230901 BUILDING AUTOMATION AND CONTROL SYSTEM COMMUNICATIONS AND INTEROPERABILITY

Cornell's Design and Construction Standards provide mandatory design constraints and acceptable or required products for all construction at Cornell University. These standards are provided to aid the design professional in the development of contract documents and are not intended to be used verbatim as a contract specification nor replace the work and best judgement of the design professional. Any deviation from the Design and Construction standards shall only be permitted with approval of the University Engineer.

PART 1: GENERAL

1.01 GENERAL

A. Building automation and direct digital control systems throughout Cornell require integration to the campus Energy Management and Control System (EMCS). To ensure compatibility, all installations of digital building automation and control equipment shall support communications via the BACnet standard, ANSI/ASHRAE Standard 135-2012, *BACnet® - A Data Communication Protocol for Building Automation and Control Networks* and the related international standard, ISO 16484-5.

1.02 OVERVIEW

A. This section provides the communication and interoperability requirements for building automation and control system components to be supplied to Cornell. Because the University's systems have evolved over many years and involve products from multiple vendors and, in several cases, multiple generations of control systems from single vendors, attention must be given to the integration of the old and the new. The objectives of this integration include: providing a mechanism for competitive procurement of building control products; assisting in meeting the University's energy conservation and environmental protection goals; improving the operational systems available to our facilities management and operations staff; reducing, if possible, overall facilities management costs; and providing an infrastructure for optimizing performance in a deregulated utility environment.

B. The objectives shall be met by the use, to the extent possible, of existing, widely-accepted data communication standards and practices.

1.03 APPLICABLE STANDARDS

A. The following standards shall govern the design and selection of equipment supplied to fulfill the requirements of this section:

1. ANSI/ASHRAE Standard 135-2012: *BACnet® - A Data Communication Protocol for Building Automation and Control Networks*, as amended, and

hereinafter referred to as "BACnet". American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. 2012.

2. ATA/ANSI 878.1 (1992), ARCNET Local Area Network.

3. ISO/IEC 8802-3 (1993), Information processing systems - Local area networks - Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications.

1.04 DEFINITIONS

A. In addition to the definitions contained in the applicable standards, the following should be noted:

1. ARCNET. Attached Resource Computer Network. See BACnet, Clause 8 and ATA/ANSI 878.1.

2. BACnet/IP. BACnet Annex J Devices. Annex J of BACnet describes how BACnet devices can make use of IP directly for communicating across IP-based internets.

3. BACnet PICS. A Protocol Implementation Conformance Statement that describes the BACnet capabilities of a specific device. See BACnet, Annex A.

4. BACS. Building Automation and Control System.

5. BACSI. The Building Automation and Control Systems Integration group within the Cornell Facilities and Campus Services organization. BACSI is responsible for the EMCS and the coordination of BACS device addressing and network numbering.

6. BBMD. BACnet Broadcast Management Device. See BACnet, Annex J.

7. BI. BACnet International. The trade association responsible for the worldwide promotion of BACnet.

8. BIBB. BACnet Interoperability Building Block. A collection of one or more BACnet services defined for the purpose of describing communication functionality in an unambiguous way. See BACnet, Annex K.

9. BTL. The BACnet Testing Laboratories of BI. The organization responsible for testing products to assure that they conform to the BACnet standard. Listings of tested products are available at www.bacnetassociation.org.

10. Campus Backbone. A fiber optic data communication infrastructure on the Cornell campus managed by CIT. Users connect to the backbone by means of CIT-supplied Ethernet switches in each building and appropriate 10/100/1000BASE-T unshielded, twisted pair wiring. The backbone uses IP for routing messages to and from computers both on and off the Cornell campus.

11. CIT. Cornell Information Technologies. The organization that manages the Cornell campus networking infrastructure, including the provision of network connections in Cornell buildings.

12. Device Profile. A collection of BIBBs that describes the minimum BACnet capabilities of a particular device in order to achieve reliable communication in one of five specified "interoperability areas." Devices include BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC) and BACnet Application Specific Controllers (B-ASC). See BACnet, Annex L.
13. EMCS. A computer complex that provides Energy Management and Control System functions for the University. The EMCS is connected to the campus backbone and uses IP for the routing of messages to and from individual buildings, and allows 24/7 monitoring of BACS alarms. The EMCS also provides other infrastructure monitoring and control functions for campus utilities and CIT's network operations.
14. Ethernet. A carrier sensing multiple access with collision detection network technology defined by ISO/IEC 8802-3.
15. Gateway. A device that translates BACnet messages into those of a non-BACnet protocol and vice-versa.
16. Internetwork. A set of two or more BACnet networks interconnected by routers.
17. Interoperability Area. A communications domain in which functional cooperation is desired. These areas are currently: 1) data sharing; 2) alarm and event management; 3) trending; 4) scheduling; and 5) device and network management. See BACnet, Clause 22.
18. IP. The Internet Protocol. A networking protocol originally developed by the federal Defense Advanced Research Projects Agency. BACnet messages can traverse the campus backbone by being encapsulated in routable IP packets.
19. Local. Pertaining to the requirements of a specific job or building project.
20. LAN. Local Area Network. One of the approved BACnet network technologies: Ethernet, ARCNET or MS/TP.
21. MS/TP. Master-Slave/Token-Passing Network. One of the approved BACnet LANs. See BACnet, Clause 9.
22. Network. One of the communication technologies for data communications specified in BACnet. Approved network technologies at Cornell are Ethernet, ARCNET, and MS/TP.
23. PICS. Protocol Implementation Conformance Statement. A document that describes in detail a device's BACnet capabilities. See BACnet, Annex A.
24. PM. Project Manager. The Owner's representative who oversees a BACS project.
25. Synchronization. In order to ensure that alarms are properly interpreted, the names of all BACnet objects within a device are stored in an EMCS database. This process of coordinating the names of the objects in the field devices and the EMCS is initiated manually whenever a device is installed or its objects

have been updated. The EMCS reads the Object_List property of the device's Device object (a BACnetARRAY of Object Identifiers) and then reads each object's Object_Name property (a CharacterString). This Object_Name is used along with the EMCS device name to identify the alarms related to this object so it must be unique and descriptive. See 3.02.B.3.

26. UDP. The User Datagram Protocol. One of the IP family of protocols. UDP is used to convey BACnet/IP messages and is characterized by a "port number" for each protocol. BACnet/IP typically uses UDP port X'BAC0' or decimal 47808.

27. VLAN. Virtual Local Area Network. A network configuration that allows devices to communicate across multiple physical local area networks (LANs) using their hardware or "medium access control" (MAC) addresses as if they shared a common networking medium. As with a physical LAN, "local" broadcast messages are also propagated to each of the participating LANs. VLAN capability depends on the configuration of the interconnecting data communication equipment. VLAN configuration is performed by CIT.

28. Zone. The facilities on the Ithaca campus are divided into groups called "zones" for the purpose of maintenance management. Each has a "Zone Facility Manager" and controls technicians responsible for the BACS equipment in their zone.

1.05 SUBMITTALS

A. In addition to any requirements specified elsewhere, the Contractor shall provide both proposed and as-built versions of the following:

1. Schematic drawings that represent the system architecture and configuration, in both hardcopy and editable electronic format.

2. A points list that includes, for each physical or logical point, the name, description, display units, alarm limits and definitions, along with the BACnet object description, object ID, and associated device ID. The list shall also indicate whether Trend Log or Schedule objects have been established for the point.

3. Documentation for any non-standard BACnet objects, properties, or enumerations utilized detailing their structure, data types, and any associated lists of enumerated values.

4. PICS files indicating the BACnet functionality and configuration of each device. In addition to the requirements of BACnet, Annex A, the Contractor shall provide information on any limitations on the numbers of supported objects in a given device including, specifically, Trend Log and Schedule objects.

5. Documentation on submitted products that have been tested and listed by the BACnet Testing Laboratory (BTL). If, for any reason, BTL testing and listing

has not been completed, a written commitment shall be provided to upgrade installed controls to a version that meets BTL testing and listing requirements should deficiencies be found during BTL testing.

1.06 COORDINATION

A. The Contractor shall be responsible for all coordination of subcontractors' work relative to the BACS. Specific questions relating to communication and interoperability shall be submitted to BACSI.

PART 2: PRODUCTS

2.01 GENERAL

A. Each networked device supplied pursuant to this section shall be installed and configured to correctly execute all sequences of operation for its intended application, as defined in other sections of this guideline. In addition, each networked device shall provide, at a minimum, the BACnet communication capabilities prescribed in the device profiles for devices of its type. See 2.02.

2.02 REQUIREMENTS FOR SYSTEM COMPONENTS

A. General: This section prescribes the minimum requirements for devices supplied pursuant to this section.

B. Controller Requirements: Controller devices supplied to meet the functional and operational requirements of this guideline shall conform, at a minimum, to one of the BACnet device profiles contained in BACnet, Annex L: BACnet Building Controller (B-BC), BACnet Advanced Application Controller (B-AAC) or BACnet Application Specific Controller (B-ASC). The interoperability requirements of such devices are contained in BACnet, Annex L. B-BC controller devices shall communicate using BACnet/IP. Other devices may use BACnet over ARCNET or BACnet over MS/TP.

C. Router Requirements: In the event that devices are provided that do not use BACnet/IP over Ethernet as their communication technology, BACnet routers shall be provided that route between BACnet/IP over Ethernet and the other BACnet LAN type(s), whether ARCNET or MS/TP. These routers shall conform to the specifications of BACnet, Clause 6.

D. Gateways: BACS devices that use BACnet as their native protocol are preferred. The use of gateways, in circumstances where no native BACnet devices are available, requires the specific approval of the Owner in each instance.

E. Switches and Hubs: If the network topology of the job requires the use of network switches, they shall be selected from the list of approved hardware, which can be found at https://pminfo.emcs.cornell.edu/switch_hardware. In the event the job requires additional switches, the proposed design of the network topology including all CIT jacks, switches, and network connected BACS devices shall be submitted in

advance to BACSI for approval. Schematic examples of typical extended network topologies can be referenced at the pminfo web site referenced above.

F. Non-BACnet Devices: For devices that are used for utility metering and other non-BACS applications, the Cornell EMCS provides several protocol handlers including Modbus and EtherNet/IP. Contractors supplying devices using these protocols need not provide a gateway as described in 2.02.D.

G. Workstation Requirements: The EMCS operator interface is the responsibility of BACSI. If, however, a specific job requires a local workstation, the Contractor shall provide a personal computer of current design and approved by the Owner equipped with a web browser that can display information from a Contractor-supplied web server that interfaces with the local BACnet network and the campus backbone, as described 2.02.H.

H. Web Server Requirements: If a local workstation is required, the Contractor shall comply with 2.02.G and in addition, shall provide a web server computer with the web page presentation, data acquisition and storage functionality described in this section, including the specific functions listed below. The web server shall be configured in such a way that there is no software-imposed limit to the number of simultaneous users.

1. Data Sharing
   a. Presentation of data (i.e., user definable reports and graphics)
   b. The ability to monitor and display the values of all BACnet object types, including all required and optional properties
   c. The ability to modify setpoints and parameters
2. Alarm and Event Management
   a. Operator notification and presentation of event information
   b. Alarm acknowledgment by operators
   c. Alarm summarization
   d. Adjustment of alarm limits
   e. Adjustment of alarm routing
3. Scheduling
   a. Modification of schedules
   b. Display of the start and stop times (schedule) of scheduled devices
4. Trending
   a. Modification of the parameters of a trend log
   b. Display and archive of trend log data
5. Device and Network Management
   a. Display of information about the status of any device on the BACnet internetwork
   b. Display of information about any object on the BACnet internetwork
   c. Ability to silence a device on the network that is transmitting erroneous data

d. Ability to cause a remote device to reinitialize itself
e. Ability to backup and restore the configuration of devices on the local BACnet network
f. Ability to query and change the configuration of local BACnet routers

I. Dual-Homed Equipment
To protect network security, dual-homed devices, i.e., devices with two (or more) Network Interface Cards that have an identity on a BACSI-administered LAN and another non-BACSI-administered LAN, e.g., a locally administered laboratory LAN is strictly prohibited without prior written authorization by BACSI.

2.03 Requirements for Network Connections

A. This section prescribes the means of interconnecting BACS devices provided pursuant to this guideline.

B. LANs

1. All control devices meeting the B-BC device profile shall be connected to an ISO 8802-3 (Ethernet) LAN provided by the Contractor. This LAN, in turn, shall be connected to the campus backbone network. Unless otherwise specified, the connection shall be via a 10/100/1000BASE-T port provided by the Owner. The location of the jack will be determined in consultation with BACSI, which will arrange for the jack's installation. The Contractor shall also provide any additional data communication hardware, such as switches, hubs, and repeaters that may be needed to interconnect the supplied BACS equipment and to connect to the Owner's backbone network. Although cascaded switches and hubs are not prohibited, they must meet the requirements of 2.02.E.

2. To facilitate maintenance technician access to the LAN, the Contractor shall also provide at least one additional 10/100/1000BASE-T access point in each mechanical room that contains BACS equipment. This requirement may be met by supplying either a hub with a spare port or a dedicated jack.

3. Control devices that meet the B-ASC profile, but do not support Ethernet, must use another approved BACnet LAN technology. These technologies are ARCNET and MS/TP. If Ethernet is not supported on any part of the internetwork, a standalone BACnet router, or a BACnet Building Controller with built-in routing capability, must be provided for routing between the Ethernet and ARCNET or MS/TP LANs.

PART 3: EXECUTION

3.01 REQUIREMENTS BY INTEROPERABILITY AREA

A. This section provides requirements pertaining to the five interoperability areas of data sharing, alarm and event management, trending, scheduling, and device and network management.

B. Data Sharing

1. Data Sharing requirements apply to the exchange of information between BACnet devices for archival storage, generating graphics and reports, the sharing of common sensor or calculated values, carrying out interlocked control strategies, and the modification of setpoints or other operational parameters.

2. All such data to be exchanged shall be represented as BACnet objects and conveyed using BACnet messages. Only standard BACnet objects and messages may be used to implement data sharing requirements unless the non-standard extensions are explicitly approved by the Owner. Any extensions to BACnet shall be fully documented in the manner used within the BACnet standard. Submission of such documentation is a prerequisite for obtaining approval of an extension.

3. Points List: The Contractor shall provide devices installed and configured with all points indicated in the BACS points list. The Contractor shall provide any additional points needed to fully implement the sequence of operations and other functionality described in this guideline.

4. Data Presentation: The following characteristics shall apply to graphic displays:

a. The graphic displays shall include schematic diagrams of the systems being displayed.

b. When a graphic display is being viewed, all values displayed shall be updated when a change of value (COV) notification is received or, if COV is not implemented, within five seconds.

c. Any data value from any networked device shall be available for plotting in real time. The operator shall be able to select binary and analog data concurrently and to plot multiple instances of each datatype on the same screen. The operator shall be able to select sampling intervals from 1 second to 60 seconds. For devices that implement COV reporting, the operator shall be able to select this as the means to update the plot. It shall be possible to save such real-time plots for subsequent recall.

5. Monitoring of Any Property: The operator shall be able to display any value of any property of any object from any networked device including all properties required by BACnet, all supported optional properties, and any proprietary extensions.

6. Global Object Definitions: The control system shall be configured with system-wide unique BACnet objects as needed to convey all globally significant information necessary to implement the control strategy.

7. Setpoint and Parameter Modifications: Operators with appropriate authority shall be able to modify all control loop setpoints and tuning parameters via BACnet messages initiated through operator interaction with graphics displays.

8. Peer-to-Peer Data Dependencies: All BACnet devices shall be installed and configured to exchange data values directly, without the need for operator intervention, to implement the sequence of operations specified in the mechanical system drawings and to share global data values. BACnet network points set up to acquire data from a peer device shall use dynamic binding. If static binding configurations are necessary, prior permission from BACSI must be obtained.

C. Alarm and Event Management

1. Alarm and Event management is the exchange of data between BACnet devices related to the occurrence of predefined conditions that meet specific criteria. Such conditions are called "events" and may be the basis for the initiation of a particular control action in response or the simple logging of the event's occurrence. The event may also be deemed to represent a condition that constitutes an "alarm" requiring human acknowledgment and intervention.

2. All alarms and events shall be implemented using standard BACnet event detection and notification mechanisms. Either intrinsic reporting or algorithmic change reporting may be used but the intrinsic reporting method is preferred. See BACnet, Clause 13.

3. Alarm Lists

a. The Contractor shall provide devices installed and configured to detect alarms and events for the points indicated in the system drawings. Software logic shall be provided to avoid nuisance alarms, e.g., no temperature or status alarms shall be generated when fan systems are not running or during start-up and shutdown transitions. It shall be possible to configure a delay between the occurrence of an alarm condition and its enunciation.

b. Alarms shall be annunciated on the network within five seconds of their occurrence. The graphics shall display an alarm message window that appears on top of any other open windows. The alarm message window shall have a distinctive color and appearance to attract the operator's attention. Operators with sufficient privilege shall be able to configure the controls to emit an audible signal (or not) when an alarm message is received.

c. Alarms that require operator acknowledgement shall cause the alarm window to remain active until such an acknowledgement is received. If multiple alarms are received, unacknowledged alarms shall be displayed on a first come first served basis grouped by priority, with the highest priority alarms displayed first.

d. Alarms shall be distributed using the BACnet notification class mechanism. Assignment of classes and destinations shall be configured according to details provided by the Owner.

e. BACnet provides a mechanism for prioritizing alarm and event notification messages using a numerical range of 0-255 with 0 being the highest priority and 255 being the lowest priority. The priorities presented in the Table 1 are consistent with the safety requirements of UL 864 (applies to fire systems) and UL 1076 (applies to security systems).

f. Alarm and event notification priorities shall be configured in the Priority Range as indicated in Table 1 and shall be conveyed using the indicated Network Priority. See BACnet, Clause 6.

Table 1 – Cornell Alarm and Event Priorities

Message Group	Priority Range	Network Priority	Brief Description
Life Safety	0 - 31	Life Safety Message	Notifications related to an immediate threat to life, safety, or health such as fire detection or armed robbery
Property Safety	32 - 63	Life Safety Message	Notifications related as an immediate threat to property such as forced entry
Supervisory	64 - 95	Critical Equipment Message	Notifications related to improper operation, monitoring failure (particularly of Life Safety or Property Safety monitoring), or monetary loss
Trouble	96 - 127	Critical Equipment Message	Notifications related to communication failure (particularly of Life Safety or Property Safety equipment)
Miscellaneous Higher Priority Alarm and Events	128 - 191	Urgent Message	Higher-level notifications related to occupant discomfort, normal operation, normal monitoring, or return to normal
Miscellaneous Lower Priority Alarm and Events	192 - 255	Normal Message	Lower-level notification related to occupant discomfort, normal operation, normal monitoring, or return to normal

4. Alarm Acknowledgment: Alarms shall be acknowledged through the EMCS alarm acknowledgement process.
5. Alarm Summarization: Alarm summarization shall be handled through the EMCS alarm summarization process.
6. Alarm Parameter Adjustment: Operators with sufficient privilege shall be able to change alarm parameters for all standard BACnet event types.
7. Alarm Routing Adjustment
    a. Operators with sufficient privilege shall be able to change alarm routing (BACnet notification classes) for each alarm including the destination for each type of alarm and alarm priority, the day of week, time of day, and the type of transition involved (TO-OFFNORMAL, TO-NORMAL, etc.).
    b. Initially, notification classes shall be configured in a manner that distinguishes between the EMCS and any local alarm.

D. Scheduling

1. Scheduling is the exchange of data between BACnet devices related to the establishment and maintenance of dates and time at which specified output actions are to be taken. All schedules shall be implemented using BACnet objects and messages.
2. Schedule Lists
    a. The Contractor shall provide devices installed and configured with start/stop, mode change, and night setback schedules as defined in the sequence of operations. As part of the installation process, the Contractor shall configure vacation, holiday, and any special event schedules as provided by the Owner.
    b. The system shall have the ability to program alterations to programmed operating schedules based on the priority of events.
    c. Based on operator privileges, the operator shall have the ability to temporarily override the programmed schedule of equipment. Operational override of a programmed schedule shall be for a specific duration following which the schedule shall revert back to the preprogrammed schedule.
3. Display of Start and Stop Times and Actions: An operator shall be able to inspect the content of any schedule and determine the specific control actions that will occur at any time, on any date. For any particular device or system parameter that is the subject of a schedule, an operator shall be able to determine the schedule of actions related to that particular device or parameter.
4. Modification of Schedules: All calendar entries and schedules shall be modifiable from the EMCS or locally by an operator with sufficient privilege.

E. Trending

1. Trending is the accumulation of (time, value) data pairs at specified rates for a specified duration. Trends are distinguished from real-time plotting of data by the fact that the data are destined for long-term storage.
2. Archival Storage of Data: Archival storage of data will be handled by the EMCS. However, the Owner may specify local trend archiving and display through the use of BACnet Trend Log objects.
3. Modification of Trend Log Parameters: An operator with sufficient privilege shall be able to change the data points to be logged, the sampling rate, and the duration of a trend log.

F. Device and Network Management: Device and network management is the exchange of data between BACnet devices concerning the operation and status of specific devices. The following functions shall be available:

1. Display of Device Status Information: Operators shall be able to display at any time the operational status of any device on the BACnet internetwork.
2. Display of BACnet Object Information: Operators shall be able to display at any time any property of any BACnet object. Operators shall be able to display property values of objects grouped by object type, object location, and building system.
3. Silencing Devices that are Transmitting Erroneous Data: Operators shall be able to direct a field device to stop transmitting event, alarm, or COV notifications until a subsequent command to resume transmissions is received.
4. Time Synchronization: Operators shall be able to set the time and date in any device on the network that supports time-of-day functionality. The operator shall be able to select to set the time and date for an individual device or all devices on a single local network.
5. Remote Device Re-initialization: Operators shall have the ability to issue re-initialization commands to any device that supports remote re-initialization.
6. Backup and Restore: Operators shall have the ability to backup and restore all BACnet devices on the network that support this capability.
7. Configuration Management of Half-Routers, Routers and BBMDs: Operators shall have the ability to display and modify the routing table entries in all supplied BACnet half-routers and routers and the broadcast distribution and foreign device registration tables in all BBMDs. Cornell BACS networks typically employ non-vendor-supplied BBMDs. Therefore, BACS devices should never be configured as a BBMD without prior authorization from BACSI.

3.02 USE OF BACNET OBJECTS

A. This section provides requirements that are specific to the representation of data and functionality using BACnet objects.

B. Naming Conventions: The following sections list the requirements for the assignment of names and identifiers for BACnet objects.

1. Device Names:

a. The EMCS uses a system for naming its control devices based on facility name, location within a facility, the system or systems that the device monitors and/or controls, or the area served.

b. Names can be up to 254 characters in length, without embedded spaces. Only the characters A-Z, 0-9, ".", and "-" may be used.

c. The goal is the shortest descriptive, but unambiguous, name. For example, if there were only one chilled water pump "P1", a valid name would be "DUFFIELD.CW.P1.CONTROL". If there are two pumps designated "P1", one in the basement mechanical room and one in the penthouse mechanical room, the names could be "CHP.BSMT.CW.P1.CONTROL" or "CHP.PENT.CW.P1.CONTROL". In the case of unitary controllers, for example a VAV box controller, a name might be "COURT.122.TV-LOUNGE". These names should be used for the value of the "Object_Name" property of the BACnet Device objects of the controllers involved so that the BACnet name and the EMCS name are the same.

2. Device Instance Numbers

a. BACnet allows 4194304 device instances per BACnet internetwork, each of which must be unique. Cornell's unique device instances are formed as follows: Device Instance = "FFFFNDD" where:

FFFF	=	Facility Code	
N	=	0-9	This allows up to 10 networks per facility or building
DD	=	00-99	This allows up to 100 devices per network

b. Facility Code assignments are unique four digit numbers assigned by the Facilities Inventory Office. Some facilities have a facility code with an alphabetic suffix to denote wings, related structures, etc. The suffix will be ignored.

c. Network numbers for facility codes above 4193 and for facilities that require more than 10 BACnet networks will be assigned in the range 0000-0999.

d. The Contractor shall contact BACSI for assignment, or confirmation, of the BACnet network and device instance numbers to be used prior to beginning device configuration. In the event of a renovation or addition,

the existing device instances are available and should be planned around as part of the project.

3. Non-Device Object Names: Objects other than Device objects shall be named in a manner analogous to Device objects. The names shall consist of a facility. [sub-facility] system. [sub-system] point designation. All BACnet object names within a particular device must be unique within that device. For those objects that will be used to generate alarms, the point name should be descriptive of the alarm. Point names are synchronized with the EMCS database at the completion of each installation or update and the object name will appear in the EMCS alarm notification.

4. Non-Device Object Instance Numbers: The instance numbers for objects other than Device objects may be assigned at the Contractor's discretion subject only to the constraint that they be unique for a given object type within a given device.

C. Commissioning / Diagnostic Mode: In order to support commissioning and troubleshooting functions, the Out_Of_Service property of all Analog, Binary, Multi-state, Loop, and Program objects shall be writable using BACnet services.

D. Using Object Descriptions

1. Each Device object and every object in BACnet Building Controllers (B-BC) shall be configured with a Description property. The descriptions used shall be submitted to the Owner for approval.

2. For all object types in all devices that support Description properties, the available string length and whether or not the Description is writable using BACnet services shall be specified in the device's PICS.

E. Issues Relating to Specific BACnet Object Types: This section provides requirements that pertain to the use of specific BACnet object types. For those object types that support Change of Value (COV) reporting, the COV_Increment must be set to a value appropriate for the parameter being measured, typically 10% of the normally-expected steady state value.

1. Analog Input, Output, and Value: All Analog_Input, Analog_Output, and Analog_Value objects shall have the capability of using the COV reporting mechanism and the COV_Increment property shall be writable using BACnet services.

2. Binary Input: The Inactive_Text and Active_Text properties of Binary Input objects shall be configured with text string values as indicated on the points list. Binary Input objects shall support COV reporting.

3. Binary Output: The Inactive_Text and Active_Text properties of Binary Output objects shall be configured with text string values as indicated on the points list. All Binary Output objects associated with motor on/off status shall

track changes of state and runtime. Binary Output objects shall support COV reporting.

4. Binary Value: The Inactive_Text and Active_Text properties of Binary Value objects shall be configured with text string values as indicated on the points list. Binary Value objects shall support COV reporting.

5. Calendar: Devices providing scheduling capability shall also provide at least one Calendar object with a capacity of at least ten entries. Operators shall be able to view the calendar object and make modifications. If the Calendar's Date_List property is writable using BACnet services, all calendar entry datatypes shall be supported.

6. Loop: All control loops using any combination of proportional, integral, and/or derivative control shall be represented by BACnet Loop objects. Operators with sufficient authority shall be able to adjust at least the Update_Interval, Setpoint, Proportional_Constant, Integral_Constant, and Derivative_Constant using BACnet services. Loop objects shall support COV reporting.

7. Multi-state Input, Output, and Value: The text to be used for the Multi-state object types shall be determined from the points list. Feedback_Value shall be determined by sensing the actual condition or mode of the device. All Multi-state objects shall support COV reporting.

8. Schedule: All building systems with date and time scheduling requirements shall have schedules represented by BACnet Schedule objects. All operators shall be able to view the entries for a schedule. Operators with sufficient privilege shall be able to modify schedule entries. Required schedules are shown on the drawings as part of the occupied and unoccupied modes.

F. Dynamic Object Creation: BACnet Building Controllers shall be configured to allow the dynamic creation of Trend Log, Calendar, and Schedule objects by means of the BACnet CreateObject service.

3.03 USE OF BACNET SERVICES

A. This section provides requirements that are specific to the use of BACnet communication services.

B. Interoperable Commands: All dampers, valves, fans, or other mechanical equipment that may need to be controlled by more than one application shall be represented as commandable BACnet objects. The application programs interacting with this equipment shall be configured to use the command priorities listed in Table 2. If implementing the sequence of operations or other required functionality requires using a command priority not listed in Table 2, the priority assignment must be approved by the Owner.

Table 2 – Cornell Command Priorities

Priority Level	Application	Priority Level	Application
1	Manual-Life Safety	9	Available
2	Automatic-Life Safety	10	Available
3	Available	11	Load Shedding
4	Available	12	Available
5	Critical Equipment Control	13	Available
6	Minimum On/Off	14	Available
7	Available	15	Available
8	Manual Operator	16	Available

C. Alarming: This section provides requirements that are specific to the use of BACnet for alarm processing.

1. **Notification Classes:**

a. The EMCS shall be designated as a recipient for all alarm notifications.

b. The Priority, Ack_Required, and Recipient_List properties of Notification Class objects shall be writable over the network using BACnet services.

2. Event Notification Message Texts: Alarm and event processing shall be configured to convey descriptive text messages along with the notification.

D. Operator Authority Levels: There shall be at least three levels of authority:

1. Administrator - All privileges
2. Controls Technician - All programming and configuration
3. Building Coordinator - Read only
4. Commissioning Agent – Read only
5. A/E, Consultant, Facilities - Read only

E. Change of Value Processing

1. Property values shall be displayed based on the receipt of confirmed and unconfirmed Change of Value notifications. Operators shall have the ability to subscribe to COV notifications for all objects that support COV subscriptions.

2. After initialization, all graphic display screens shall update the displayed values using COV notifications if COV notification capabilities are available from the data source.

3. The COV increment shall be adjustable by an operator using BACnet services.

3.04 LOCAL AREA NETWORKS

A. This section provides requirements that are specific to the integration of multiple BACnet networks, possibly on different LAN types, into a single BACnet internetwork.

B. Network Numbering

1. Cornell BACnet network numbers are based on a "facility code, network" concept. The "facility code" is the Cornell-assigned numeric value assigned to a specific facility or building. See 3.02.B.2 above. The "network" typically corresponds to a "floor" or other logical configuration within the building. BACnet allows 65535 network numbers per BACnet internetwork.

2. Cornell's network numbers are thus formed as follows: Network Number = "FFFFN" where

   FFFF = Facility Code
   N = 0-9 This allows up to 10 networks per facility or building

3. N = 0 (zero) will generally be assigned to a facility's BACnet Ethernet LAN. Normally, this network is connected to the campus backbone. The additional N-numbers will be assigned to any ARCNET or MS/TP networks as required.

4. The Contractor shall contact BACSI for assignment, or confirmation, of the Network Number(s) to be used prior to beginning device configuration.

C. IP Address Assignments

1. Cornell maintains specially configured VLANs for the purpose of securely transporting BACS communication traffic. Address assignments are coordinated by BACSI.

2. The Contractor shall contact BACSI for assignment of IP addresses (and possibly non-standard UDP ports) prior to beginning device configuration.

3.05 BACNET ROUTERS

A. This section provides requirements that are specific to the use of BACnet routers.

B. Error Message Destination: The Contractor shall configure each BACnet router to transmit network layer (routing) error messages to the EMCS.

3.06 PROCEDURES

A. This section provides procedures that must be followed to ensure that BACS projects run smoothly, from start to finish. Any project that involves the campus network, either because of the demolition or removal of existing control equipment, or the addition of new control equipment, runs the risk of causing serious disruptions to the

Owner's ability to monitor critical campus systems. Therefore, the main procedural requirement is to inform EMCS Operations (607-255-5777) before any potential connection to, or interruption of, the data communication network. Additional current information can be found at *pminfo.emcs.cornell.edu*.

B. Procedures for the Installation, Modification, Retrofit, and Removal of BACS Hardware and Software

1. Unless otherwise stated, these procedures apply to the party performing the work, the Contractor, whether the Contractor is an internal Cornell group or an external controls company. The purpose of these procedures is to ensure the coordination of activities between the Contractor, EMCS Operations, and the BACSI group, each of which has specific roles to play in any successful controls project.

2. EMCS/BACSI want to work with PMs to ensure that Contractors respect the BACS network infrastructure of the University. If controls work is executed in a thoughtful and conscientious way, time-consuming and costly network disruptions can be avoided and integration of the new systems with the EMCS can be implemented smoothly and efficiently.

3. Prior to commencing work, the PM shall contact the EMCS Operations Supervisor or the EMCS General Foreperson to initiate the project coordination. These contacts will take care of informing BACSI of the project and ensure BACSI's participation.

   a. PMs shall ensure that the Controls Contractor notifies EMCS of the scope of work, date work is to start, tentative schedule of remaining work, and the contact information for the responsible application engineer, technicians and contractor personnel.

   b. On larger Controls Projects (300 or more devices) the PMs shall ensure that the Controls Contractor has conferred with EMCS/BACSI regarding measures to be employed during construction to protect the BACS network infrastructure of the University before and during the project, e.g., firewalls, sequestered construction servers, Virtual Private Network connections, etc. Transfer of programs, point names, and other configuration from the construction server to the production server should be done by the vendor as part of commissioning.

   c. The Controls Contractor shall review with, and provide documentation to, EMCS/BACSI regarding the network topology and device instance numbering scheme for the new controls being installed. Upon job completion, accurate as-built drawings are required that clearly show the network topologies including all switches, repeaters, and devices, both for IP and child MS/TP and ARCNET networks.

   d. On Controls Projects involving active in-service Campus BACS networks, the PMs shall ensure that:

i. The Demolition Contractor confers with the Controls Contractor or Zone Facility Manager prior to any demolition activities. Demolition activities should be planned to proceed in an orderly way to minimize impact and disruption to Campus BACS networks;

ii. The EMCS General Foreperson, with the assistance of the PM and Commissioning Agent (if present on the job), has seen to it that the appropriate procedures have been followed and that the BACS infrastructure is sound during and after the controls installation.

e. On Controls Projects involving retrofit/replacement of existing BACS devices in a facility:

i. Upon request, EMCS will provide an MS-Excel spreadsheet that indicates which existing points appear in EMCS graphics, trends and reports; which points have previously come into alarm; and the remaining points in the controller;

ii. The Contractor shall then provide to EMCS a mapping of all controller points that have been renamed or removed showing the old and new designation or status;

iii. The PM shall ensure that the Controls Contractor informs EMCS of all changes to communication, including any addresses that have been retired, replaced, etc., so that the Owner's network database can be kept current;

iv. The Zone Facility Manager, with the assistance of the PM and Commissioning Agent (if present on the job), needs to ensure that the appropriate procedures have been followed, BACS networks and devices have been properly secured and demolished, and that the BACS infrastructure is sound during and after the controls installation. In particular, BACS equipment removed from existing "legacy" control systems will require follow-up EMCS software and hardware cleanup.

f. As new BACS devices are added to Campus networks, the PM shall ensure that the Controls Contractor is completing and submitting the appropriate checklists for EMCS/BACSI and EMCS General Foreperson review. Visit http://*pminfo.emcs.cornell.edu* for downloadable copies of the checklists. Devices added to in-service non-sequestered building automation networks must be configured and submitted to EMCS for definition and synchronization within one business week of activation.

g. When the Controls Installation is complete and the project desires alarm reporting to EMCS, the PM shall inform EMCS.

i. EMCS/BACSI shall review with Contractor previous submitted documentation, status of job, and network safety measures in place.

ii. EMCS/BACSI will work with the PM and the Contractor to complete final integration of new controls into the Campus BACS infrastructure, including defining and synchronizing field panels with the EMCS database for alarm reporting.

iii. PMs shall set up a walkthrough and training for Shift Mechanics commensurate with the requirements for after-hours facility emergency response.

iv. The PM shall provide EMCS Operations procedures and contact lists to be used during the warranty period. Procedures should include desired daytime and off-hours response procedures. If Shift Mechanic response is desired after-hours, please provide a billable work order number.

4. Since EMCS/BACSI is primarily focused on the integration of a facility's BACS systems with the EMCS, the proper reporting of alarms, and the various campus BACS networks in the aggregate, PMs should strongly consider employing Zone Control Technicians to review new controls installations with respect to both functional equipment and alarm programming of the field controllers. Even if there is a commissioning effort on the project, the project will almost always benefit from the BACS platform-specific knowledge available in EMCS and the Zones. Review of the project by the these Cornell personnel independent of, or as part of a larger Commissioning effort, frequently exposes underlying dysfunction that would have otherwise been initially missed and can, potentially, be the source of future difficulties.

C. Procedures for the Checkout of BACnet/IP Installations

1. Prior to connection to the Campus backbone network, it must be demonstrated to the EMCS General Foreperson that these criteria have been met:

a. The IP address, subnet mask and IP gateway address of the device to be connected must be shown to be correct for the network connection about to be made. See 3.04.B.

b. The device's Device Name must be shown to conform to Cornell standards.

c. The names of BACnet objects within a device must be shown to conform to Cornell's naming conventions.

d. The device's Device Instance Number (DIN) must be shown to conform to Cornell's naming conventions.

e. In the case of devices that route to subordinate BACnet MS/TP or ARCNET networks, the network numbering must be shown to conform to Cornell numbering standards.

f. The BACnet alarm Recipient List must contain the DIN (or BACnet Address, i.e., [BACnet Network Number, MAC Address]) of both the appropriate vendor server (ALC or Alerton) and the EMCS alarm server.

g. For each device containing network variables, a list of network variables must be provided showing that each network variable references a valid network-accessible point.

h. For each device containing points that are to issue UnconfirmedCOVNotifications, a list of the points and their respective Change of Value (COV) increments must be provided to prove that the device will not generate COV storms.

i. BACnet Broadcast Management Device (BBMD) capability must be shown to be disabled unless explicitly authorized by Cornell, i.e., the device's Broadcast Distribution Table (BDT) must be shown to be empty or non-existent.