

Division 25 00 00 Integrated Automation

March 2021

SECTION 25 00 00 – INTEGRATED AUTOMATION

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Integrate all low-voltage control systems specified under Division 25 utilizing the **new project name** Building Management System (BMS).

**** NOTE TO SPECIFIER **** Delete any system below not relevant to this project; add others as required.

- B. Integrated Automation (IA) system contractor shall connect the building stakeholders with BMS and provide useful command and control capability. The IA system contractor is responsible for the integration of building control services such as, but not limited to, **HVAC, Lighting Control, Electrical Metering, Security, CCTV, Data Center, and other controller assets as shown in the system architecture**. The IA system contractor shall provide a unified database and graphical user interface tools by collaboration with the owner's building control needs.
- C. IA system contractor coordinates the responsibilities of mechanical and electrical trade contractors pertaining to control products of the system, furnished by each trade, that will be integrated by this division. See Integration Matrix Below.

Div 23, 26, and 25 Responsibility Matrix					
Systems	Spec Section Furnished by	Protocol	Master Systems Integrator (MSI)	Electrical Contractor Div 26	Mechanical Contractor Div 23
HVAC DDC Controls	Div 25	BACnet MS/TP or BACnet IP	Integrate HVAC DDC Controls into IoT Server Integrate to the OT Network		
Lighting Controls	Div 25	BACnet MS/TP or BACnet IP	Integrate Lighting Controls Data into IoT Server Integrate to the OT Network		
OT Network	Div 25	IP	MSI contractor to provide OT network for all other disciplines to be integrated into the IoT Server		
Electrical Metering	Div 26	BACnet MS/TP or BACnet IP	Integrate Electrical Distribution Data into IoT Server Integrate to the OT Network	Furnish, Install, Program and Connect Bus to IoT Server.	
Security	Div 26	BACnet MS/TP or BACnet IP	Integrate Security Data into IoT Server Integrate to the OT Network	Furnish, Install, Program and Connect Bus to IoT Server. Expose BACnet Point to IA system contractor and provide documentation to IA system contractor	
CCTV	Div 26	BACnet MS/TP or BACnet IP	Integrate CCTV Data into IoT Server Integrate to the OT Network	Furnish, Install, Program and Connect Bus to IoT Server. Expose BACnet Point to IA system contractor and provide documentation to IA system contractor	

- D. It is the owner's goal to implement an open system that will allow products from various suppliers to be integrated into a unified system to provide flexibility for expansion, maintenance, and service of the system. The owner shall be the named license holder of all software associated with any and all incremental work on the project(s).
- E. Provide all necessary IA networking hardware and software to meet the system's functional specifications.
- F. Prepare individual hardware layouts, interconnection drawings, and software configuration

from project design data.

- G. Implement the detailed design for all analog and binary objects, system databases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.
- H. Design, provide, and install all associated hardware including equipment cabinets, panels and data communication network cables needed.
- I. Provide and install all interconnecting routers and cables between supplied cabinets, integration routers/hubs/controllers, and input/output devices.
- J. Route all new IA network information from this project to the preferred BACnet manufacturer's devices.
- K. Provide supervisory specialists and technicians throughout the duration of the project to assist in all phases of network system installation, startup, and commissioning.
- L. Provide as-built documentation, diagrams, and all other associated project operational documentation (such as technical manuals) on approved media, the sum of which accurately represents the final system.

1.2 SYSTEM DESCRIPTION

- A. All alarms are defined within the [BACnet manufacturer of choice] Server and annunciated to selected workstations and operator terminals based upon origin and priority. Critical Alarms are announced via email and SMTP to selected mobile and stationary devices.
- B. All new IA network data from this project is to be seamlessly processed, managed, and broadcasted using a Building Management System from a provider of your choice as described above in this section.
- C. The intent of this specification is to provide a system that is consistent with the Building Management System (BMS) throughout the owner's facilities running a Building Management System from a provider of your choice.
- D. IA contractor shall furnish all labor, material, and equipment necessary for a complete and operating integration platform, utilizing Direct Digital Controls (DDC) as shown on mechanical drawings and as described herein. Drawings are diagrammatic only. All controllers furnished in this section shall communicate on a peer-to-peer bus over open protocol bus (BTL Certified BACnet MS/TP, BACnet IP, LonTalk, or Modbus). The IA contractor shall submit a data plan that includes database standards, graphics, dashboard, data tagging, and program guidelines for the engineer's review.
- E. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum BTL Certified BACnet MS/TP, BACnet IP, LonTalk, and Modbus.
- F. A laptop computer including engineering/programming software to modify operating system server BMS programs and graphics shall be included.
- G. Owner shall receive all administrator level login and passwords for the engineering toolset at

the first training session. The owner shall have full licensing and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the BMS.

- H. All products of the Integration Platform shall be provided with the following agency approvals. Verification that the approvals exist for all submitted products shall be provided on request, with the submittal package. Systems or products not currently offering the following approvals are not acceptable.
1. Federal Communications Commission (FCC), Rules and Regulations, Volume II -July 1986 Part 15 Class A Radio Frequency Devices.
 2. FCC, Part 15, Subpart B, Class B
 3. FCC, Part 15, Subpart C
 4. FCC, Part 15, Subpart J, Class A Computing Devices.
 5. UL 504 - Industrial Control Equipment.
 6. UL 506 - Specialty Transformers.
 7. UL 910 - Test Method for Fire and Smoke Characteristics of Electrical and Optical-Fiber Cables Used in Air-Handling Spaces.
 8. UL 916 - Energy Management Systems All.
 9. UL 1449 - Transient Voltage Suppression.
 10. Standard Test for Flame Propagation Height of Electrical and Optical - Fiber Cables Installed Vertically in Shafts.
 11. EIA/ANSI 232-E - Interface Between Data Technical Equipment and Data Circuit Terminal Equipment Employing Serial Binary Data Interchange.
 12. EIA 455 - Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices.
 13. IEEE C62.41- Surge Voltages in Low-Voltage AC Power Circuits.
 14. IEEE 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
 15. NEMA 250 - Enclosures for Electrical Equipment.
 16. NEMA ICS 1 - Industrial Controls and Systems.
 17. NEMA ST 1 - Specialty Transformers.
 18. Performance of control system shall meet or surpass the requirements of ASHRAE/IESNA 90.1-2019
- I. Approved Control Manufacturers:
1. The base bid shall be from **manufacturer/bid specifier**. Other manufacturers may bid based upon meeting all requirements of the specification and receiving approval from the Architect 30 days prior to bid. A paragraph-by-paragraph comparison of base bid specified system versus alternative system along with three references of similar projects (including the project name, contact, phone number, location, consultant, value of contract, and a brief description of the control system and how it operates) shall be submitted 45 days prior to the bid for review process. If approved, other manufacturers' bids shall be shown as an add or deduct on the bid form.
 2. **Optional additional manufacturers – insert as needed**
 3. No Equals.

**** NOTE TO SPECIFIER ** Delete any subparagraphs below not relevant to this project; add others as required.**

1.3 QUALITY ASSURANCE

- A. The IA system shall be designed, installed, commissioned, and serviced by manufacturer-authorized and trained personnel. The system provider shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory, and necessary test and diagnostic equipment.
- B. The authorized representative shall provide an on-site, experienced project manager for this work who is responsible for direct supervision of the installation, startup, and commissioning of the IA system.
- C. The Bidder shall be regularly engaged in the manufacturing, installation, and maintenance of IA systems and shall have demonstrated technical expertise and experience in the manufacture, installation, and maintenance of IA systems similar in size and complexity to this project.
- D. Contractor shall have a proven record of successful native BACnet installations and maintenance of equivalent native BACnet systems for a minimum period of 5 years utilizing the same native BACnet manufacturer's products that the Contractor proposes to use on this project.
- E. To provide the level of support and response required by the Owner, the IA system contractor shall have a fully staffed service, including 24/7 Service Call Center staffed by live operators enabling immediate response to Owner's critical emergency IA systems concerns.

1.4 SUBMITTALS

- A. Eight copies of shop drawings of the entire Integrated Platform shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions. Shop drawings shall also contain complete wiring and schematic diagrams, software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.
- B. Submittal shall also include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media and protocol. The IA contractor shall be responsible for coordinating and integrating third-party system diagrams into the overall trunk cable schematic diagrams for the entire Operational Technology Network (OTN).
- C. Submittal shall also include a copy of each of the graphics developed for the Graphic User Interface including a flowchart (site map) indicating how the graphics are to be linked to one another for system navigation. The graphics are intended to be 80–90% complete at this stage with the only remaining changes to be based on review comments from the A/E design team.
- D. Upon completion of the work, provide a complete set of "as-built" drawings and application software. Drawings shall be provided as AutoCAD™ or Visio™ compatible files. Eight copies of the 'as-built' drawings shall be provided in addition to the documents. Division 23 and 26 contractors shall provide 'as-builts' for their portions of work. The Division 25 contractor shall be responsible for 'as-builts' pertaining to overall BMS architecture, network diagrams, and control schematics. All 'as-built' drawings shall also be installed into the integrated platform

server in a dedicated directory.

1.5 PRE-INSTALLATION MEETINGS

- A. Convene a minimum two weeks prior to starting work of this section.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Maintain integrity of shipping cartons for each piece of equipment and control device through shipping, storage and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

1.7 JOB CONDITIONS

- A. Cooperation with other trades: Coordinate the work of this section with that of other sections to ensure that the work will be carried out in an orderly fashion. It shall be this contractor's responsibility to check the contract documents for possible conflicts between his work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers and structural and architectural features.

1.8 RELATED WORK IN OTHER SECTIONS

- A. Section 23 05 00 – Common Work Results for HVAC
- B. Section 25 50 00 – IA Instrumentation and Control of HVAC
- C. Section 25 60 00 – IA Instrumentation and Control of Lighting Systems
- D. Section 26 05 00 – Common Work Results for Electrical

1.9 WARRANTY

- A. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one year from completion of system acceptance.
- B. Personnel: Provide qualified personnel to accomplish all work promptly and satisfactorily. Owner shall be advised in writing of the name of the designated service representative, and of any changes in personnel.
- C. Owner will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the complete system. Furnish owner with a telephone number where service representatives can always be reached. Service personnel shall be at the site the next business day (within 24 hours) after receiving a request for service.
- D. This warranty shall apply equally to both hardware and software.

PART 2 - PRODUCTS

2.1 GENERAL

- A. The IA platform shall be comprised of a network of interoperable, stand-alone digital controllers, global controller, graphics and programming, and other control devices for a complete system as specified herein.
- B. The installed system shall provide secure strong password access to all features, functions, and data contained in the overall BMS.

2.2 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURE

- A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system utilizing open protocols in one open, interoperable system.
- B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. Physical connection of any BACnet control equipment such as chillers, boilers, VRF's, RTU's, or any other third-party system shall be via BACnet MS/TP, BACnet IP, LonTalk, or Modbus.
- C. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.
- D. The supplied system shall incorporate the ability to access all data using HTML5-enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on the operating system server located in **location** on the OTN. Systems requiring proprietary database and user interface programs shall not be acceptable.
- E. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data. Systems employing a "flat" single-tiered architecture shall not be acceptable.
 - 1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
 - 2. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote connected user interfaces.

2.3 IOT SERVER HARDWARE

- A. General structure of workstation interaction shall be a standard client/server relationship. Server shall be used to archive data and store system databases for the BACnet network as specified in these contract document Specifications and project Plan Drawings. Thick and Web Clients shall access servers for all archived data. Server shall support a minimum of 20 simultaneous clients.

B. BACnet Conformance

1. Operator workstation shall be approved by the BTL as meeting the BACnet Advanced Workstation (AWS) requirements.
2. Please refer to Section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented, and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types accessed by the workstation shall include as a minimum: Analog Value, Analog Input, Analog Output, Binary Value, Binary Input, Binary Output, Calendar, Device, Event Enrollment, File, Notification Class, Program, and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented, and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
4. The AWS shall comply with Annex J of the BACnet specification for IP connections. Must support remote connection to the server using a thick client application. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN. Must support interoperability on wide area networks (WANs) and campus area networks (CANs). Workstation shall support Foreign Device Registration to allow temporary workstation connection to IP network.

C. Data Displays

1. Data displays shall render all data associated with the project as called out on drawings and/or object type list supplied. Graphic files shall be created using digital, full-color photographs of system installation, AutoCAD or Visio drawing files of field installation drawings and wiring diagrams from as-built drawings.
2. Data displays shall render all data using iconic graphic representations of all mechanical equipment. System shall be capable of displaying graphic file, text, and dynamic object data together on each display and shall include animation. Information shall be labeled with descriptors and shall be shown with the appropriate engineering units. All information on any display shall be dynamically updated without any action by the user.
3. Data display frame shall allow users to change all field-resident AWS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc. from any screen, no matter if that screen shows all text or a complete graphic display. This shall be done without any reference to object addresses or other numeric/mnemonic indications.
4. Analog objects shall be displayed with operator modifiable units. Analog input objects may also be displayed as individual graphic items on the display screen as an overlay to the system graphic.

5. All displays and programming shall be generated and customized by the local EMS Contractor. Systems requiring factory development of graphics or programming of DDC logic are specifically prohibited.
6. AWS shall be supplied with a library of standard graphics, which may be used unaltered or modified by the operator. AWS shall include a library of equipment graphic components to assemble custom graphics. Systems that do not allow customization or creation of new graphic objects by the operator (or with third-party software) shall not be allowed.
7. Data display frame shall include customizable and persistent tree navigation for building, equipment, and system diagnostic centric display organization.
8. Each display may be protected from viewing unless operator credentials have the appropriate access level. An access level may be assigned to each display and system object. The menu label shall not appear on the graphic if the operator does not have the appropriate security level.
9. Data displays shall have the ability to link to content outside of the BAS system. Such content shall include but is not limited to: Launching external files in their native applications (for example, a Microsoft Word document) and launching a Web browser resolving to a specified Web address.
10. Data displays shall support:
 - a. Graphic items with custom geometry that offer both color gradient shading and variable opacity in scale to system variables and range set points.
 - b. Clear and custom geometry navigation buttons to provide intuitive navigation.
 - c. Graphic files in .jpg, .png, and .gif file types.
 - d. Viewing of 1,024 system data points in a single screen.
11. All graphical user interface screens developed for Thick or Web Client devices on this project shall be seamlessly integrated to the existing Building Management System Server PC by the EMS Contractor. Graphical user interface screens for this project requiring software enabling/support beyond the Building Management System are specifically prohibited.

D. Password Protection

1. Provide a security system that prevents unauthorized use unless the operator is logged on. Access shall be limited to the operator's assigned functions when the user is logged on. This includes displays as outlined above.
2. AWS shall provide security for a minimum of 200 users. Each user shall have an individual User ID, Username, and Password. Entries are alphanumeric characters only and are case-sensitive (except for User ID). User ID shall be 0–8 characters, Username shall be 0–29 characters, and Password shall be 4–8 characters long.
3. Each user shall be allowed individual assignment of only those control functions, menu items, and user-specific system start display, as well restricted access to *discrete BACnet*

devices to which that user requires access.

4. All passwords, usernames, and access assignments shall be adjustable online at the operator's terminal.
5. Users shall also have a set access level, which defines access to displays and individual objects the user may control. System shall include 10 separate and distinct access levels for assignment to users.
6. System shall include an Auto Logout Feature that shall automatically logout users when there has been no keyboard or mouse activity for a set period of time. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by the system administrator. Operator terminal shall display a message on screen that the user is logged out after Auto Logout occurs.
7. The system shall permit the assignment of an effective date range, as well as an effective time of day, that the User IDs are permitted to authenticate.

E. Operator Activity Log

1. Operator Activity Log that tracks all operator changes and activities shall be included with AWS. System shall track what is changed in the system, who performed this change, date and time of system activity, and value of the change before and after operator activity. Operators shall be able to display all activity, sort the changes by user and by operation. Operator shall be able to print the Operator Activity log display.
2. Log shall be gathered and archived to hard drive on AWS as needed. Operators shall be able to export data for display and sorting in a spreadsheet.

F. Scheduling

1. AWS and Web Client shall show all information in easy-to-read daily format including calendar of this month and next. All schedules shall show actual ON/OFF times for the day based on scheduling priority. Priority for scheduling shall be events, holidays, and daily, with events being the highest.
2. Holiday and special event schedules shall display data in calendar format. Operators shall be able to schedule holidays and special events directly from these calendars.
3. Operator shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate access privileges.
4. AWS shall include a Schedule Wizard for setup of schedules. The Wizard shall walk users through all steps necessary for schedule generation. The Wizard shall have its own pull-down selection for startup or may be started by right-clicking on the value displayed on graphic and then selecting Schedule.
5. Scheduling shall include optimum start based on outside air temperature, current heating/cooling setpoints, indoor temperature and history of previous starts. Each and

every individual zone shall have optimum start time independently calculated based on all parameters listed. User shall input schedules to set time that occupied setpoint is to be attained. Optimum start feature shall calculate the startup time needed to match zone temperature to setpoint. Users shall be able to set a limit for the maximum startup time allowed.

6. Schedule list shall show all schedules currently defined. This list shall include all standard, holiday and event schedules. In addition, users shall be able to select a list that shows all scheduled points and zones.
7. Display of all three schedules must show all ON times for standard, holiday, and event schedules in different colors on a given day. In addition, OFF times for each must also be shown in additional colors. Users shall be able to select from a standard calendar what days are to be scheduled and the same display shall show all points and zones affected. Users shall be able to set time for one day and select all days of the week that shall be affected as a recurrence of that same schedule for that given day.
8. Any displayed data that is changeable by the operator may be selected using the right mouse button and the schedule shall then be selectable on the screen. Selection of the schedule using this method shall allow the viewing of the assigned schedule and allow the point to be scheduled.
9. Schedule editor shall support drag and drop events and holidays onto the schedule calendar.
10. Schedule editor shall support drag and drop events default to a 2hr period, which can then be adjusted by the user.
11. Schedule editors shall support drag and drop holidays that are defaulted for OFF all day and can be edited for multiple-day holidays.
12. Schedule editor shall support the View of affected zones when adding or editing timed events of a schedule.

G. Alarm Indication and Handling

1. AWS shall provide visual, printed, and email means of alarm indication. Printout of alarms shall be sent to the assigned terminal and port. Alarm notifications can be filtered based on the User ID's authorization level.
2. Web clients shall display a persistent alarm state for the system regardless of the data view including points in alarm but not acknowledged, and points that have gone into alarm and returned to normal without being acknowledged.
3. Alarm History shall provide a log of alarm messages. Alarm log shall be archived to the hard disk of the AWS. Each entry shall include a description of the event-initiating object generating the alarm. Description shall be an alarm message of at least 256 characters in length. Entry shall include time and date of alarm occurrence, time and date of object state return to normal, time and date of alarm acknowledgment, and identification of

operator acknowledging alarm.

4. Alarm messages shall be in user-definable text (English or other specified language) and shall be delivered either to the operator's terminal, client, or through remote communication using email (Authenticated SMTP supported).
5. AWS shall include an Alarm Wizard for setup of alarms. The Wizard shall walk the user through all steps necessary for alarm generation. The Wizard shall have its own pull-down selection for startup or may be started by right-clicking on the value displayed on graphic and then selecting alarm setup.
6. AWS shall support color-coded indication of current alarms as follows:
 - a. Red indicator shows the number of active alarms that have not been acknowledged.
 - b. Yellow indicator shows the number of alarms that are still active but have been acknowledged.
 - c. Blue indicator shows the number of alarms that have returned to normal but have not been acknowledged.
 - d. Color-coded indicators, when selected by the user, navigate to a pre-filtered view of Alarm History.
 - e. Alarm history can be filtered by color-coded indicator states.
7. Alarm annunciation includes a navigation link to a user selected display or URL.
8. Users can silence audible annunciation for the current session.
9. Users can disable auto-refresh of alarm annunciation for current session.
10. Any displayed data that is changeable by the operator may be selected using the right mouse button and the alarm shall then be selectable on the screen. Selection of the alarm using this method shall allow the viewing of the alarm history or allow the creation of a new alarm.

H. Trend log Information

1. AWS shall periodically gather historically recorded data stored in the building controllers and store the information in the system database. Stored records shall be appended with new sample data, allowing records to be accumulated. Systems that write over stored records shall not be allowed unless limited file size is specified. System database shall be capable of storing up to 50 million records before needing to archive data. Samples may be viewed at the web client. Operators shall be able to view all trended records, both stored and archived. All trend log records shall be displayed in standard engineering units.
2. AWS shall be capable of trending on an interval determined by a polling rate or change-of-value.
3. AWS shall be able to change trend log setup information. This includes the information to be logged as well as the interval at which it is to be logged. All operations shall be password protected. Viewing may be accessed directly from any and all graphics on which

a trended object is displayed.

4. AWS shall include a trend log Wizard for setup of logs. The Wizard shall walk the user through all necessary steps. The Wizard shall have its own pull-down selection for startup or may be started by right-clicking on the value displayed on graphic, and then selecting trend logs from the displayed menu.
5. AWS shall be capable of using Microsoft SQL as the system database.
6. Any displayed data that is changeable by the operator may be selected using the right mouse button and the trend log shall then be selectable on the screen. Selection of the trend log using this method shall allow the viewing of the trend log view.
7. Trend log viewer shall provide:
 - a. Software that is capable of graphing the trend logged object data shall be included.
 - b. Access and ability to create, edit, and view are restricted to users by user account credentials.
 - c. Specific and repeatable URL defines the trend log(s) that comprise the view.
 - d. Call out of trend log value at intersection of trend line and mouse-over vertical axis.
 - e. Trend log and companion logs can be configured to display on one of two independent vertical scales.
 - f. Click zoom for control of data set viewed along either graph axis.
 - g. User specifiable start and end dates as well as a fast scroll feature that supports click zoom of macro scale view of the data for quickly finding data sets based on visual signature.
 - h. User export of the viewed data set to MS Excel.
 - i. Web browser-based help.
 - j. Optional min/max ranges (Upper Control Limits, Lower Control Limits) for each value.

I. Energy Log Information – As Scheduled

1. AWS shall be capable of periodically gathering energy log data stored in the field equipment and archiving the information. Archive files shall be appended with new data, allowing data to be accumulated. Systems that write over archived data shall not be allowed unless limited file size is specified. Display all energy log information in standard engineering units.
2. All data shall be stored in database file format for direct use by third-party programs. Operation of the system shall stay completely online during all graphing operations.
3. AWS Operator shall be able to change the energy log setup information as well. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. All meters monitored by the system may be logged. System shall support using flow and temperature sensors for BTU monitoring.
4. AWS shall display archived data in tabular format form for both consumption and peak

values. Data shall be shown in hourly, daily, weekly, monthly, and yearly formats. In each format, the user shall be able to select a specific period of data to view.

J. Demand Limiting – As Scheduled

1. AWS shall include a demand limiting program that includes two types of load shedding. One type of load shedding shall shed/restore equipment in binary fashion based on energy usage when compared to shed and restore settings. The other type of shedding shall adjust operator selected control setpoints in an analog fashion based on energy usage when compared to shed and restore settings. Shedding may be implemented independently on each and every zone or piece of equipment connected to the system.
2. Binary shedding shall include a minimum of five (5) priority levels of equipment shedding. All loads in a given priority level shall be shed before any loads in a higher priority level are shed. Load shedding within a given priority level shall include two methods. In one, the loads shall be shed/restored in a “first off-first on” mode, and in the other the loads are just shed/restored in a “first off-last on” (linear) fashion.
3. Analog shed program shall generate a ramp that is independently used by each individual zone or individual control algorithm to raise the appropriate cooling setting and lower appropriate heating setting to reduce energy usage.
4. AWS shall be able to display the status of each and every load shed program. Status of each load assigned to an individual shed program shall be displayed along with English description of each load.

K. Tenant Activity – As Scheduled

1. AWS shall include a program that monitors after-hours overrides by tenants, logs that data, and generates a bill based on usage and rate charged for each tenant space. Tenant Activity programs shall be able to assign multiple zones, from a list of every zone connected to the system, to a particular tenant. Every zone is monitored for after-hour override usage and that data logged in AWS. Operators may then generate a bill based on the usage for each tenant and the rate charged for any overtime use.
2. Configuration shall include entry of the following information for use in logging and billing:
 - a. Tenant’s contact name and address
 - b. One or multiple tenant zones that make up a total tenant space, including a separate billing rate for each separate zone
 - c. Minimum and maximum values an event duration and event limit
 - d. Property management information
 - e. Overall billing rate
 - f. Seasonal adjustments or surcharge to billing rate
 - g. Billing notification type including but not limited to printer, file, and email
 - h. Billing form template
3. Logging shall include recording the following information for each and every tenant event:

- a. Zone description
 - b. Time the event begins
 - c. Total override time
 - d. Limits shall be applied to override time
4. A tenant bill shall be generated for a specific period using all the entered configuration data and the logged data. Users with appropriate security level shall be able to view and override billing information. Users shall be able to select a billing period to view and be able to delete events from billing and edit a selected tenant activity event's override time.

L. Reports

1. AWS shall be capable of periodically producing reports of trend logs, alarm history, tenant activities, device summary, energy logs, and override points. The frequency, content, and delivery are to be user adjustable.
2. All reports shall be capable of being delivered in multiple formats including text- and comma-separated value (CSV) files. The files can be printed, emailed, or saved to a folder, either on the server hard drive or on any network drive location.

M. Configuration/Setup

1. Provide means for operators to display and change system configuration. This shall include, but not be limited to, system time, day of the week, date of daylight savings set forward/set back, printer termination, port addresses, modem port and speed, etc. Items shall be modified using understandable terminology with simple mouse/cursor key movements.

N. Field Engineering Tools

1. AWS shall include field engineering tools for programming all controllers supplied. All controllers shall be programmed using graphical tools that allow the user to connect function blocks on screen that provide sequencing of all control logic. Function blocks shall be represented by graphical displays that are easily identified and distinct from other types of blocks. Graphical programming that uses simple rectangles and squares is not acceptable.
2. Users shall be able to select a graphical function block from the menu and place it on the screen. Provide zoom in and zoom out capabilities. Function blocks shall be downloaded to the controller without any re-entry of data.
3. Programming tools shall include a real-time operation mode. Function blocks shall display real-time data and be animated to show status of data inputs and outputs when in real-time operation. Animation shall show change of status on logic devices and countdown of timer devices in graphical format.
4. Field engineering tools shall also include a database manager of applications that include logic files for controllers and associated graphics. Operators shall be able to select unit type, input/output configuration and other items that define the unit to be controlled.

Supply minimum of 250 applications as part of workstation software.

5. Field engineering tools shall include Device Manager for detection of devices connected anywhere on the BACnet network by scanning of the entire network. This function shall display device instance, network identification, model number, and description of connected devices. It shall record and display software files loaded into each controller. A copy of each file shall be stored on the computer's hard drive. If needed, this file shall be downloaded to the appropriate controller using the mouse.
6. AWS will automatically notify the user when a device that is not in the database is added to the network.
7. AWS shall include a backup/restore function that will back up the entire system to a selected medium and then restore the system from that media. The system shall be capable of creating a backup for the purpose of instantiating a new client PC.
8. The system shall provide a means to scan, detect, interrogate, and edit third-party BACnet devices and BACnet objects within those devices.

O. Workstation Hardware – As Scheduled

1. Provide operator's workstation(s) at location(s) noted on the plans.
2. AWS Server
 - a. 64-bit OS Required
 - b. Windows 10 Pro or Enterprise or Windows Server 2019
 - c. Quad-core or Eight-core processors.
 - d. 8 GB RAM or higher.
 - e. 500 GB (or higher) hard drive
 - f. Network interface card (10/100/1000 Mbps).

P. Software

1. Provide 10 concurrent "Thick Client" Engineering Workstation Licenses for Programming / Configuration.
2. At the conclusion of the project, the contractor shall leave with the owner a CD ROM that includes the complete software operation system and project graphics, setpoints, system parameters, etc. This backup shall allow the owner to completely restore the system in the case of a computer malfunction.

Q. Web Client

1. BAS supplier shall provide an HTML5-based browser access to AWS as part of standard installation. Users must be able to access all displays of real-time data that are part of the AWS using a standard Web browser. Web browser shall tie into the network through owner-supplied Ethernet network connection. AWS must be able to support 20 concurrent web client users at a minimum.

2. Browser shall be the latest version of Microsoft Edge, Firefox, and Chrome. No special vendor-supplied software shall be needed on computers running browsers. Data shall be displayed in real-time and update automatically without user interaction.
3. Web pages shall be automatically generated using HTML5 from the data display files that reside on AWS. Any system that requires use of an HTML editor for generation of Web pages shall not be considered.
4. Access through web clients or thick clients shall utilize the same hierarchical security scheme as the AWS. Users shall be asked to log on once the client makes connection to AWS. Once the user logs in, any and all changes that are made shall be tracked by AWS. The user shall be able to change only those items they have authority to change. A user activity report shall show any and all activity of the users who have logged in to the system, regardless of whether those changes were made using a web client, thick client or through AWS.

R. Graphic Based Displays: For each system.

1. Operator Workstation: Point data for each system. Update every 30 seconds.
2. Dynamically update data on any action by the user.
3. Graphic Displays: Iconic graphic representations of mechanical equipment. Display graphic files, text, trend log, and dynamic object data displays including animation.
4. Graphic Displays: "Drill Down" capability from main display to more specific system displays or navigations tree for building equipment and system diagnostic centric display organization.
5. Tree Navigation Contents: Customizable per-user and per-group basis.
6. Systems with Terminal Unit Controls: Building floor plan with dynamic temperatures, drillable for more specific terminal information.
7. Points on graphics allow users to change field-resident Operator Workstation functions associated with the project, including setpoints, weekly and exception schedules, from any screen, whether screen shows text or graphic display. Do without reference to object addresses or other numeric/mnemonic indications.
8. Protect display views unless operator credentials have proper access level. Assign access levels to each display/system object. Menu labels not to appear on graphic if operator does not have appropriate security level.
9. Analog objects: Displayed with operator modifiable units. Input objects may be displayed as graphic items on the display screen as an overlay to the system graphic.
10. Information: Labeled with descriptors and shown with appropriate engineering units.

11. DDCs system must provide graphic displays and files. Systems requiring graphics development or logic programming are prohibited. Graphic Files: JPG, GIF or PNG.
 12. Submit graphic displays to Owner for review and approval. Approved graphics to be in place prior to commissioning.
 13. Operator Workstation: Supply graphics library, to use unaltered or modified. Include a library to assemble custom graphics. System to allow creation of new graphics.
 14. Data Displays: Ability to link to content outside of the BAS system. Content to include, but not limited to, launching external files in their native applications.
- S. Omni graphics: Graphics with custom geometry offering color gradient shading and variable opacity in scale to system variables, analog and digital, and color range settings.
1. Omni graphics must support:
 - a. Displaying current values in the geometric shapes.
 - b. Geometric shapes to be clickable allowing another graphic display.
 - c. Color scale: Support using AVs to define the color scale ranges.

**** NOTE TO SPECIFIER **** Delete any subparagraphs below not relevant to this project; add others as required.

- T. Portable Operator's Terminal. Provide all necessary software to configure an IBM-compatible laptop computer for use as a Portable Operator's Terminal. Operators shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting.

2.4 CONTROL PROGRAMMING SOFTWARE

- A. All DDC programming throughout the BMS network shall adhere to the following standards:
1. Programming on all controllers must be completely operator definable and modifiable and must use a single common programming language for all control devices. Use of pre-canned, factory burned-in DDC programming on controllers is not acceptable and is grounds for rejection of the EMS system.
 2. Programming shall be developed in an object-oriented graphical programming environment. Line-by-line code programming is specifically prohibited and is not acceptable.
 3. Programming must accommodate all written sequences of operations.
 4. Programming shall be modifiable from any server PC, operator console PC and/or portable laptop PC workstation without requiring the burning of new chips or having to directly access the local controller. Software shall accommodate the downloading of

programming via established network Ethernet or modem connections.

5. Programming must support the use of virtual software points in the same manner as all physical points are supported.
6. All programming points, virtual or real, for any specific device in the entire EMS network shall be accessible to all other network devices at any given time, regardless of physical location.
7. All programming shall adhere to the BACnet protocols for Standard Command Priorities.
8. Programming software must include a pre-developed cohesive PID (proportional-integral-derivative) algorithm whereby a user can adjust gain and anti-windup coefficients accordingly to effectively accomplish advanced sequence of operation requirements.

2.5 IOT GATEWAY (BUILDING (GLOBAL) CONTROLLER

A. General Requirements

1. BACnet Conformance
 - a. Building Controller shall be approved by the BTL as meeting the BACnet Building Controller requirements.
 - b. Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
2. Building controllers shall be of scalable design such that the number of trunks and protocols may be selected to fit the specific requirements of a given project.
3. The controller shall be capable of panel-mounted on DIN rail and/or mounting screws.
4. The controller shall be capable of providing global control strategies for the system based on information from any objects in the system, regardless if the object is directly monitored by the building controller module or by another controller.
5. The controller shall be capable of running up to six independent control strategies simultaneously. The modification of one control strategy does not interrupt the function or runtime others.
6. The software program implementing the DDC strategies shall be completely flexible and user-definable. All software tools necessary for programming shall be provided as part of project software. Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site, using a WAN or downloaded through remote communications are not acceptable. Changing global strategies using firmware changes are also unacceptable.

7. Programming shall be object-oriented using control function blocks, and support DDC functions. All flowcharts shall be generated and automatically downloaded to the controller. Programming tools shall be supplied and be resident on the workstation. The same tools shall be used for all controllers.
8. Programming tools shall provide means to graphically view inputs and outputs to each program block in real-time as the program is executing. This function may be performed using the operator's workstation or field computer.
9. Controller shall have 6000 Analog Values and 6000 Binary Values.
10. Controller IP configuration can be done via a direct USB connect with an operator's workstation or field computer.
11. Controllers shall have at a minimum a Quad Core 996Ghz processor to ensure fast processing speeds.
12. Global control algorithms and automated control functions shall execute using a 64-bit processor.
13. Controllers shall have a minimum of 1 GB of DDR3 SDRAM on a 533Mhz bus to ensure high speed data recording, large data storage capacity and reliability.
14. Controllers shall support two on-board EIA-485 ports capable of supporting various EIA-485 protocols including but not limited to BACnet MS/TP and Modbus.
 - a. Ports are capable of supporting various EIA-485 protocols including but not limited to BACnet MS/TP and Modbus.
15. Controllers shall support two gigabit speed Ethernet (10/100/1000) ports.
 - a. Ports are capable of supporting various Ethernet protocols including but not limited to BACnet IP, FOX, and Modbus.
16. All ports shall be capable of having protocol(s) assigned to utilize the port's physical connection.
17. The controller shall have at a minimum four onboard inputs, two universal inputs, and two binary inputs.
18. Schedules
 - a. Building controller modules shall provide normal seven-day scheduling, holiday scheduling, and event scheduling.
 - b. Each building controller shall support a minimum of 480 BACnet Schedule Objects and 480 BACnet Calendar Objects.
19. Logging Capabilities
 - a. Each building controller shall log as minimum 1920 objects at 15-minute intervals. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.

- b. Logs may be viewed both on site or off site using WAN or remote communication.
- c. Building controllers shall periodically upload trended data to the networked operator's workstation for long-term archiving if desired.
- d. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.

20. Alarm Generation

- a. Alarms may be generated within the system for any object change of value or state (either real or calculated). This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
- b. Each alarm may be dialed out as noted elsewhere.
- c. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.
- d. Controllers must be able to handle up to 1920 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.

21. Demand Limiting

- a. Demand limiting of energy shall be a built-in, user-configurable function. Each controller module shall support shedding of up to 1200 loads using a minimum of two types of shed programs.
- b. Load shedding programs in building controller modules shall operate as defined in section 2.1.J of this specification.

22. Tenant Activity Logging

- a. Tenant Activity logging shall be supported by building controller modules. Each independent module shall support a minimum of 480 zones.
- b. Tenant Activity logging shall function as defined in section 2.1.K of this specification.

B. BACnet MS/TP

- 1. BACnet MS/TP LAN must be software-configurable from 9.6 to 115.4Kbps
 - a. Each BACnet MS/TP LAN shall support 64 BACnet devices at a minimum
 - b. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. BACnet IP

- 1. The building controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN.
- 2. Must support interoperability on WANs and CANs and function as a BACnet Broadcast Management Device (BBMD).
- 3. Each controller shall support at a minimum 128 BBMD entries.

4. BBMD management architecture shall support 3000 subnets at a minimum.
5. Shall support BACnet Network Address Translation.
6. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

D. Expansion ports

1. Controller shall support two expansion ports.
 - a. Combining the two on-board EIA-458 ports with fully loaded expansion ports the controller shall support (6) EIA-485 trunks simultaneously.
2. Expansion cards that mate to the expansion ports shall include:
 - a. Dual port EIA-485 card

E. Modbus Protocol Support:

1. Controller shall support reading from and writing to TCP Slaves and Serial Connections 4 (RTU or ASCII over either EIA-485 or EIA-232).
 - a. Shall be capable of mapping Modbus register coil data to BACnet AV, BV, MV, AI, BI, and MI object types.
 - b. Support a minimum of 6000 Mapped Modbus points.
2. Support up to 384 virtual groupings of Modbus points where each grouping is represented as a single virtual BACnet device.
 - a. Virtual BACnet devices support BACnet Change of Value (COV) notifications
 - b. Each virtual device has diagnostic information for troubleshooting Modbus 4 point mapping. Diagnostic point should include the following:
 1. Number of points mapped.
 2. Number of messages Transmitted and Received.
 3. Modbus Exception Counts.
 4. Display of last exception message.
 5. Serial Setting (Baud rate, Parity, Stop Bits).
3. Integration Performance: Data age of integrated point shall be capable of 1 second for 5000 points.

F. Power Supply

1. Input for power shall accept between 17–30VAC, 47–63Hz.
2. Optional rechargeable battery for shutdown of controller including storage of all data in flash memory.
3. On-board capacitors will ensure continuous operation of real-time clocks for a minimum of 14 days.

G. Controller shall be in compliance with the following

1. UL 916 for open energy management
2. FCC Class B
3. ROHS
4. IEC 60703
5. C-Tick Listed
6. CE (EN 60730-1)

H. Controller shall operate in the following environmental conditions:

1. -4 to 149 °F (-20 to 65 °C) without optional battery, or 32 to 122 °F (0 to 50 °C) with optional battery.
2. 0 to 95% RH, non-condensing.

PART 3 - OPERATIONAL TECHNOLOGY NETWORK

3.1 GENERAL

- A. The Operational Technology Network (OTN) shall be provided, installed, programmed, and commissioned by an IA system contractor. Refer to Mechanical Drawings for system architecture.
- B. The IA system contractor shall furnish and install a separate OTN that is optimized for the needs and safety of Operational Technology (OT) devices, services, and building technology i.e., HVAC, Lighting Control, Electrical Metering, Security, CCTV, Data Center, and other Controller Assets. The OTN shall be Fiber Ethernet based.
- C. The OTN shall be an intelligent network that presents information in the context of automation equipment. The solution provided shall be designed to be easily scalable and repeatable so it can be deployed to a wide variety of building technology applications.
- D. The OTN is designed for standalone or networked IP operation with all the software and hardware to ensure the building system operation. Outside network connections should only be supplied through an operational network platform firewall. The OTN software shall include a web-based Network Management Tool. The OTN hardware shall include all Fiber switches, Fiber to Copper switches, and all Fiber and Ethernet cabling and associated wiring devices.
- E. The IA system contractor shall supply the data from all connected systems to the owner in a graphics format. The graphics shall be web based and work on all devices capable of running on latest version of Microsoft Edge, Firefox, or Chrome browser

3.2 SYSTEM DESCRIPTION

- A. This specification outlines the various OTN requirements and functions. This includes the Service Level Agreement, Schedule, Types of Data, Traffic Requirements, Responsibilities, Coordination, Security, Remote Access, OT Network Topology, IP Subnets and VLANs, and OT Network Visibility Requirements.

3.3 SERVICE LEVEL AGREEMENT

- A. A Service Level Agreement is required between OT and IT. If IT is managing the network,

then they must be able to respond to any inquiry within 15 minutes or less. If the time is longer this will cause an increase in service and maintenance costs.

- B. If the Implementor is managing the network:
 - 1. The Implementor will provide a dedicated resource to support the Building Management System (BMS) solution.
 - a. This resource shall be capable of providing corrective action.
 - b. This resource shall have all experience required to complete any corrective action.
 - 2. The Implementor shall provide resources to complete network diagnostics and troubleshooting for OT, network connected ports, and backbones with response times no greater than 30 minutes.
 - 3. The Implementor shall provide corrective action, in either proposed or direct action, within 4 hours.

3.4 SCHEDULE

- A. The OT Network must be installed and operational prior to the installation of all OT devices.
 - 1. Once the OT equipment can be connected to the devices and systems it is controlling, full operational set-up must be completed no later than 10 weeks after the scheduled start date.
 - 2. Once the OT Network architecture is finalized, the Implementor will have 10 weeks to complete installation and operational set-up.
- B. Typical schedule:
 - 1. Core network before any work has begun
 - 2. Mechanical equipment is installed
 - 3. OT devices are connected
 - 4. OT Network is stood up
 - 5. Programming of equipment
 - 6. Commissioning of equipment and control strategies
 - 7. Equipment startup
 - 8. Graphics
 - 9. Integration
 - 10. Occupancy
- C. This procedure must follow the mechanical equipment schedule or there will not be any control for the equipment. This allows for integration, graphics, and dashboard creation, which allows for commissioning.

3.5 TYPES OF DATA

- A. BACnet: This data is passed over UDP. Retries are built into the software and can be adjusted to fit the application. This can affect the total amount of traffic.
- B. API: This traffic typically has no retries but the amount of data and frequency can vary greatly. There are various types of integration such as:

1. RESTful
2. SOAP
3. Node Red
4. MQTT
5. IFTTT
6. etc.

C. Niagara: This is a proprietary protocol commonly referred to as Fox Protocol.

3.6 TRAFFIC REQUIREMENTS

- A. The network must be able to handle broadcast traffic in both steady state and burst.
- B. The Implementor shall test all network segments and provide a report to the IA system contractor indicating that all parameters are within documented acceptable limits and that there are no network wiring issues, communications issues, bandwidth issues, or address conflicts, and that the required 100% growth capacity is available.
- C. External connections are required for:
 1. Analytics Platform (duplex)
 2. Remote Access for external OPS monitoring and control (duplex)
 3. CLE/CIN monitoring, control and programming (site redundancy)
- D. OT Network operations require bandwidth reservation of 1 Gigabit uplink per telecommunications room.
- E. All OT switch ports shall be capable of 1 Gigabit transmission speeds and supporting IEEE 802.3ab Gigabit Ethernet.
- F. All traffic types are equally important. All Data is equally important.
- G. As multiple devices from multiple vendors can be connected to the network, each device can have its own set of requirements which need to be met.
- H. Retries are built into the software and can be adjusted to fit the application. This can affect the total amount of traffic.

Service	Critical	Bandwidth	Traffic Pattern
BAS	Medium/High	Low	Predictable
CCTV	High	High	Planned
Lighting	High	Low	Predictable
Vertical Lift	Low	Low	Predictable
Energy Meters	Low	Low	Predictable

Analytics	Low	Medium	Predictable
AI	Low	Medium	Predictable
API	Low	Low	Predictable
UPS	High	Low	Unpredictable
Fire/Life Safety	High	Low	Unpredictable

3.7 RESPONSIBILITIES

- A. When working with an OT Network that will involve controls, responsibility for both regular and urgent matters must be assigned. To avoid having multiple service personnel being sent to site, a single resource needs to be called to alleviate nuisance requests. Recommended contacts include:
 1. A first point of contact
 2. A networking point of contact for any hour of the day
- B. It is also recommended to clearly outline an expected outcome with a date of conclusion for maintenance and support.
- C. The IA system contractor will be responsible for BMS network management, integration, as well as development of all GUI pages and related content.
- D. There shall be clear visibility with access to OT Network switches and ports, with full permission to allow for configuration, programming, startup, and testing of all products connected to the OT Network. This can be by, but not limited to IT, the IA system contractor, or Contractors.
- E. The Implementor will ensure all ports required for communication protocols for DDC as designated by Section 26 50 00 shall be open and remain open unless coordination is done for switch upgrades, replacements, and such.
- F. The Implementor will guarantee support of all DDC communications protocols including unicast and multicast, where required.

3.8 COORDINATION

- A. During installation of OT devices (e.g. BAS Controllers, Lighting Controllers, Surveillance Cameras, etc), a responsible party must provide clarity on what ports are to be used by each Contractor.
- B. Any switch that is connected to and/or is part of the OT Network cannot be reset or upgraded without prior notification to the OT group. These resets and updates can cause waves of traffic within the OT Network.
- C. When a network port changes status, the OT system sees a device offline and instantly tries to find it. If there is programming, graphics, alarming, and integration that is linked to this device, everything will start the search or start giving out notifications that the device is no

longer present. This creates a lot of traffic on the network and can require service to be called to correct the problem.

- D. In some cases, this could be linked to critical equipment or crucial lab experiments and could cause irreparable damage.
- E. The Implementor shall provide a minimum 25% spare capacity in all port allocations and/or configurations for future expansion. They shall provide a minimum of 6 spare ports per telecommunications closet.
- F. The Implementor shall ensure that personnel and contractors' network and computing permissions shall be sufficient to manage all aspects of the OT Network as set forth in this specification.
- G. The OT team and IA system contractor shall have direct input on how the OT Network devices are connected to the network. In many cases, different OT devices need to be connected in different configurations to provide fault tolerance. The network architecture should also provide predictable failure operations so that if a system fails, it is clear where it has failed, as well as which devices or systems are affected.

3.9 SECURITY

- A. Network security best practices should be applied to all OT devices while allowing the lack of certain IT approaches such as 802.1x and IPSec. Recommended basic network security for OT Network includes:
 - 1. Port-based MAC security (filtering) including support device daisy-chain where more than one device is connected to a switch port.
 - 2. Disable ports if ports are unused.
 - 3. Firewall and double-firewall. In some cases, a dual firewall may be adequate: one managed by IT to protect from both the outside and inside world, and one managed by OT to allow communication with IT systems (e.g. calendars, dashboards).

3.10 REMOTE ACCESS

- A. There shall be remote access to the OT Network from outside the building. The OT team shall be able to manage and grant authority to both internal and external resources to be able to run the building and OT Network as needed remotely.

3.11 OT NETWORK TOPOLOGY

- A. Active daisy-chain and ring connectivity is popular in OT systems to significantly reduce cost and space. The OT Network must support Spanning Tree Protocols (STP, RSTP, etc) with automated STP cost configuration.

3.12 IP SUBNETS AND VLANS

- A. Separation between services and between segments (e.g. floors and buildings) is important. Each segment should have its own VLAN and subnet.
- B. Communication between VLAN and subnets (inter-VLAN routing) should be carefully configured based on services that require inter-communication.

- C. Multiple subnets will likely be necessary, especially in multi-service (e.g. BAS, Lighting, etc.) systems or systems with more than 256 OT devices (e.g. 1000 VAVs).

3.13 OT NETWORKS, SWITCHES, VLANS, AND PORT VISIBILITY

- A. The network, switches, and ports must all be visible to the OT Network team. To manage the system properly and quickly, everything that is connected to the OT Network must be clear. The following list is a sample of some, though not all, that the OT Network users need to know:
 - 1. Status of all switches
 - a. It shall be clear whether the switches are up and running
 - b. The switches' uptime shall also be clear
 - 2. Status of all ports
 - a. It shall be clear if the ports are online or offline
 - b. This shall include multi-device networks off of a single port (i.e. IP daisy-chain)
 - c. There shall be an alert if the status is offline
 - 3. Security status
 - a. Each port shall show whether it is being secured by MAC authorization rules, and if those rules are enabled.
 - 4. Power over Ethernet (POE) status
 - a. It will be clear if PoE is enabled
 - b. It shall show the current power draw of PoE connected devices
 - c. It shall show PoE per port
 - d. It shall show PoE total draw per switch
 - 5. RSTP status
 - a. It will be clear if RSTP is enabled
 - b. It shall show what ports the RSTP is connected to
 - c. It shall show if the RSTP state has changed (i.e. a broken loop)
 - d. There shall be an alert if RSTP is active
 - 6. Individual status of all switches
 - a. It will be clear if the switch is online or offline
 - b. There shall be an alert if the switch is offline
 - 7. VLAN
 - a. It shall show which VLANs are being used within each switch
 - 8. IP addresses and range, as well as static or dynamic assignments
 - a. All IP addresses that are being used will be visible
 - b. It will show the MAC and Host of each connected IP device
 - c. It shall show the entire DHCP range
 - d. It shall show what is used and unused within the DHCP range
 - e. It shall show any IP address that is statically assigned
 - 9. VLAN routing
 - a. Any VLAN routing rules will be clearly shown
 - b. It will show which VLANs have access outside the VLAN or between VLANs
 - 10. Internet status
 - a. The status of the Internet connection will be clear

3.14 APPROVED OPERATIONAL TECHNOLOGY NETWORK MANUFACTURERS

A. Approved OTN Manufacturers:

1. Optigo Networks Inc.
2. No Equals.

PART 4 - OPERATIONAL TECHNOLOGY NETWORK PRODUCTS

**** NOTE TO SPECIFIER ** Select the correct Footprint for your building and delete the rest of the footprints.**

4.1 WIDE-FOOTPRINT BUILDINGS

- A. In order to build with Optigo Connect Spectra, you'll need a Spectra Aggregation Switch and Network Controller, Passive Optical Splitters, a software license, and Edge Switches. Start with ONS-C401i Edge Switches and if you need to increase density, you can upgrade to the larger switch at any time.

- B. Follow the simple formula for a standard, wide building design, such as shopping, mall, data, center, schools etc.

Spectra Aggregation Switch and Accessories:

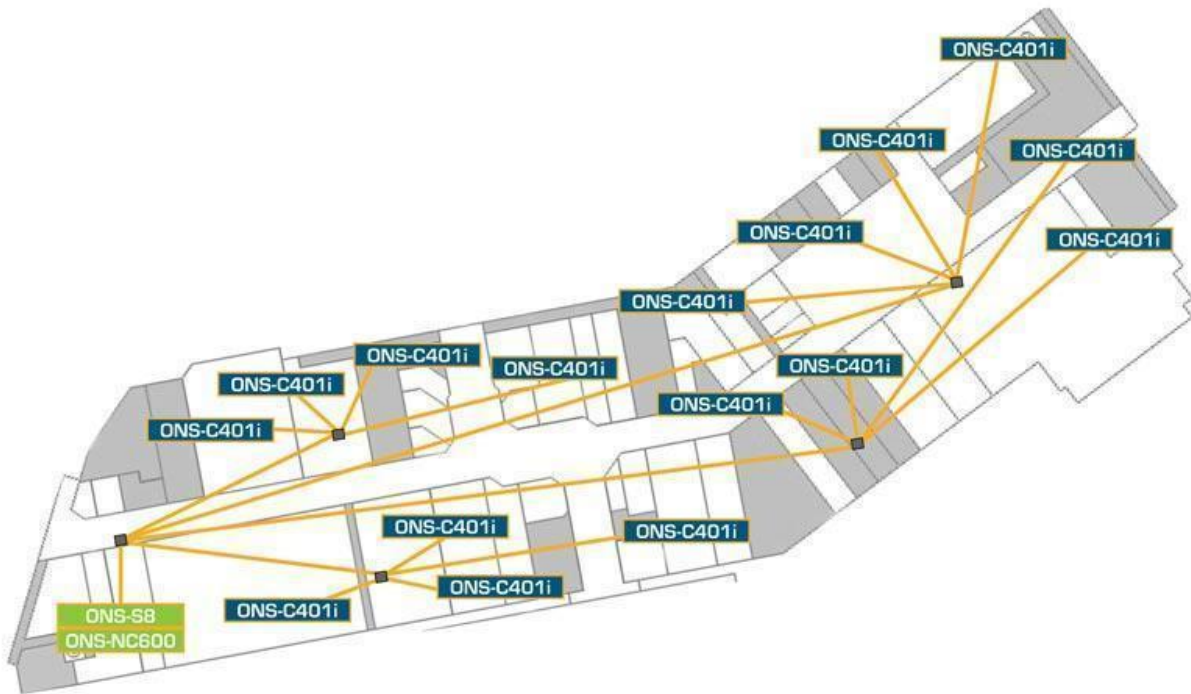
- a. ONS-S8 = 1
- b. ONS-NC600 = 1
- c. ONS-SX-SFPs = 1 per fiber strand from the ONS-S8
- d. ONS-SW-100P = 1 license included for the first 100 ports. A license must be purchased per additional 100 ports.

Edge Switches and Accessories:

- a. ONS-C401i = up to 16 per fiber network
- b. ONS-CX-SFPs = 1 per Edge Switch

Splitters and Accessories:

- a. ONS-YPS-4 = 5



**** NOTE TO SPECIFIER **** Select the correct Footprint for your building and delete the rest of the footprints.

4.2 10-FLOOR BUILDINGS

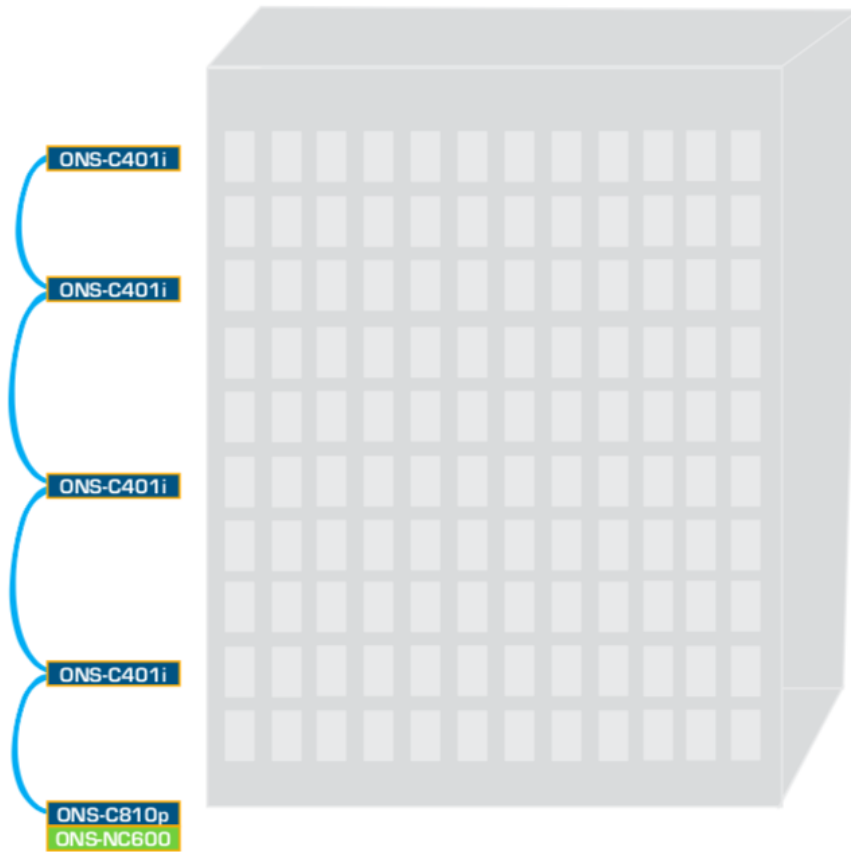
- A. In order to build with Optigo Connect Hybrid, you'll need one switch designated as the Aggregation switch, a Network Controller, an Optigo OneView software license and Edge switches. Start with ONS-C401i Edge Switches and if you need to increase density, you can upgrade to a large switch at any time.
- B. Follow the simple formula for the standard, 10-floor building with switches on every third floor and copper connecting the floor above and below each installation.

Hybrid Aggregation Switch and Accessories:

- a. ONS-NC600 = 1
- b. ONS-C810p = 1
- c. ONS-SW-100P = 1 license included for the first 100 ports. A license must be purchased per additional 100 ports.

Edge Switches and Accessories:

- a. ONS-C401i = up to 5 Edge Switches per chain, with a maximum of 4 chains per building network
- b. ONS-CU-SFPs = 2 per copper cable up link



**** NOTE TO SPECIFIER **** Select the correct Footprint for your building and delete the rest of the footprints.

4.3 HIGH-RISE BUILDINGS

- A. In order to build a bid with Optigo Connect, you'll need a Spectra Aggregation Switch and Network Controller, Passive Optical Splitters, couplers, a software license, and Edge Switches. Start with an ONS-C401i Edge Switch, and if you need to increase density, you can upgrade to a larger switch at any time.
- B. Follow the simple formula for standard, 15-floor high-rises.

Spectra Aggregation Switch and Accessories:

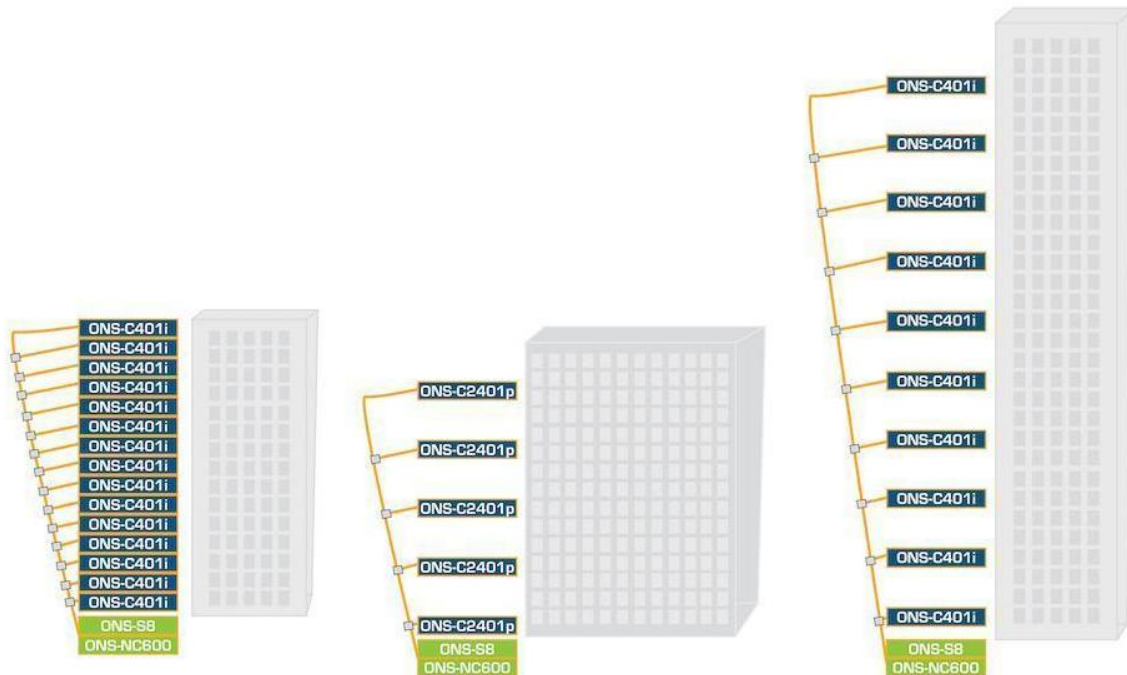
- a. ONS-S8 = 1
- b. ONS-NC600 = 1
- c. ONS-SX-SFPs = 1 per 15 switches
- d. ONS-SW-100P = 1 license included for the first 100 ports. A license must be purchased per additional 100 ports.

Splitters and Accessories:

- a. ONS-YPS-2-A05-LR = 7
- b. ONS-YPS-2-A10-LR = 6
- c. ONS-YPS-2 = 1
- d. ACC-CPL-SC = 1 per splitter connection

Edge Switches and Accessories:

- a. ONS-C401i = 1 per floor
- b. ONS-CX-SFPs = 1 per switch



Sample 15-floor high-rise, 15-floor dense high-rise, 30-floor high-rise. Increase height up to 45 floors.

**** NOTE TO SPECIFIER **** Select the correct Footprint for your building and delete the rest of the footprints.

4.4 HIGH-RISE BUILDING WITH REDUNDANCY

- A. There are two options for building redundancy on a high-rise with Optigo Connect: Aggregation Switch Redundancy or Path Redundancy.
- B. Generally, Aggregation Switch Redundancy is sufficient. It ensures that if one Aggregation Switch has a failure, a second Aggregation Switch will continue to drive the building. Simply add a second Spectra Aggregation Switch (ONS-S8) and Network Controller (ONS-NC600) to your high-rise network. You can quickly configure redundancy with Optigo OneView. The Passive Optical Splitters (ONS-YPS-X) allow you to connect both Aggregation Switches to your network of Edge Switches (ONS-C401i). Start with ONS-C401i Edge Switches, and if you need to increase density, you can upgrade to a larger Edge Switch at any time.
- C. Follow our simple formula for a high-rise with Aggregation Switch Redundancy.

Spectra Aggregation Switches and Accessories:

- a. ONS-S8 = 2
- b. ONS-NC600 = 2
- c. ONS-SX-SFPs = 2*
- d. ONS-SW-100P = 1 license included for the first 100 ports. A license must be purchased per additional 100 ports.
- e. ONS-SW-RED = 1 license per redundant fiber run

Edge Switches and Accessories:

- a. ONS-C401i = 11**
- b. ONS-CX-SFPs = 1 per Edge Switch

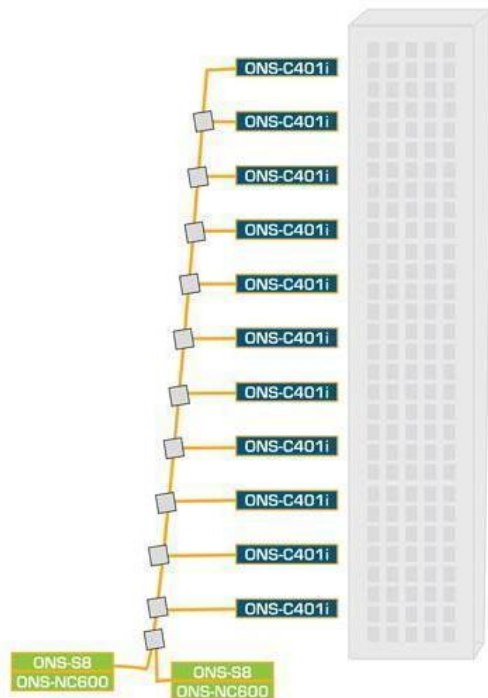
Splitters and Accessories:

- a. ONS-YPS-2-A05-LR = 7
- b. ONS-YPS-2-A10-LR = 2
- c. ONS-YPS-2 = 2
- d. ACC-CPL-SC = 1 per splitter connection
- e. FPC-20m = 1

**Assumed on a single fiber run. Each ONS-S8 supports eight fiber runs.*

***Note that you can use a maximum of 11 splitters on an aggregation switch redundant network. Some configurations may exceed your optical budget.*

Aggregation Switch Redundancy



**** NOTE TO SPECIFIER **** Select the correct Footprint for your building and delete the rest of the footprints.

B.

- D. Path Redundancy provides additional reliability by protecting failures of the Aggregation Switch and in the fiber path. Simply connect each end of the fiber to a Spectra Aggregation Switch (ONS-S8), creating a ring. You can quickly configure redundancy in Optigo OneView. The Passive Optical Splitters (ONS-YPG-X) allow you to connect these Aggregation Switches to your network of Edge Switches (ONS-C401i). Start with ONS-C401i Edge Switches, and if you need to increase density, you can upgrade to a larger Edge Switch at any time. If the fiber is cut somewhere in the ring, the second Spectra Aggregation Switch will continue to drive the section of the network that would otherwise be dark.
- E. Follow our simple formula for high-rise with Path Redundancy.

Spectra Aggregation Switches and Accessories:

- a. ONS-S8 = 2
- b. ONS-NC600 = 2
- c. ONS-SX-SFPs = 2**
- d. ONS-SW-100P = 1 license included for the first 100 ports. A license must be purchased per additional 100 ports.
- e. ONS-SW-RED = 1 license per redundant fiber run

Edge Switches and Accessories:

- a. ONS-C401i = 5
- b. ONS-CX-SFPs = 1 per Edge Switch

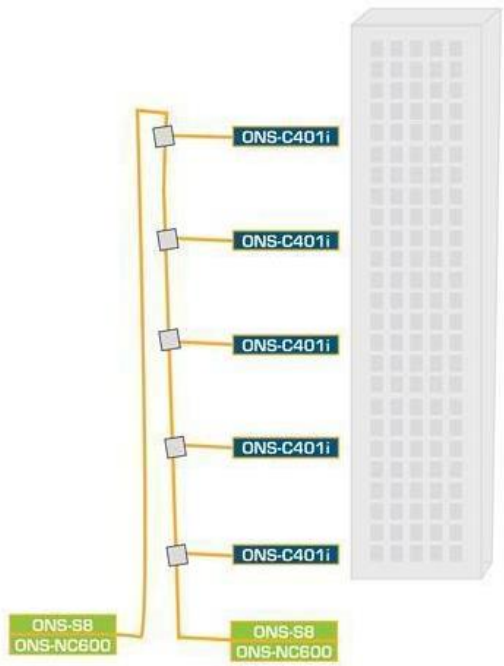
Splitters and Accessories:

- a. ONS-YPG-X = 5*
- b. ACC-CPL-SC = 1 per splitter connection

**Note that you can use a maximum of five splitters on a path redundant network. Some configurations may exceed your optical budget.*

***Assumed on a single fiber run. Each ONS-S8 supports eight fiber runs.*

Path Redundancy



C.

END OF SECTION