National Manual of Assets and Facilities Management

Volume 5, Chapter 5

Building Management System (BMS) Operations - Schools and Universities Procedure

Document No. EOM-ZO0-PR-000017 Rev 001

Document Submittal History:

Revision:	Date:	Reason For Issue
000	28/03/2020	For Use
001	18/08/2021	For Use

THIS NOTICE MUST ACCOMPANY EVERY COPY OF THIS DOCUMENT

IMPORTANT NOTICE

This document, ("Document") is the exclusive property of Government Expenditure & Projects Efficiency Authority.

This Document should be read in its entirety including the terms of this Important Notice. The government entities may disclose this Document or extracts of this Document to their respective consultants and/or contractors, provided that such disclosure includes this Important Notice.

Any use or reliance on this Document, or extracts thereof, by any party, including government entities and their respective consultants and/or contractors, is at that third party's sole risk and responsibility. Government Expenditure and Projects Efficiency Authority, to the maximum extent permitted by law, disclaim all liability (including for losses or damages of whatsoever nature claimed on whatsoever basis including negligence or otherwise) to any third party howsoever arising with respect to or in connection with the use of this Document including any liability caused by negligent acts or omissions.

This Document and its contents are valid only for the conditions reported in it and as of the date of this Document.

.

Table of Contents

1.0 PURPOSE

The purpose of this document is to provide guidelines and practices to the Entity to manage the operations of the Building Management System (BMS) in school and university facilities. It is essential to operate and manage BMS according to the installation and design methodology to achieve efficient and effective building operations.

These guidelines contain operations expectations consistent with the Expro approach, using best practice developed through industry experience. Furthermore, they provide adequate references and best practice to follow as a minimum in order to ensure optimal performance of the engineering systems through BMS to meet operational needs.

2.0 SCOPE

The scope of this document is to provide guidelines to the school and university facilities or service providers to improve and enable site-specific Operation Management processes in relation to BMS operational activities such as, but not limited to:

- Performance of the BMS and integrated building systems
- Controlling and monitoring to achieve operational efficiency
- Comfortable and productive indoor working environment
- Control climate of building/safety of assets
- Customized control strategies
- Operational flexibility and ease of change
- Auto-change over failed equipment
- Improved operational environment and comfort
- Support energy utilization and operational cost
- Integration with other building services to improve effectiveness
- Optimize quality service delivery

3.0 DEFINITIONS

Term	Definition
Adaptive Control System	A system in which automatic means are used to adjust system parameters to achieve optimum performance.
Building Automation and Control Network (BACNet)	The Building Automation and Control network communication protocol (American National Standards Institute (ANSI)/American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 135). It provides a means by which building automation devices from various manufacturers can share data and work together.
Building Management System (BMS)	A building – wide network that controls and monitors building engineering systems. It may also include any third-party systems.
Direct Digital Controller (DDC)	Implies that the control algorithms are in the form of software. Analogue inputs or outputs may coexist with digital control.
Energy Management Control System (EMCS)	A computer system designed to automate the building operations of energy consuming assets such as heating, ventilation and air conditioning (HVAC), power, lighting, security systems and water systems; also capable of monitoring environmental conditions and load demand, and adjusting operations to optimize energy usage accordingly.
Extra Low Voltage (ELV)	Not exceeding 50 V between conductors and not exceeding 30 V AC or 50 V DC between conductor and earth.
Local Area Network (LAN)	An arrangement that enables computer or processor-based equipment to be linked so that they can communicate with each other.

Local Operating Network (LON)	Local Operating Network using LonWorks protocol.
Modbus	A serial communication protocol that has become a standard communication protocol in industry and is now the most commonly available means of connecting industrial and buildings electronic devices.
Open Communication	A term used for the exchange of data between various pieces of equipment on the basis of open or standardized protocols.
Outstation	A device connected to sensors and actuators which can perform local control and other functions.
Transmission Control Protocol/Internet Protocol (TCP/IP)	Encompasses media access, data packet transport, and session communications. TCP/IP is supported by a large number of hardware and software vendors.
Abbreviations	
ACOPS	Approved Code of Practice
ACS	Access Control System
AHG	Authority Having Jurisdiction
AI	Analog Input
ANSI	American National Standards Institute
AO	Analog Output
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ATS	Automatic Transfer Switch
BAS	Building Automation System
BCS	Building Controls Specialist
BIM	Building Information Modeling
BMCS	Building Management and Control System
BMS	Building Management System
BOD	Basis of Design
CB	Capacitor Banks
CIBSE	Chartered Institution of Building Service Engineers
CMMS	Computerized Maintenance Management System
CMT	Crisis Management Team
DDC	Direct Digital Controller
DI	Digital Inputs
DMC	Digital Master Controller
DO	Digital Outputs
ELV	Extra Low Voltage
EMCS	Energy Management Control System
EMP	Emergency Management Plan
EMS	Elevator Management System
FAS	Fire Alarm System
FM	Facilities Management
FMC	Facilities Management Company (Facilities Operations)
FOC	Facilities Operating Clients
FOM	Facilities Operations Management (Client/Building owner representative)
HF	Harmonics Filter
HLI	High-Level Interface

HMI	Human-Machine Interface
HVAC	Heating, Ventilation, and Air Conditioning
IPS	Isolated Power Supply
ISO	International Organization for Standardization
IT	Information Technology
LAN	Local Area Network
LCS	Lighting Control System
LON	Local Operating Network
LV	Low Voltage
M&T	Measuring and Targeting
MDB	Main Distribution Unit
MEP	Mechanical, Electrical, and Plumbing
MOS	Method of Statement
NFPA	National Fire Protection Association
O&M	Operation and Maintenance
OE	Operations Engineer
OEM	Original Equipment Manufacturer
OM	Operations Management
PMCS	Power Monitoring and Control System
PMS	Parking Management System
PPE	Personal Protective Equipment
PTW	Permit to Work
RAMS	Risk Assessment and Method Statement
RMU	Ring Main Unit
SCADA	Supervisory Control and Data Acquisition
SMDB	Sub Main Distribution Unit
SOO	Sequence of Operation
SOP	Standard Operating Procedure
UPS	Uninterruptable Power Supply
VFD	Variable Frequency Drive
WLDS	Water Leakage Detection System

Table 1 – Definitions

4.0 REFERENCES

- American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE 135) Specifying Building Automation Systems
- Chartered Institute of Building Services and Engineers (CIBSE guide H) – Building Control Systems
- EPM-KE0-GL-000007 ELV Systems Integration Guideline
- EPM-KEO-GL-000009 Building Management System and Mechanical System Integration Guideline
- HSE Approved Code of Practice (ACOPS) L8 & HSG274
- International Organization of Standardization (ISO 50001) – Energy Management
- National Fire Protection Association (NFPA 101) – Life Safety Code
- National Fire Protection Association (NFPA 72) – National Fire Alarm and Signaling Code
- SBC 201 Building Code – General
- SBC 401 Electrical Code
- SBC 501 Mechanical Code

- SBC 601 Energy Conservation

These shall be selectively applied based on the evaluation of individual requirements. Where the standards stipulated conditions conflict, the most stringent shall govern, unless otherwise noted herein. When there is any conflict with the Saudi Building Code (SBC), only the Saudi Building Code will be applied.

5.0 RESPONSIBILITIES

The Entity is the final Authority Having Jurisdiction (AHJ) unless specifically stated otherwise in other sections of the National Manual of Assets and Facilities Management. If a conflict is discovered between these guidelines and other operations management documents, it shall be brought to the attention of the Entity, who will provide a resolution or direction to ensure that all BMS goals and requirements have been met.

5.1 Management Responsibilities

It is primarily the responsibility of management to ensure that inspections, services, and daily operational activities are carried out safely without any hazard to the Operations Team or stakeholders. Clear lines of managerial responsibility should be in place to prevent any ambiguity for the safe operations of building engineering systems through BMS/EMS. Management should conduct a periodic review of the systems in order to ensure that the operational standards are being met. BMS/EMS systems require periodic inspections and verification. Hence, management should ensure that a competent team is appointed to perform all these assessments. The Operations Management Team shall ensure that staff are adequately trained and competent to carry out operational tasks which should include, but are not limited to:

- Staff briefing
- Safe systems of works
- Personal Protective Equipment (PPE)
- Quality control and assurance
- Health and Safety Executive (HSE)
- Risk Assessment and Method Statement (RAMS)
- Permit to work (PTW)
- Stakeholder communication
- Training

5.2 Designated Staff Functions

Only trained and competent persons should be appointed by management to operate and maintain BMS/EMCS.

Role	Description
Designated Person (Electrical)	An individual who has overall authority and responsibility for the premises containing the electrical supply and distribution system within a school and university facility and has a duty to prepare and issue a general policy statement on health and safety at work.
Duty Holder	A person on whom the ‘electricity at work’ regulations impose a duty in connection with safety.
Authorizing Engineer (Low Voltage (LV))	A Chartered Engineer or Incorporated Electrical Engineer with appropriate experience and the necessary degree of independence from local management who is appointed in writing by school and university facility management to implement, administer and monitor the safety arrangements for low voltage electrical supply and distribution systems. This appointed individual shall be responsible for ensuring compliance and assessing the suitability of candidates to be Authorized Persons.
Authorized Person (LV/ELV)	An individual possessing adequate technical knowledge and appropriate training, to be responsible for the practical implementation and operation of management’s safety policies and procedures.

Competent Person (LV/ELV)	An individual who, at the discretion of an Authorized Person, has sufficient technical knowledge and experience to prevent danger when carrying out operations on defined low voltage systems.
Operations and Maintenance Person (BMS)	A member of engineering staff, BMS manufacturer, or operations maintenance organization employed by management to carry out BMS/EMCS related duties.
BMS Operator	An authorized individual who operates BMS/EMCS.

Table 2: Designated Staff Functions

5.3 BMS/EMS Levels of Operations

BMS/EMS is designed for monitoring and control of MEP systems and includes maintainability and future system expansion. System architecture shall incorporate functional overview for monitoring the status, health and operational aspects of MEP systems and shall comprise the following logical layers:

- Management user level processor (System access)
- Operations user level processor (System access)
- System user level controllers (System access)

Interaction with the BMS may take place at all levels of the system and, at each level; there may be different requirements for different operator classes.

BMS Network Integration Structure		
Levels	**Operator**	**Function**
BMS Managers Level	Facilities Manager System Administrator	Reporting Energy Monitoring and Targeting (M&T) Offline Data Analysis
Operations Level Central Supervisor	Non-Technical Personnel (Security, Caretaker)	Response to alarm notifications and messages
	Specialist Engineer	Reprogramming Fault-Finding Expansion
Service Tools	Specialist Engineer	Monitoring Reconfiguration Fault Finding
System Level Outstations	Non-Technical Personnel	Some local control of operations
Zone Level Local Control	Specialist Engineer	Parameter Adjustment Reprogramming Fault Finding
	Occupants	Set Point adjustments

Table 3: BMS Network Integration Structure

5.3.1 Operations Level: Plug in Additional Keypad

A keypad may be plugged into a BMS outstation to review events, receive alarms and provide some parameters adjustment for all the controls mounted within the panel. For example, pressure, temperature, and overrides according to building requirements for schools and universities.

5.3.2 Systems level: Touchscreen and Network PCs

A PC can sit on the network, providing either full control or reduced input and output capacity compared with the main supervisor computer. However, it can have access to an entire network. This may consist of graphs, pictures, knobs, dials, and text. This display screen may function differently, based on building specific BMS/EMS.

5.3.3 Operators Level: Supervisor

The supervisor computer also known as 'head end PC' is commonly connected with a printer. The head end PC is the prime interface between the system operator and BMS/EMS. This is where the Operational Team can perform limited BMS/EMS functions such as local overrides, set point change, and alarms identifications.

5.3.4 Users Level

The enormous power and flexibility of the PC-based supervisor means that the software must be carefully chosen to allow appropriate operation by different user levels. Generally, there are three levels of operation:

- Operation and adjustments by technicians
- Operation by senior technicians and supervisors
- Operations by controlled engineer

5.3.5 Training

The successful operation of a BMS/EMS depends on the skills and knowledge of the operators. A proper training schedule is essential to understand the requirements for operating a BMS. Building owners must decide who will operate the BMS. These individuals could be internally trained staff. However, contracting out FM services is becoming more common. It is recommended that:

- At least two BMS operators attend courses administered by the BMS Specialist to train operators in order to manage school and university facilities operations
- All new operators who may subsequently be appointed should also receive proper training
- An internally trained individual can develop an in-house training module to train other operators and technicians
- It is recommended that refresher training is administered periodically to all staff members

6.0 PROCESS

6.1 BMS Overview

BMS is also known as Building Management and Control System (BMCS) or Building Automation System (BAS) according to OEM terminology. The fundamental requirement of the system remains the same, irrespective of the label used, which is that building Mechanical, Electrical and Plumbing (MEP) services shall be automated and monitored to control engineering systems such as, but not limited to, heat pumps, lighting systems, security systems, and Heating, Ventilation, and Air Conditioning (HVAC) systems. This simplifies the work requirements of engineers and building operators. These building systems should operate with optimal energy efficiency while maintaining safe, healthy and comfortable conditions for the occupants of the spaces being served.

Furthermore, BMS/BAS cannot effectively optimize building operations management, since its primary purpose is to automate and control MEP systems. However, this is supported by an Energy Management Control System (EMCS) which provides school and university building's Operation Managers with advance analytics tools to act as the brains of engineering operations. EMCS captures data from BMS/BAS and processes the information as it is logged in terms of energy consumption of power, water, gas and steam. Additionally, it can perform advance analytics and highlight areas where energy can be potentially saved. This results in energy saving opportunities and will reduce overall operating costs for schools & university buildings. Below are some key features of BMS/EMCS for Operation Managers to focus and base their forecasts on:

- Building performance monitor
- Generate reports, graphs and, annunciate alarms during system malfunction
- Operation management in an energy efficient and economical manner
- Environment friendly
- Sustainability
- Advance reports

- Energy management, demand and consumption dashboards
- Air quality management
- Sequence selections based on building demand
- Equipment's lifecycle

The Operation Managers shall endorse specific building requirements, policies, and procedures to optimize BMS/BAS and EMCS to obtain the above results.

6.1.1 BMS Key Components:

- Hardware
  - Direct Digital Controller (DDC)
  - Sensors
  - Actuators
  - Human Machine Interface (HMI) display
  - PC workstation
  - Server to store extensive database

- Software
  - Programming or configuration tools
  - Graphics or User Interface

- Networking Protocols including, but not limited to, the following:
  - Transfer Control Protocols/Internet Protocol (TCP/IP)
  - Building Automation and Control Network (BACNet)
  - Modbus
  - LonWorks
  - CAN bus

The most essential function of all the aforementioned protocols is to transfer data from one device to another device with high-level security.

Below are approved BMS protocols for sending and receiving BMS related information.

6.2 BMS & MEP Systems

All engineering plant, system, and equipment associated with the internal environment of school and university buildings should be monitored and controlled by a BMS where possible.

Effective systems should be in place for both off-site and on-site alarm responses.

BMS within school and university facilities shall cover the control and/or monitoring of HVAC, Mechanical, Electrical, ELV, and any other third-party integration.

The diagram below provides the Operations Team a high-level view of the configuration for all associated systems.

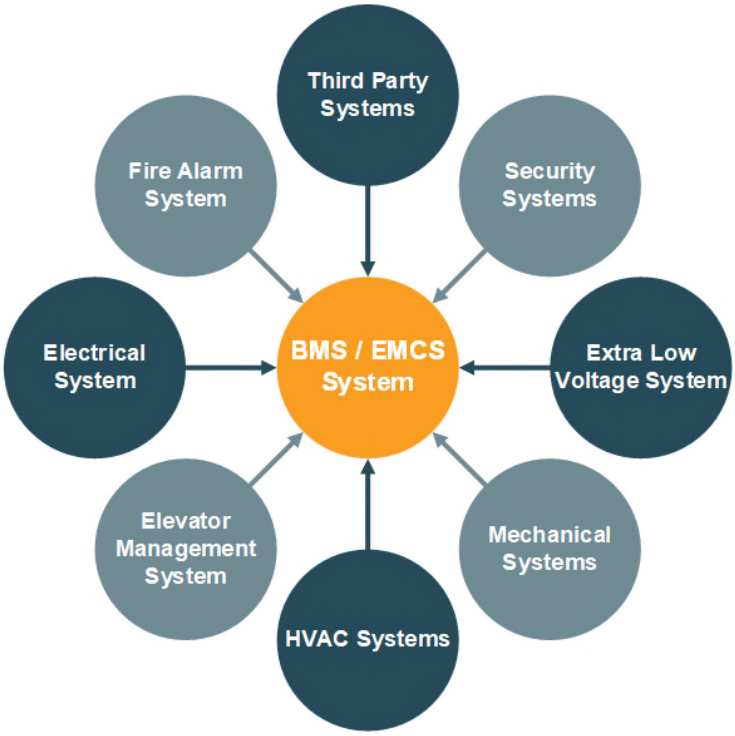

Figure 1: High-Level View of the Configuration of BMS and MEP Systems

The systems listed below are expected to run through BMS in order to meet building operational requirements. These systems must be monitored and controlled to ensure HVAC, mechanical, and electrical services are operating effectively. If these systems partially or fully fail to operate, this can lead to a significant impact on the operation of school and university buildings. Hence, operational control measures such as emergency response Standard Operating Procedures (SOP) or emergency action plan shall be in place for Operations Managers to refer to in case such a critical event or emergency should arise.

A BMS used within school and university facilities shall cover the control and monitoring of HVAC, mechanical, electrical, ELV, and any other third-party integration, as follows:

6.2.1 HVAC

HVAC systems for monitoring and control through BMS should include, but are not limited to:

- Equipment monitoring and control:
  - Air handling unit
  - Fan coil unit
  - Variable air volume boxes
  - Exhaust fans
  - Chilled water pumps
  - Cooling tower
  - Condenser water pumps
  - Hydronic hot water pumps
  - Chillers
  - Condensate recovery unit
  - Others

- System monitoring and control for building systems:
  - Chilled water distribution – Primary or primary/secondary system

- Condenser water distribution
- Air distribution system
- Others

6.2.2 Mechanical System

Mechanical systems for monitoring and control through BMS include, but are not limited to:

- Control of Mechanical Fire and Life Safety System such as:
  - Zoned smoke control system
  - Staircase pressurization utilizing Variable Frequency Drive (VFD) scheme
- Monitoring of Mechanical Fire and Life Safety System such as:
  - Lift lobby or lift shaft pressurization system
  - Atrium smoke extraction system
  - Car parking smoke extraction system
- Plumbing booster and sewage pumps
- Fire pumps (as applicable)
- Water tank level status
- Fuel tank level status
- Fuel transfer and distribution systems
- Others

6.2.3 Electrical

Electrical and equipment integration systems for monitoring and control through BMS include, but are not limited to:

- Switchgear
- Automatic Transfer Switch (ATS)
- Transformer
- Ring Main Unit (RMU)
- Main Distribution Unit (MDB)
- Sub Main Distribution Unit (SMDB)
- Generators
- Digital Master Controller (DMC)
- Isolated Power Supply Unit (IPS)
- Capacitor Banks (CB)
- Harmonics Filter (HF)
- Uninterrupted Power Supply (UPS)
- Variable Frequency Drive (VFD)
- Power Monitoring and Control System (PMCS)
- Elevator Management System (EMS)
- Others

6.2.4 Extra Low Voltage (ELV)

ELV system integration for monitoring and control through BMS should include the following, as applicable to the building:

- Fire Alarm System (FAS)
- Security Systems
- Access Control System (ACS)
- Lighting Control System (LCS)
- Parking Management System (PMS)
- Water Leak Detection System (WLDS)

- CO monitoring
- Voice and data infrastructure
- Master clock system
- Others

6.3 BMS/EMCS Functions

The main functions of BMS are listed below, but may vary based on installed third-party systems:

- Measures
  - Energy
  - Power quality
- Fix the basics
  - Power quality
  - Insulation material
  - Low consumption devices
  - Power reliability
- Automation
  - Variable speed drives
  - Motor control systems
  - BMS
- Monitor and Improve
  - Energy management
  - Remote monitoring systems

The figure illustrated below depicts the three functions of basic BMS/Building Control Systems

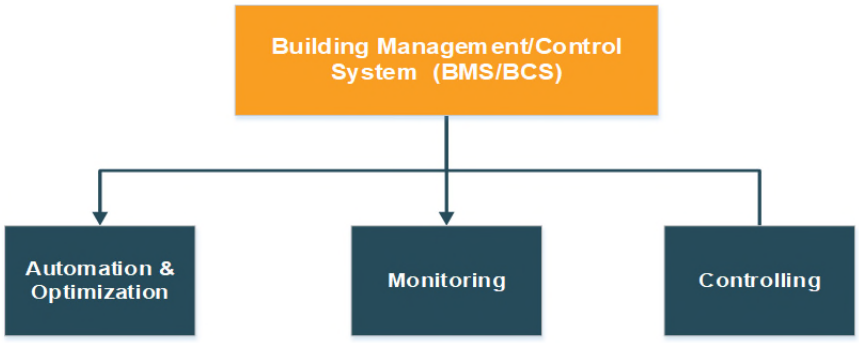

Figure 2: Function of basic BMS/Building Control System

6.3.1 Control Strategies for BMS/EMCS and Subsystems

A control system must ensure safe operations of the system it controls. It shall give adequate warning of any malfunction and if necessary, to take appropriate action in the event of equipment failure. BMS/EMCS employs a variety of alarms, interlocks and control strategies to automate school and university building operations. These strategies are found over a wide range of different engineering systems and are treated together below to avoid repetition.

- **Alarms:** Installed to indicate the operator that a system variable has exceeded a predetermined limit

- **Interlocks:** Interlocks ensure that particular system or equipment may only operate together or are prohibited from operating together

- **Safety strategies:** Safety switches override normal engineering systems' operation to prevent harm to plant or personnel and should be monitored and controlled through BMS/EMCS. The use

of safety switches through complex computer systems may serve to conceal potential problems or unexpected control actions in alarm situations. A process must be in place to ensure correct Sequence of Operations (SOO) during start-up and shutdown of school and university building engineering systems

- **Fire and Smoke Control:** The operations of fire control system are separate from other school and university building engineering systems. The BMS receives fire alarm signals and must act accordingly. A stringent process shall be put in place by the operations team in the event of receiving such alarms to manage operations. Where there is a central HVAC system integrated with BMS, the BMS/EMCS response to a fire alarm may be either:
    - Plant shutdown including supply and extract fans with inlet and exhaust dampers closed
    - Plant shutdown with the extract fan continuing to run with exhaust damper open

6.3.2 Fine Tuning

School and university buildings operate under the control of appropriate staff which includes, but is not limited to, in-house staff, a contracted FM company, OEM Specialist or internal or external contractor who manages the BMS operations. Fine tuning/adjustments are essential because the manner in which a building is used by its occupants cannot always be predicted. Therefore, it is expected that BMS/EMCS will require attention and tuning/overrides by BMS operators on a day-to-day basis. A stringent process/provision should be developed to ensure that these adjustments are managed in a controlled manner without having an impact on operational performance.

6.3.3 Monitoring

In some situations, it is possible to monitor the condition of a system or plant. This provides valuable information on the performance and reliability of school and university building engineering systems and can detect early signs of trouble in systems or equipment. The central head end computer (BMS/EMCS) receives and processes the metered data (systems information). The computer may be a separate machine dedicated to monitor and display the BMS/EMCS engineering data or information. Within some school and university buildings, this may be situated offsite and communicates via modem or internet. Failing to actively monitor information can result in:

- Pressure drop which can lead to MEP systems failure
- Efficiencies can be significantly impacted
- Operating variables can be compromised

A Facility Manager is responsible for monitoring the following items:

- KPIs, which are agreed upon between the Facilities Management Company (FMC) and the Entity
- The power consumption within buildings or by different systems, to analyze high consumption areas and identify potential power saving opportunities. A custom-made report should be set to determine power consumption
- Energy usage is monitored and recorded in relation to site volume, floor area, employee count, and/or official equipment utilization. Seasonal variations in energy usage should also be monitored to assist in highlighting anomalies in energy usage across the site and to benchmark energy utilization against other similar entities.
- Work orders under the Computerized (or paper) Maintenance Management System (CMMS) should be actioned in accordance with the agreed contract requirements and standards.
- Assets in the Computerized (or paper) Maintenance Management System (CMMS) should be audited and kept up to date as per the agreed contract requirements and standards. This should be undertaken to prevent an accumulation of unregistered assets on the CMMS.
- A staff training matrix should be used and updated regularly. Staff training should be relevant and include any new applicable statutory and mandatory legislation. A percentage of operational staff should be trained on first aid as per site requirements.
- Regular checks are carried out to ensure that operational and maintenance remedial actions are in place to prevent minor faults from developing into operational issues. Once these issues have been addressed, the associated work orders must be closed within specified SLAs.

6.3.4 Metering

Energy metering hardware in a BMS/EMCS consists of, but is not limited to, the following components:

- **Meter Module:** Measures the desired quantity and converts it to an electrical output; could function with Modbus or LonWorks
- **Display Module:** Displays the present values of the rate of energy consumption in addition to other derived quantities
- **Data Logger:** Accepts pulses from the meter, processes and stores data on energy consumption, and transmits data on demand to the central computer containing BMS/EMCS software
- **Data Transmission System:** Connects one or more data loggers to the central computer
- **Computer:** Contains the analysis software

6.3.5 Records/Drawings/System Architecture

The Entity should have accurate and up-to-date records and/or drawings. Where possible, these should be backed up electronically and should be made readily available on site, in an appropriate format, for use by BMS/EMCS Engineering Services Team. The FM should also be aware of the increasing use of Building Information Modeling (BIM) and have the provisions to access BIM information where possible.

Refer to **Attachment 5** for a sample of a BMS Integration Block Diagram.

6.3.6 Energy Monitoring and Targeting (M&T)

A major feature of BMS/EMCS is energy conservation and management. Although the proper and efficient control of school and university building engineering systems contributes to efficient energy consumption, but it is also imperative that the school and university Facility Operations Manager receive accurate and up-to-date information on energy utilization in the school and university building. M&T requires that data on energy consumption be regularly collected, summarized and compared with target consumption figures. Computerized (BMS/EMCS) collection and analysis of data makes M&T a power tool for the control of reduction of energy consumption.

School and university Facilities Engineering Managers should utilize this tool to determine:

- The control of energy (power, heat, steam, fuel and water) use by monitoring consumption through BMS and comparing it against historical data and benchmarks for similar buildings
- Improvements in the efficiency of energy utilization by the setting of future targets. The monitoring portion of M&T shall have four stages as a minimum:
    - Data collection
    - Data analysis
    - Reporting
    - Action

6.3.7 Supervisor/Graphics

A supervisor is a computer which allows an operator access to data stored within controllers and allows modifications to the software held inside the controller. Large BMS/EMCS are appointed a head end supervisor which has access to and can monitor and control the entire BMS network to:

- Clearly present data required to check the status of a system or subsystem without clutter and in a logical visual format
- Facilitate navigation from a graphic page, either up to a system overview or down to a sub-unit or point history in an intuitive, point-and-click manner
- Ensure that graphics are available on all systems and sub systems
- Ensure that temporary trend graphics can be set up by all users and do not require high level skills or access
- Configure a full building system report to enable effective systems management

- Enable different levels of user authorization (e.g. programmer, system controller, maintenance staff, managers)
- Enable intuitive, point-and-click access to data, graphics, and agreed control functions for each user

6.4 BMS Operations Management

Within a school and university facility, there are critical pieces of equipment (assets) and engineering systems which have a greater impact on overall performance of the services. Therefore, there is a need to identify what equipment or system is critical in ensuring the safety, comfort and amenity of a facility, particularly in areas such as security control rooms, telecom rooms, hub rooms, data centers, and utility areas.

The loss of service of these areas would seriously degrade the ability of the premises to deliver optimal services. In order to ensure reliable service provisions, it is essential to inspect, verify and maintain these school and university facility utility systems at appropriate intervals. For many of these systems, a Permit-to-Work will need to be completed to ensure that taking these systems out of service does not compromise the activities of the user department. In any event, it will be necessary to liaise with the user department when taking the system offline to carry out routine inspections and maintenance.

6.4.1 Alarm Management

A process should be in place to handle active alarms that appear on head end PC's. Some BMS forward these alarms on to the other networked PCs (or display, CMMS) as per designed configuration. The alarm handling system (BMS) is vulnerable to failure due to maintenance, programming or any breakdown (hardware or software) and no alarms will be forwarded during this time. Hence, a manual process to access field routers shall be in place to manage BMS operations. A process shall be developed to determine the response to alarm messages. These responses can be as follows:

- **Acknowledged**: This may be used where confirmation is required that an alarm has been received (or, in non-alarm terms, that a message was received by another controller)
- **Request/Response**: A message is sent to a controller. When the message has been processed; the response confirms that the alarm was received and understood
- **Repeated**: A message is sent and re-sent a number of times, but no acknowledgement is required (e.g., low priority alarms)

At the receiving end (BMS/EMCS – head end PC), where the alarm is displayed and acted upon, the following points should be considered depending on the desired reliability and the importance of the alarms being handled:

- Resilient power supplies
- Dual redundant servers
- A resilient Information Technology (IT) Network
- Software for alarms acknowledgement

6.4.2 Alarm Requirements

Alarm priorities will vary based on the severity of the fault and the nature of the building and associated plant. Alarm points for specialist equipment or particular complex systems that are part of utility services in schools and universities. It should be monitored on regular intervals and escalated to the relevant engineering discipline to action these in the field.

6.4.2.1 High Priority

Emergency notifications triggered by fire alarm status, power failures, control circuit failures, alarm inhibit switch operations, and gas sensor alarms are sent directly to the Entity's Facility Maintenance Team and Operations Manager.

6.4.2.2 Medium Priority

Notifications related to high temperatures experienced within critical areas in a facility should be sent directly to the Maintenance Team. If these conditions persist, the Facility Operations Manager should be notified.

6.4.2.3 Low Priority

Change of state reports, hardware alarms, and dirty filter alarms should be sent directly to the Entity's Facility Maintenance Team.

6.4.3 Operation Schedule

Operational schedules are essential to managing a school or university facility's operations efficiently. These schedules can be changed based on required and load demand in the facility. Operation schedules should not include basic sequence and design schedules. Threshold limits must be taken into consideration while conducting any changes in the controlled part of the systems. Specific schedules may include the following areas:

- Zoning
- Environmental parameters
- Alarm limits, priority, and routing
- Initial time programs
- Plant operating sequences
- Load shedding sequences
- Actions on start-up
- Actions on shutdowns/warnings/alerts
- Actions on seasonal shutdown
- Actions on communication failure
- Actions on BMS failure
- Actions of total power failure

6.4.4 Risk Management

In developing operations management processes for school and university facilities, it is vital to consider the risks associated with the inappropriate operation of the BMS and associated engineering systems which include, but are not limited to:

- Asset loss or system failure, including consequential financial loss
- Reduced asset life
- Breach of statutory obligations
- Creating an unhealthy or unsafe environment and consequential liabilities
- Risk of harm to the environment
- Inefficient operational performance resulting in higher operating costs;
- Adverse perception among stakeholders

6.4.4.1 Shutdown & Outage Management

In the facility operations management of schools and universities, planned utility plant or system shutdowns or outages are significant events that must be managed with due diligence. A clearly agreed upon and approved strategy shall be in place including implementation by Operations and Maintenance (O&M) Schools and Universities Facility Team. A shutdown and outage strategy shall identify the shutdown/outage duration, along with the required material, manpower, specialist contractors, and other critical resources to deliver the required work.

6.4.4.2 Faults & Incident Response

Faults and incident response entails responding to faults and incidents related to building operations in a systematic manner. There shall be a process in place, which includes incident detection and identification, fault analysis, use of standard responses, temporary and permanent repair procedures, reporting and updating equipment or systems information.

6.4.5 Documentation

Sound operations management documentation is necessary for effectively managing the day-to-day operations of the engineering services of school and university facilities. The documentation should include:

- Written description of plant operations
- Control strategies or logic diagrams
    - Network architecture drawings
    - Diagrams detailing physical wiring connections to controllers
- Details of system application software configuration
- Point list including hard and soft points
    - DI – Digital Inputs
    - DO – Digital Outputs
    - AI – Analogue Input
    - AO – Analogue Output
    - HLI – High Level Interface
- Copies of certificate of compliance with relevant standards
- Data sheets for all control components and equipment
- Instructions for switching on, operation and switching off, isolation, fault finding, and for dealing with emergency conditions
- Instructions for any precautionary measures
- Instructions for servicing
- Instructions in the use of software routines for creating procedures, and graphic reports, where applicable
- Description of user adjustable points

6.4.6 Operational Considerations

- Data consolidation onto a single system to improve reporting, information management, and decision making
- Increased operational savings – efficient resource deployment results in reduced operational costs, empowering operators, simplifying training, and decreasing false alarms
- Energy efficient – Real time monitoring into facility operations and trends analysis provide data–driven insight to optimize energy management strategies and minimize operational costs
- Reduced risk – Strategic mobile or desktop control, exceptional alarm management, and integrated security solution help speed up response time and mitigate risks for the school and university property, people and business
- Intelligent reporting – Intelligent reporting with functionality to customize reports to deliver operational excellence and promote compliance
- Energy savings due to occupied and unoccupied modes according to school and university operations

6.5 Procedures

6.5.1 Start-up Procedures

A start-up procedure is a reference document to be used when preparing a process to operate a system from an offline position. The actions within the procedure are intended to ensure that a methodological approach is taken when bringing an engineering system or piece of equipment back online. Start-up procedures for BMS and associated MEP systems shall include the following:

- Health and safety
- Pre-approvals
- System readiness
- Pre-start checks
- Start checks
- Notifications

Refer to **Attachment 1** for full generic BMS start-up procedure.

6.5.2 Shutdown Procedures

A shutdown procedure is a reference document for a planned activity to take a system or a piece of equipment offline. The shutdown procedure should be clear, prescriptive and well understood. The specific steps often mirror those taken with a start-up procedure, but include additional consideration for the effect on utilities and other building services connected to the process. HVAC and integrated MEP system shutdown procedures shall include the following:

- Health and Safety
- Pre-approvals
- Standby system condition
- Pre-shutdown checks
- Routine stops
- Post-stop checks
- Notifications

Refer to **Attachment 2** for full generic BMS shutdown procedure

6.5.3 Daily Reporting/Monitoring

A well designed and managed BMS provides great opportunities for improvements in energy efficiency and monitor early alarms/faults to prevent equipment failures or any catastrophic failures of engineering systems. Therefore, a clearly understood process is required to manage alarms and equipment's events to avoid any incidents related to the operations of Entity facilities. This process shall define timelines required to raise any reactive, corrective, or emergency issues occurring in monitoring, control, or running of the BMS as well as integrated sub systems with acceptable time period to address any faults in a timely manner. Daily reports/monitoring provide great opportunities for improvements in energy efficiency by:

- Enabling school and university Facility Operations Managers to provide an optimal working environment consistent with maintaining a building's energy efficiency rating
- Early identification of equipment failure
- Identification of unusual patterns, trends of energy usage such as equipment and/or systems being left on outside operating hours in common areas.
- Monitoring effectiveness of Emergency Management Plans (EMPs)

Refer to **Attachment 3** for a full generic BMS monitoring/daily rounds checklist.

6.5.4 Emergency Response

Emergency procedures are intended to highlight the key issues that may arise at the departmental level in the event of monitoring or controls failures. Good practice in emergency management should include development of an EMP and actions that outline responsibilities, identification of high-risk areas, and appropriate responses. Clear identification of safe areas during an emergency, an evacuation plan for disabled persons, and an emergency plan with response actions will be further detailed in **Attachment 4 – Emergency Response Actions**.

Within the school and university facility operating procedures, there will be many elements of the overall Facilities Operating Clients (FOC) EMP that the Facilities Management Companies (FMC) plan will need

to feed into and take direction from. The response actions required will then depend on these plans and integrations.

Below is an example of the possible FMC emergency plan integration elements, reporting entities, and designated person organization that are required to build a basic plan:

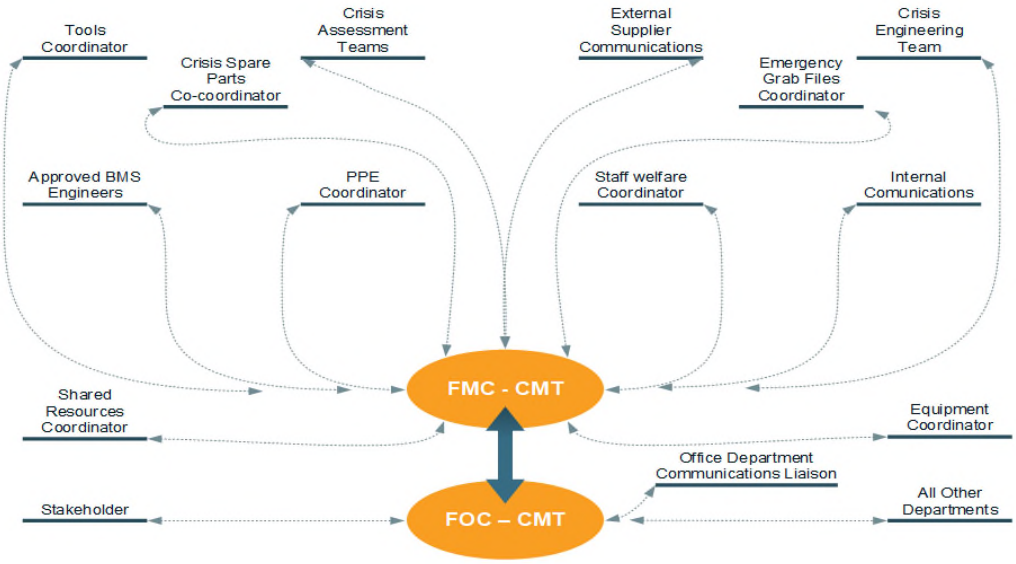

Figure 3: FMC Emergency Plan Integration Elements

For FMC Operations, this will be focused around management for the continuation of service to and from the facility, as outlined below:

To:

- Power
- Water
- Gas
- Fuel
- HVAC
- Medial gas
- Oxygen
- Spares Supplies
- Other

From:

- Sewage
- Grey water
- Waste
- Other

Plan development should consider how different emergency situations and scenarios will impact the operation of facilities and the areas in which the emergency has originated. It is good practice to prioritize these emergency origins and impact areas into specific categories and document the influence on site operations that may occur due to these emergencies. Emergency origins may be categorized as:

- **External Disaster** (e.g., earthquake, flooding, weather, multi-discipline disruptions)
- **External Specific** (e.g., major distribution service provider outage, localized area outage, specific transformer outage, local cabling, BMS communication, IT connectivity)

- **Internal Disaster** (e.g., major fire, major flooding, critical site wide systems failure)
- **Internal Specific** (e.g., power failure to the BMS controllers, communication failure, data loss, programming issues, or any specific malfunction in system monitoring or control from these categorized headings the plan can be expanded and action direction formulated.

From the high-level headings, the impact to other systems and/or facilities can be identified and the action plans can be subsequently formulated.

Below is an example of how the emergency action planning development may flow for one scenario. Other plans applicable to other scenarios should also be put into emergency grab packs giving the FMC emergency response staff clear direction on how to handle an emergency while the FMC Crisis Management Team (CMT) and FOC – CMT are convened and become fully operational.

External Disaster (e.g. earthquake, flooding, weather, multi discipline disruptions)

Scenario 1 Major Earthquake

1. **Scenario parameters:**

- External electrical supply has been lost
- External supply chain is not responding
- Business loss

2. **Initial actions:**

- Relevant grab packs to be distributed to and or taken by the emergency response engineering staff
- Implement the FMC emergency action plan/plans
- Convene at the FMC crisis management command center/designated area
- Establish communication with the FOC (client) Crisis Management Team (CMT)
- Establish the communication process with external governmental departments through FOC CMT process

3. **Assessments**

- Assess the impacted BMS and other integrated systems
- Formulate action requirements from the emergency grab packs
- Prioritize in conjunction with FOC CMT direction and/or consultation
- Calculate load shedding requirements to conserve resources (e.g. stored diesel) in line with FOC CMT direction and/or consultation
- Access the monitoring and control through other redundant BMS measuring points in building network

4. **Implementation**

- Deploy to FMC - CMT designated command area
- Initiate initial action process
- Establish communications processes
- Initiate initial assessment process
- Select relevant emergency grab packs
- Report initial assessment findings to FOC – CMT
- Take informed direction from FOC – CMT
- Initiate emergency grab pack process
- Initiate staff deployment
- Report, update, and direct FMC CMT ↔ FOC – CMT
- Continue intensive situation assessments until emergency is stabilized
- Initiate forward operation requirements
- Assess staffing requirements

- Assess staffing welfare requirements
- Operate on emergency operations requirements until emergency stand – down is agreed
- Initiate emergency stand-down processes in conjunction with FOC – CMT

The following procedures and checklists have been prepared for FM personnel to meet the needs of their own organizations during failure of a system.

They are not intended to be appropriate or definitive for all facilities, but they provide an idea of the general format that may be used and the different levels of technical content that may be applied to contrasting sites.

Further procedures will be required within a school and university related Entity and a regular review is important to ensure that the directives of staff and equipment remain current.

Refer to **Attachment 4** for Full Emergency Response Actions.

7.0 ATTACHMENTS

Attachment 1: EOM-ZO0-TP-000093 – Start-up Procedure BMS and Associated Systems Checklist
Attachment 2: EOM-ZO0-TP-000094 – Shutdown Procedure BMS and Associated systems Checklist
Attachment 3: EOM-ZO0-TP-000095 – System Monitoring Procedure Checklist
Attachment 4: EOM-ZO0-TP-000096 – Emergency Response Actions Checklist
Attachment 5: BMS and Other Systems Integration Block Diagram

Attachment 1: EOM-ZO0-TP-000093 - Start-up Procedure BMS and associated Systems Checklist

Building Name:	Reference No:	REV- 00A:		
No.	**Start-Up Procedure**	**CHECKED SATISFACTORY**		
		N/A	YES	NO
	BMS and Associated System – School & University			
	Health and Safety			
1	Required PPE available	☐	☐	☐
2	Risk Assessments Method Statement (RAMS) available	☐	☐	☐
3	Location of first-aid instructions and supplies available	☐	☐	☐
4	Emergency eyewash and showers available	☐	☐	☐
5	Emergency evacuation plan reviewed	☐	☐	☐
6	Emergency contact details of the authorized person and the contractors	☐	☐	☐
7	Life Safety Systems (fire extinguishers, sprinklers, gas suppression & fire alarm)	☐	☐	☐
8	Ventilation	☐	☐	☐
	Pre-approvals			
9	System owner/ Manager/ Engineering team approvals available	☐	☐	☐
10	End-user department head approvals available	☐	☐	☐
11	QHSE approvals available	☐	☐	☐
12	Specialist contractor schedule of work	☐	☐	☐
13	Approved permit to work (PTW)	☐	☐	☐
	BMS Checks			
14	BMS server communication	☐	☐	☐
15	BMS workstations are powered and communication System	☐	☐	☐
16	Field DDC and switches communication	☐	☐	☐
17	BACNet routers communication	☐	☐	☐
18	BMS firewalls active	☐	☐	☐
19	Base LAN/WAN communication	☐	☐	☐
20	Building Network Communication	☐	☐	☐
21	Areas are cleaned and egress checks	☐	☐	☐
	BMS and integrated system functional checks			
22	System fault free / alarm free checks	☐	☐	☐
23	Original Equipment Manufacturers (OEM) startup procedure available	☐	☐	☐
24	Automatic controller checks (Communication checks)	☐	☐	☐
25	Parameters set point checks (Pressure, Temperature, and Flow)	☐	☐	☐
26	Previous service reports checks (3rd party specialist)	☐	☐	☐
27	Primary supplies systems / plant checks	☐	☐	☐
28	System Architecture Function	☐	☐	☐
	BMS Post Start checks			
29	MEP System operating / parameters checks	☐	☐	☐
30	MEP System alarms / warnings checks	☐	☐	☐
31	MEP systems duty / stand by communication of equipment's	☐	☐	☐
32	System / programming BMS operation running checks	☐	☐	☐
33	System running and online, (cause & effects checks if any activated)	☐	☐	☐

Attachment 2: EOM-ZO0-TP-000094 - Shutdown Procedure BMS and associated Systems Checklist

Building Name:	Reference No.	REV- 00A		
No.	**Shut Down Procedure**	**CHECKED SATISFACTORY**		
		N/A	**YES**	**NO**
	BMS and Associated System – School & University			
	Health and Safety			
1	Required PPE available	☐	☐	☐
2	Risk Assessments Method Statement (RAMS) available	☐	☐	☐
3	Location of first-aid instructions and supplies available	☐	☐	☐
4	Emergency eyewash and showers available	☐	☐	☐
5	Emergency evacuation plan reviewed	☐	☐	☐
6	Emergency contact details of the responsible person and the contractors	☐	☐	☐
7	Life Safety Systems (fire extinguishers, sprinklers, gas suppression & fire alarm)	☐	☐	☐
8	Ventilation	☐	☐	☐
	Preapprovals			
9	System Owner/ Manager /Engineering team approvals available	☐	☐	☐
10	End-user department head approvals available	☐	☐	☐
11	QHSE approvals available	☐	☐	☐
12	Specialist contractor schedule of work	☐	☐	☐
13	Approved permit to work (PTW)	☐	☐	☐
	BMS Checks			
14	Redundant BMS working			
15	Server connection	☐	☐	☐
16	Data saved	☐	☐	☐
17	Soft shutdown SOP / Procedure to follow	☐	☐	☐
18	Auto mode / Overrides	☐	☐	☐
19	Events / Logs saved	☐	☐	☐
20	Redundant BMS working	☐	☐	☐
	Pre-Shutdown Checks (Integrated system functional checks)			
21	System is alarm free	☐	☐	☐
22	Automatic control panel parameters checks	☐	☐	☐
23	Stand by systems working	☐	☐	☐
24	Overrides / auto functions active	☐	☐	☐
	Routine Stop			
25	LOTO checks	☐	☐	☐
26	Server working	☐	☐	☐
27	No events / alarms on standby systems	☐	☐	☐
	Post Stop Checks			
28	MEP system functioning	☐	☐	☐
29	Other monitoring PC's active	☐	☐	☐
30	Control active	☐	☐	☐

Attachment 3: EOM-ZO0-TP-000095 - BMS Monitoring Procedure Checklist

Building Name:	Reference No.	REV- 00A		
No.	**BMS and associated Systems Monitoring**	**CHECKED SATISFACTORY**		
		N/A	**YES**	**NO**
	BMS and Associated System – School & University			
	This monitoring checklist is intended to highlight the key issues that may arise day to day at local level. The procedure and any supporting information should be reviewed and amended as necessary to ensure the document remains up-to-date and definitive for the facility			
1	System inspection and checking: (Is the BMS running)	☐	☐	☐
2	System assessment: Is the unit and its associated plant secure from unauthorized access	☐	☐	☐
3	Remote monitoring of ventilation and air conditioning systems and equipment through BMS	☐	☐	☐
4	Identifying maintenance risks on equipment and raising work orders in case any discrepancy into MEP systems	☐	☐	☐
5	Investigating fault / alarms for MEP systems.	☐	☐	☐
6	Security systems, lighting system, and other specialized systems are healthy	☐	☐	☐
6	Ensure BMS program, back end applications, software is running	☐	☐	☐
7	Duty / Standby system are healthy and communicating	☐	☐	☐
8	Field controllers, routers, switches are online and communicating	☐	☐	☐
9	System architecture functioning	☐	☐	☐
10	Performing emergency repairs promptly and efficiently.	☐	☐	☐
11	Providing technical direction to ensure system maintains online	☐	☐	☐
12	Keeping daily logs and records of all operation functions.	☐	☐	☐
10	Ensuring compliance with appliance standards and with Occupational Health and Safety	☐	☐	☐
11	Complying with service standards, work instructions and user requirements.	☐	☐	☐

No.	**Reviewer's Comments**	**Resolution**
Originator's Name / Signature and Date:		Checker's Name / Signature and Date:

Attachment 4: EOM-ZO0-TP-000096 - BMS Emergency Response Actions Checklist

Building Name:	Reference No.	REV- 00A

No.	Emergency Response Actions	CHECKED SATISFACTORY		
		N/A	YES	NO
	BMS – Schools & Universities			
	This Emergency Response Action Plan (ERA) is a guide intended for areas of school and university facilities with complex services, for example a major utility service house or specialist control room. The actions to be taken by Designated and Authorized persons may be expressed in a checklist. The steps below are simple indication of some issues that may arise although a more detailed list may be appropriate for each specific area. The designated staff functions of school and university facilities need to be made clear in order that the correct measures are taken to minimize the impact of any crisis.			
1	Define ownership of the problem	☐	☐	☐
2	Will tenants / public / staff safety / care be affected	☐	☐	☐
3	Will evacuation be required	☐	☐	☐
4	Risk of fire outbreak, or reduced re-fighting ability	☐	☐	☐
5	Consider impact on electricity supply and BMS controls	☐	☐	☐
6	Consider impact on water supply and BMS controls	☐	☐	☐
7	Consider impact on drainage and BMS controls	☐	☐	☐
8	Consider impact on any third-party system and BMS controls	☐	☐	☐
9	Consider impact on site security	☐	☐	☐
10	Consider impact on data loss and data security			
11	Impact on alarms	☐	☐	☐
12	Will critical system be affected and time period of outage	☐	☐	☐
13	Agree responsibility boundaries	☐	☐	☐
14	School and University internal department procedures	☐	☐	☐
15	Do public relations need to be addressed	☐	☐	☐
16	Consider Service Level Agreements with suppliers	☐	☐	☐
17	Involve commercial services	☐	☐	☐
18	Record entities personnel contact details	☐	☐	☐
19	Locate supply of specialist / redundant BMS equipment	☐	☐	☐

No.	Reviewer's Comments	Resolution
Originator's Name / Signature and Date:		Checker's Name / Signature and Date:

Attachment 5: BMS and Other Systems Integration Block Diagram