valve	AO

10.7.4 General Ventilation Fan

Inputs

Description	Device	Point Type
Fan status	Air differential pressure switch or current CT	DI
Room temperature (if fan is temperature controlled)	Room temperature sensor	AI
Fan VSD fault (if VSD fitted)	From VSD	HLI
Fan VSD Kw (if VSD fitted)	From VSD	HLI
Fan VSD kW (if VSD fitted)	From VSD	HLI

Outputs

Description	Device	Point Type
Fan start/stop	Low level wired to mech board	DO
Fan VSD speed (if VSD fitted)	Low level wired to VSD	AO

10.7.5 Kitchen Exhaust Fan

Inputs

Description	Device	Point Type
Fan status	Air differential pressure switch	DI
Local control switch	Pushbutton or control switch	AI
Duct pressure (if VSD fitted)	Differential air pressure sensor	AI
Fan VSD fault (if VSD fitted)	From VSD	HLI
Fan VSD Kw (if VSD fitted)	From VSD	HLI
Fan VSD kW (if VSD fitted)	From VSD	HLI

Outputs

Description	Device	Point Type
Fan start / stop	Low level wired to mech board	DO
Fan VSD speed (if VSD fitted)	Low level wired to VSD	AO

10.7.6   CHW / HHW pump

Inputs

Description	Device	Point Type
Pump status	Water differential pressure switch	DI
Field differential pressure	Water differential pressure sensor	AI
Pump VSD fault (if VSD fitted)	From VSD	HLI
Pump VSD Kw (if VSD fitted)	From VSD	HLI
Pump VSD kW (if VSD fitted)	From VSD	HLI

Outputs

Description	Device	Point Type
Pump start / stop	Low level wired to mech board	DO
Pump VSD speed (if VSD fitted)	Low level wired to VSD	AO

10.7.7   Fire Monitoring

Inputs

Description	Device	Point Type
Zone fire alarm for each zone	From Mech board	DI
General fire alarm	From Mech board	DI

10.7.8   Electrical Meter

Inputs

Description	Device	Point Type
Red phase volts	From electrical meter	HLI
White phase volts	From electrical meter	HLI

Blue phase volts	From electrical meter	HLI
Red phase amps	From electrical meter	HLI
White phase amps	From electrical meter	HLI
Blue phase amps	From electrical meter	HLI
3 phase kW	From electrical meter	HLI
3 phase kWh	From electrical meter	HLI
Power factor	From electrical meter	HLI

10.7.9 Gas / Water Meter

Inputs

Description	Device	Point Type
Gas / Water meter pulse	From gas / water meter pulse interface	Totaliser

10.7.10 Thermal Meter

Inputs

Description	Device	Point Type
Supply water temperature	From thermal meter	HLI
Leaving water temperature	From thermal meter	HLI
Flow rate	From thermal meter	HLI
Thermal kW	From thermal meter	HLI
Thermal kWh	From thermal meter	HLI

10.8 BAS CONTROL STRATEGIES

The University has a standard template of high level BAS control strategy requirements for any new typical plant for consistency in building operations, control and energy efficiency.

A general summary of the standard control strategy requirements are as follows:

- Average zone temperature control based on supply air temperature reset strategy;
- Wide temperature dead bands for 20.5 to 24.5. degree room temperature control;
- CO_2 monitoring for indoor air quality for outside air damper control;
- Chiller outside air temperature lockout;
- Boiler outside air temperature lockout;
- Chilled water temperature reset;

- Heating water temperature reset;

- Variable AHU static pressure control for VAV systems;

- Variable AHU supply airflow based on zone temperatures for non VAV systems;

- Variable CHW/HHW pumping based on pressure reset;

- Motion sensor monitoring for theatre, meeting & lecture rooms to provide a standby control mode with reduced fan speeds and wider temperature control;

- After Hours pushbuttons in areas likely to be used inconsistently for operating business hours;

- Upon a mismatch of a fan control and fan status, a fan start fail or fan running in manual alarm shall be generated after a delay period of 1 minute;

- Upon zone temperatures greater than 3 degrees from setpoint for a period of 30 minutes generate a high priority alarm on the BAS front-end if relevant plant is operating in time schedule hours;

- Generate a dirty filter alarm when the filer pressure drop reading is above a default setpoint of 250pa for a period of 2 minutes;

- The BAS shall mimic the mechanical switchboard fire controls and fully close/open outside and spill air dampers and control fan speeds based on the specified project fire matrix; and,

- SMS alarming for critical plant alarms.


10.9   CONTROLS CONTRACTOR REQUIREMENTS

Only a person experienced with the installation and maintenance of the equipment and software proposed shall install the system as to ensure that the entire system can interface seamlessly.
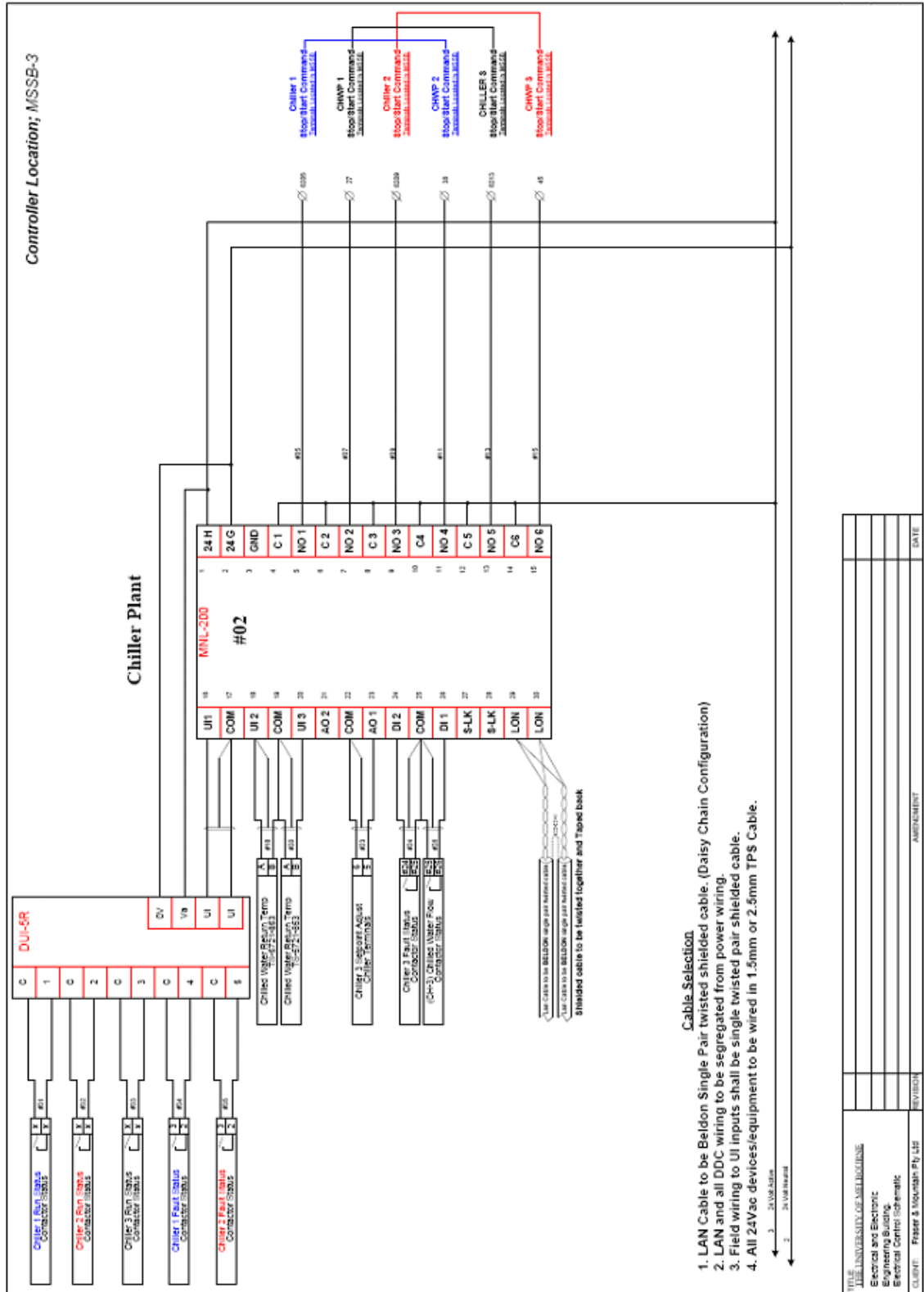
Each technician from the vendor is required to have completed training prior to performing any works on the controls they are using. Vendors working on the Tridium Niagara N4 software must be Tridium licensed and an authorised Tridium System Integrator.
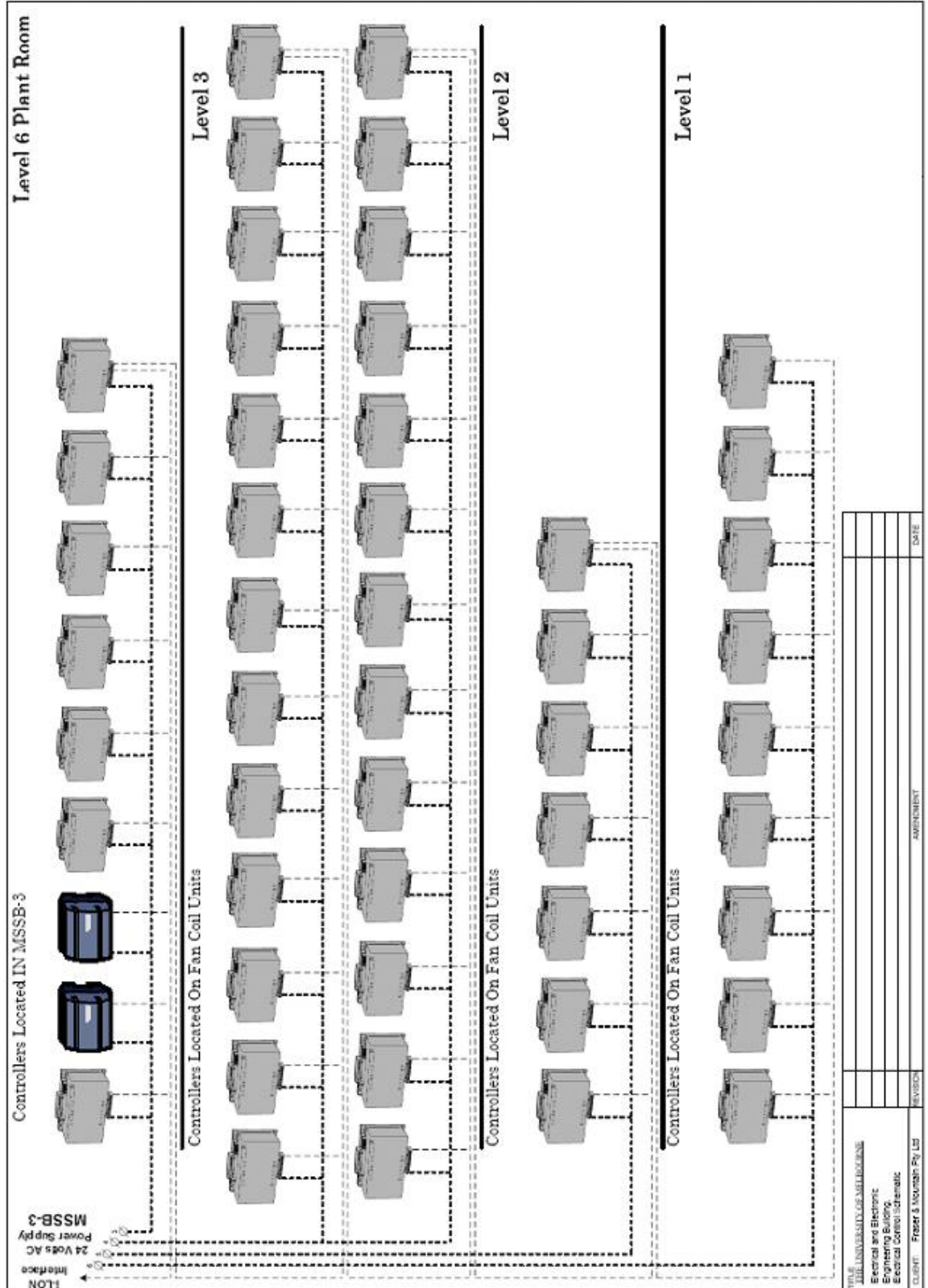
10.10 SAMPLE SCHEMATIC DIAGRAMS
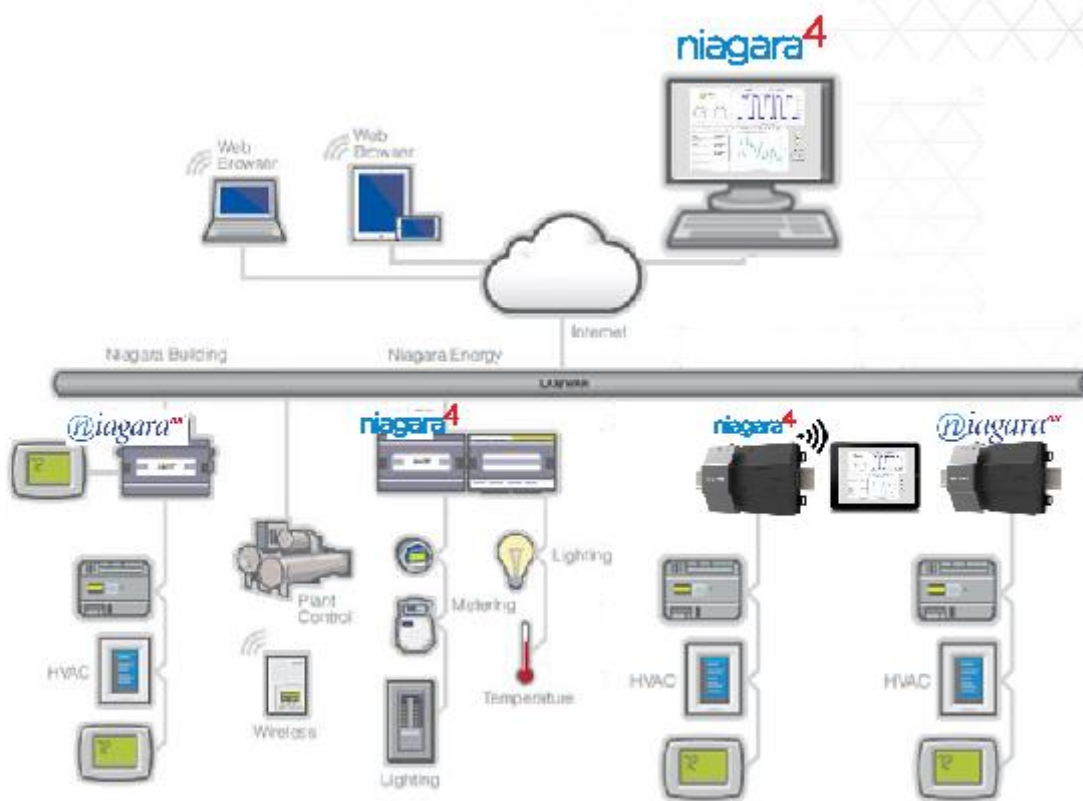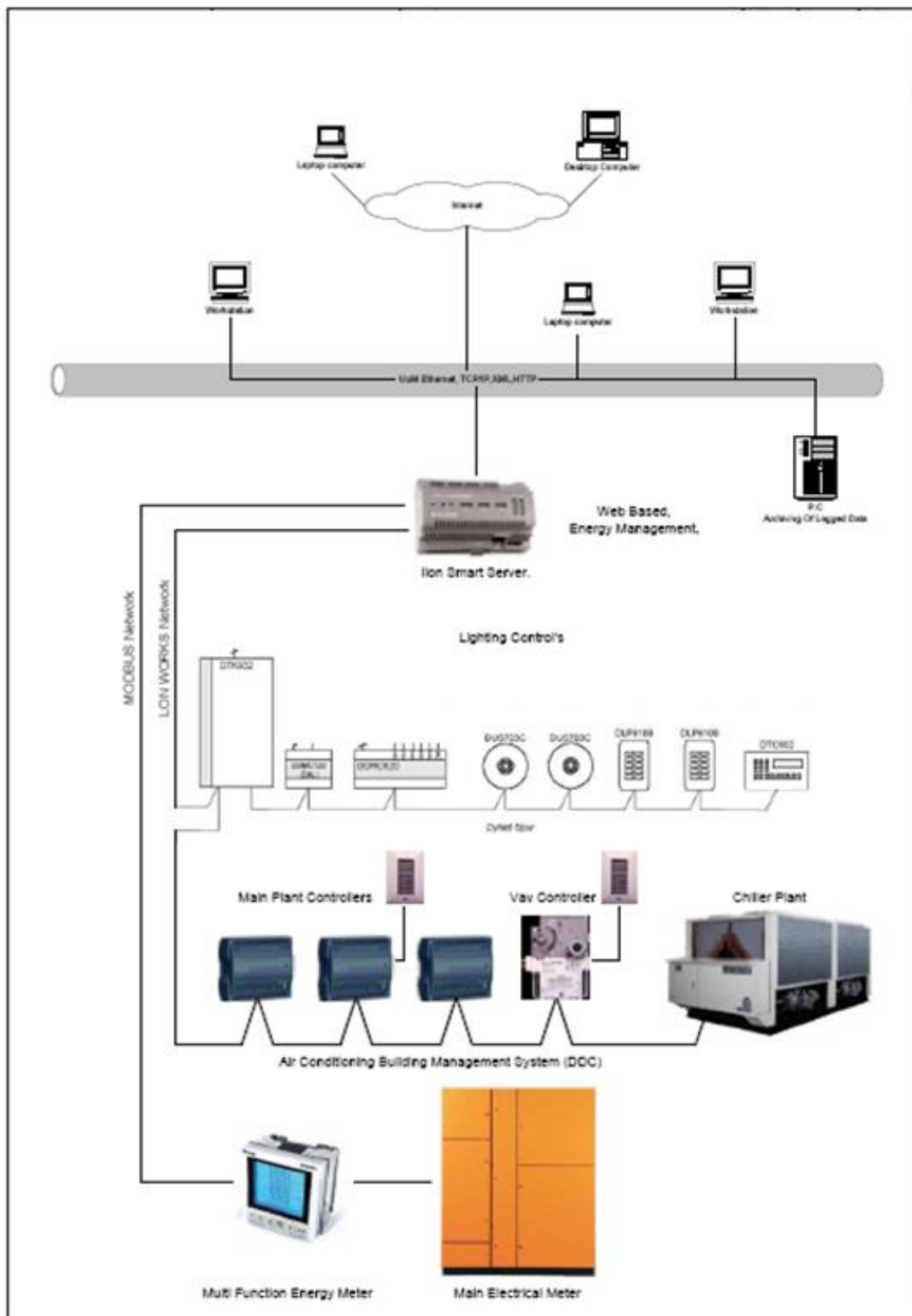
10.11   DESIGN CHANGE AUTHORISATION

All requests for changes to the requirements of the Design Standards must be made on the Modification Request Form. No design work is to proceed on the basis of the proposed modification until the modification request has been approved in writing.

A signed copy of all approved Modification Request forms, together with a schedule of all approved changes is required to be submitted as party of the project handover documentation.