SECTION 2

DIVISION 25

FACILITY MANAGEMENT AND CONTROL SYSTEM

DIVISION 25 - FACILITY MANAGEMENT AND CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This section describes the scope of work for the Facility Management and Control System that must be installed by a qualified FMCS Contractor and integrated to the Enterprise Server by the Enterprise Developer.

B. Provide Facility Management and Control System (FMCS) incorporating Direct Digital Control (DDC), energy management and equipment monitoring consisting of the following elements:
   1. Microprocessor based remote control panels interfacing directly with sensors, actuators, and environmental delivery systems to provide complete standalone DDC/EMS functionality. (i.e., HVAC equipment, etc.).
   2. Communication network to allow data exchange between remote panels and central web supervisor.
   3. Personal computer (PC) based central and associated operator station(s), and software functioning as the primary operator interface for FMCS. System shall utilize a graphics front end.
   4. Pneumatic, electric and electronic control for all items indicated including dampers, valves, panels and pneumatic and electrical installation.

C. Chiller control:
   1. Controls installer shall interface the FMCS systems with the FMCS panel provided by the chiller manufacturer for each chiller. Control installer shall provide integrator panel and all wiring from FMCS to central chiller panel and from central chiller panel to individual chillers. **Chiller panel communications protocol shall be LONWORKS, BACnet MSTP or Modbus RTU to a JACE. BacNet/Modbus IP must be a separate network communicating through the Jace secondary IP port.**

D. Provide submittals, installation, data entry, programming, startup, test and validation of FMCS, instruction of Owner's representative on maintenance and operation of FMCS, as-built documentation, and system warranty. See Section 1.11

E. Completely coordinate with work of other trades.

F. 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 in order 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).

G. All labor, material, equipment and software not specifically referred to herein or on the plans, that is required to meet the functional intent of this specification, shall be provided without additional cost to the Owner.

1.2 ANNEX L

B-1 – General list of abbreviations and acronyms.
B-2 – Glossary of Terms.
B-3 – Standard for Screen Graphic Abbreviations.
B-4 – Niagara AX Control System Point Naming Convention.
B-5 – Default Building Occupancy Schedule.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Related Sections include but are not necessarily limited:
   1. Division 00 – Bidding Requirements, Contract Forms and Conditions of the Contract.
   2. Division 01 – General Requirements.
   3. Section 20 05 00 – Special Mechanical Requirements
   4. Section 22 11 23 – Plumbing Pumps.
   5. Section 23 21 23 – HVAC Pumps.
   6. Section 25 10 10 – Facility Monitoring and Control System (FMCS) Integration.
   7. Section 26 00 10 – Electrical General Requirements.

B. Other products which may be integrated and installed but not furnished under this section.
   1. Project specific equipment.
   2. Metering (if applicable)
   3. Electric pulse meter (if applicable)
   4. Gas metering (if applicable)
   5. Water metering (if applicable)
   6. Fire Alarm monitoring, with a minimum of a status if it is available from the panel
   7. Roof Top Units
   8. Lighting (if applicable)
   9. CRAC Computer Room Air Conditions

1.4 SCOPE OF WORK

A. The Facility Management and Control System (FMCS) shall be comprised of Java Application Control Engine or Controllers (JACE) within each facility. The JACE shall connect to the owner's local or wide area network, depending on configuration. Each User shall configure a dashboard view of the pertinent data and this view shall be saved for later use. Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through a standard Web browser, via the Internet and/or local area network. Each JACE shall communicate directly to LonMark/LonTalk (IDC), BACnet MSTP (IBC), MODBUS RTU devices and other open and legacy protocol systems/devices provided under this Division. It is the owner's goal to eliminate any gateway or redundant (redundant to the JACE functionality) device(s).

B. The Facility Management and Control System (FMCS) as provided in this Division shall be the based on the Niagara^{AX} Framework (or "Niagara^{AX}"), a Java-based framework developed by Tridium

C. The work provided in this specification shall be performed by multiple entities. The FMCS Contractor shall have overall responsibility for the Division work. The Enterprise Developer shall be appointed by the Owner and shall provide all work at the Enterprise Server level. Owner will oversee and provide procurement for Enterprise Developer services.

D. Systems Integrator shall provide overall management, coordination and responsibility for delivering integrated FMCS systems. The Systems Integrator shall review work performed by other Specialty Contractors such as low voltage, IT, security and control system subcontractors and coordinate the connection of these systems to the Owner's IT infrastructure in conjunction with the Owner's IT staff.

E. All materials and equipment used shall be standard components. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.

F. All wiring shall be done in accordance with all local and national codes.

1.5 DIVISION OF WORK

A. The FMCS contractor shall be responsible for all communicating thermostats, any miscellaneous controllers (IDC and IBC), control devices, control panels, controller programming, and controller programming software, controller input/output and power wiring and controller network wiring specified to be provided in Division 23.

B. The **Division 28** (if applicable) contractors shall be responsible for all controllers Security JACE, control devices (BACnet, LONworks or Modbus), control panels, controller programming, controller programming software, controller input/output and power wiring and controller network wiring specified to be provided in **Division 28**. These devices shall be configured and commissioned by **Division 28** contractors and later managed in the JACE by FMCS contractor.

C. The FMCS contractor shall be responsible for the Java Application Control Engine(s) (JACE), software and programming of the JACE, graphical user interface software (GUI), User Configurable Dashboard software and connection of the JACE to the local or wide area network. FMCS shall also be responsible for development of all graphical screens, Web browser pages, setup of schedules, logs and alarms, and network management for all IDC or IBC devices provided in Division 23 and 26. IDC or IBC devices not provided by FMCS contractor shall be configured and commissioned by appropriate contractor and later managed in the JACE by FMCS contractor.

D. For reasons of security and consistency, it is the owner's intention to divide the work defined in this section into two sections. Work performed at the JACE level and below shall be performed by a qualified FMCS Systems Integrator. All work provided at the Enterprise Server and between the server and other systems shall be provided by the owner appointed Enterprise Developer. The Enterprise Developer shall be responsible for the "learning" of the WBI (web browser interface) from the JACE to the Enterprise Server, the configuration of the Periscope Dashboard software and the global integration strategies across JACE s and other intelligent building systems. The Enterprise Developer shall also be responsible for all Security integration at the Server level, if applicable. **All work pertaining to global strategies across sites and other intelligent building systems including between the** JACE **and other subsystems shall be by the FMCS.**

1.6 QUALITY ASSURANCE

The FMCS system shall be designed and installed, commissioned and serviced by Factory trained personnel (Niagara Ax Certification or equivalent). FMCS Contractor shall have an in-place support facility within 100 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment.

A. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, and Governing Radio Frequency Electromagnetic Interference and be so labeled.

B. UPS to be installed for 120v feeding power supply to JACE and battery backup option for Jace to also be installed.

C. System to be installed by competent technicians, with full responsibility for proper operation of FMCS, including debugging and proper calibration of each component in entire system.

D. Codes and approvals:
   1. Complete FMCS installation to be in strict accordance with national and local electrical codes, and Electrical Specification Divisions of these specifications. All devices designed for or used in line voltage applications to be UL listed.

E. All system components shall be fault tolerant.
   1. Provide satisfactory operation without damage at 110 percent and 85 percent of rated voltage, and at +/- 3 hertz variation in line frequency.

2. Provide static, transient, short circuit, and surge protection on all inputs and outputs. Communication lines to be protected against incorrect wiring, static transients, and induced magnetic interference. Bus connected devices to be a.c. coupled, or equivalent so that any single device failure will not disrupt or halt bus communication.
3. All real time clocks and data file RAM to be battery or capacitor backed.

F. System overall reliability requirement: The system, including all components and appurtenances, shall be configured and installed to yield a Mean Time Between Failure (MTBF) at least 1000 hours.

G. System accuracy and display: The system shall maintain an end-to-end accuracy for 1 year from sensor to Operator's console display for the applications specified and shall display the value as specified.

H. All field equipment shall be rated for continuous operation under ambient environmental conditions of 35 to 120 degF dry bulb and 10 to 95 percent relative humidity, non-condensing. Instrumentation and control elements shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity and vibration conditions specified or normally encountered for the installed location.

1.7 SUBMITTALS

A. Shop Drawings: Provide individuals experienced with the installation and startup of equipment related to this type of integration.
   1. One copy of shop drawings of the entire FMCS shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions.
   2. Complete system design information including:
      a. Data entry forms for initial parameters. All text and graphics to be approved prior to data entry.
      b. Valve, and damper schedules showing:
         1) Size.
         2) Configuration.
         3) Capacity.
         4) Location.
      c. Wiring and piping interconnection diagrams, including panel and device power and sources.
      d. Equipment lists (bill of materials) of all proposed devices and equipment.
      e. Software design data including:
         1) Flow chart of each DDC program showing interrelationship between inputs, PID functions, all other functions, outputs, etc.
         2) Sequence of operation relating to all flow chart functions.
      f. Control sequence.
      g. DDC installation, block diagrams, and wiring diagrams for each piece of equipment.
      h. DDC panel physical layout and schematics.
      i. The network topology diagram shall indicate the location and room number of all DDC controllers.
      j. The FMCS Contractor shall submit an architecture layout that depicts devices from the JACE down to the device level.
      k. The FMCS Contractor shall submit an architecture layout that depicts network diagrams for JACE to JACE communications as well as JACE to Server.
      l. BACnet specific designs:
         1) The FMCS Contractor shall submit a network topology diagram that includes the following on all BACnet devices
            a) TCP/IP Address
            b) MAC Address

c) Device instance number
d) BACnet Port
e) Devices configured for BBMD
f) BACnet routers and subnets

b. LonWorks specific designs:
1) The FMCS Contractor shall submit a network topology diagram that includes the following on all LON devices
a) Neuron IDs
b) Routers

3. Sequence of Operations: A complete written Sequence of Operation shall also be included with the submittal package. The FMCS Contractor shall coordinate data from other contractors supplying products and systems, as part of their package and shall provide catalog data sheets, wiring diagrams and point lists to the owner for proper coordination of work.
4. If a project is considered a renovation project the FMCS Contractor shall update all existing master diagrams in order to keep as-built drawings completely accurate for the entire building.
5. Digital Visio updateable drawings should be contained in JACE and Flashdrive.
6. A copy of all networks must be drawn on the actual physical daisy chain as installed. This is the actual blueprint showing the floorplan, equipment location and the route in which the network was run. The Niagara Network must also be included I.e. Friday bldg. communicates to RUP (See ANNEX L section 20.0)

B. Product Data:
1. Complete list of product data including:
a. Data sheets of all products.
b. Valve, damper, and well and tap schedules showing size, configuration, capacity, and location of all equipment.

C. Project Information:
1. Certification of installer qualifications.

D. 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 and/or Owner. Submittal shall also include a copy of the expected Dashboard viewlets being provided for owner configuration. It is expected that the successful FMCS Contractor shall utilize the UNC Charlotte graphic templates as much as possible. The owner will provide an example of an acceptable graphic template. Where a particular graphic template does not exist, the Integrator shall create a similar template and gain approval during submittal process.

E. Upon completion of the work, provide a complete set of 'as-built' drawings and application software on compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files.

F. Contract Closeout Information:
1. Operating and maintenance manuals.
2. Owner instruction report.
3. Certification that Owner Training has been provided by FMCS installer.
4. As Built Instrumentation and Control Diagrams.
5. Plan As-Builts at 1/8 inch scale showing:
a. Upon completion of the work, provide a complete set of 'as-built' drawings and application software on compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files.
b. Two copies of the 'as-built' drawings shall be provided in addition to the documents on compact disk.

c. Division 23, 25 and 26 contractors shall provide as-builts for their portions of work.
d. The FMCS Contractor shall be responsible for as-builts pertaining to overall FMCS architecture and network diagrams. All as built drawings shall also be installed into the FMCS server in a dedicated directory.
e. Communication cable circuiting drawing with DDC panels and communication devices labeled.
f. Power wiring circuiting drawing showing 120 volt circuit source and low voltage transformer locations, identifications, and circuit to each controlled device per transformer for the DDC system.

G. Any software needed to program or calibrate controls system will be provided along with any setup, configurations and data files. Also, any hardware needed to communicate with the controllers and/or devices will also be included.

1.8 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 Systems Integrator'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.

1.9 SOFTWARE LICENSE AGREEMENT

A. It is the owners express goal to implement an open system that will allow products from various suppliers to be integrated into a unified Niagara system in order 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). In addition, the Owner shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project. This shall include:
   1. All custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the JACE, FMCS Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices.
   2. Any and all required IDs and passwords for access to any component or software program shall be provided to the owner.

B. The Owner has signed a software and firmware licensing agreement for the FMS software. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software. Systems Integrators that participate in the integration of UNC Charlotte's direct digital control systems must:
   1. Be certified in the use, application and service of Niagara^{AX} software and shall provide documentation from the manufacturer's training center as such. However, certification in the above does not automatically qualify an integrator to bid on proposed UNC Charlotte projects. Only approved integrators listed in this specification are eligible to participate in the project.
   2. Agree to use on any UNC Charlotte project any application standards, html pages, graphics templates, etc. developed by or for UNC Charlotte for the purpose of digital control, scheduling, alarming, graphics, etc.
   3. Agree that the application standards, html pages, graphics templates, etc. developed only for UNC Charlotte are the property of UNC Charlotte (subject to the manufacturer's license agreement) and shall not be reproduced, etc. for use on any other customer, project, etc. without the expressed written permission of the UNC Charlotte facilities staff.

4. Agree that certification on the manufacturer's software does not guarantee continued participation in UNC Charlotte's FMS projects.
5. Agree to provide UNC Charlotte's staff with the highest level of administrative password.
6. Agree that UNC Charlotte staff and other Systems Integrators can use the onsite UNC Charlotte software tools to modify JACE s, license files, passwords, provide software maintenance, etc., after warranty period expires.
7. The owner requires that all Niagara^{AX} based software and hardware on this project have the following Niagara Information Compatibility Statement (NICS). The Existing Niagara^{AX} Server complies with the requirements below. Organizations without the NICS below shall not be allowed to bid.

a. Brand ID = Vykon
b. Station Compatibility In = *
c. Station Compatibility Out = *
d. Tool Compatibility In = *

1.10 WARRANTY

A. Provide all services, materials and equipment necessary for the successful operation of the entire FMCS for a period of two years after acceptance by the State Construction Office and provide hardware and software upgrade support during that period that corresponds with any upgrades performed by FM FIS.

B. Within this period, upon notice by the Owner, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by the FMCS contractor at no expense to the Owner.

C. The adjustment, required testing, and repair of the system includes all computer equipment, transmission equipment and all sensors and control devices.

D. With owner pre-approval, the on-line support services shall allow the local FMCS Contractor remote access to monitor and control the facility's building automation system. Pending owner approval, this remote connection to the facility shall be within 2 hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekends and holidays.

E. Warranty Access

1. Pending owner pre-approval, the Owner shall grant to the FMCS contractor, reasonable access to the FMCS during the warranty period. The owner shall allow the contractor to access the FMCS from a remote location for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period.

1.11 ACCEPTABLE SYSTEM CONTRACTORS

A. The FMCS Contractor shall provide JACE hardware, software and DDC components. The successful FMCS Contractor shall not have password access to the Enterprise Server (Web Supervisor) and shall be restricted to JACE access.

B. The FMCS Contractor shall have a technical support group accessible that is staffed with qualified personnel, capable of providing instruction and technical support service for networked control systems.

C. FMCS Systems Contractors of the hardware and software components must be approved by UNCC prior to winning projects.

D. UNCC List of Acceptable Contractors;

1) **Platinum Building Automation** (using Honeywell Lonworks Controllers).
2) **Schneider Electric Controls** (using Invensys I/A series Lonworks or approved BACnet).
3) **United Automation Corporation** (using Honeywell Lonworks Controllers).
4) **Mechanical Systems and Services** (using Honeywell Lonworks Controllers).

5) **Johnson Controls** (using open protocol BACnet controllers and an approved Tridium systems integrator).

PART 2 - PRODUCTS

2.1 GENERAL

A. The Facility Management Control System (FMCS) shall be comprised of a network of interoperable, stand-alone digital controllers, a computer system, graphical user interface software, network devices and other devices as specified herein.

B. The installed system shall provide secure passwords access to all features, functions and data contained in the overall FMCS.

2.2 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES

A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate the most current ANSI/ASHRAE Standard BACnet, LonWorks technology, MODBUS, existing OPC if applicable, and other existing open and proprietary communication protocols if applicable in one open, interoperable system.

B. The supplied computer software shall employ component-based technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including the most current ANSI / ASHRAE™ Standard, BACnet and LonMark to assure interoperability between all system components is required. For each LonWorks device that does not have LonMark certification, the device supplier must provide an XIF file and a resource file for the device. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via RS-485 (BACnet MSTP) or Ethernet (BACnet Ethernet/IP,) only by exception with prior UNCC FIS approval and only through the Jaces secondary IP port.

C. All components and controllers supplied under this Division 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 must incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. 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 a supplier-installed server for all database access. 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 without unduly burdening the customer's internal Intranet network. 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.

2.3 MATERIALS

A. Temperature control system:

1. Include:
   a. Temperature sensors.
   b. Humidity sensors.
   c. Controllers.
   d. Switches.
   e. Relays.
   f. Valves.

g. Dampers.
h. Damper operators.
i. Thermostats.
j. Humidistats.
k. Hygrometers.
l. Other associated controls required to maintain conditions described in detail on drawings, together with thermometers, gauges and other accessory equipment.

2. Provide complete system of wiring and air piping as necessary to fill intent of these specifications.
3. Control sequences indicated illustrate basic control functions only.
4. Provide additional controls required to meet intent of these specifications and make a complete system.
5. Space temperature and humidity control.
6. Control of air handling units.
7. Control of exhaust systems.
8. Control of cooling systems.
9. Control of heating systems.

B. Control panels. Where electronic sensing is used, furnish amplifier relays and transformer complete with overload protection.

C. Electrical drawings indicate type of motor control required by equipment.
1. NETWORKS The Local Area Network (LAN) shall be a 100 Megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, and OBIX for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Java Application Control Engine (JACE s), user workstations and, if specified, a local server.

D. Local area network minimum physical and media access requirements:
1. Ethernet; IEEE standard 802.3
2. Cable; 100 Base-T, UTP-8 wire, category 6
3. Minimum throughput; 100 Mbps.

2.4 NETWORK ACCESS AND SECURITY

A. Remote Access
1. For Local Area Network installations the Owner shall provide a connection to the Internet to enable access via the customer's Intranet to a corporate server. FMCS Contractor shall connect to IP drop provided by the Owner within 25 feet utilizing a minimum of Category 6 grade of patch cabling.

B. JACE IP communications
1. FMCS Contractor will use DHCP and DNS for IP communications.
a. No static IPs or "hardcoded" IP addresses in the JACE will be accepted.
b. The FMCS Contractor shall request from UNCC FIS all required primary port TCP/IP network configuration settings for all JACE s via standard RFI. **The FMCS Contractor shall not assign any of the following configuration settings without FM FIS approval.**
1) Domain name
2) Host name
3) Station Name
c. Secondary port
1) For troubleshooting purpose, The FMCS Contractor shall configure the JACE's secondary port to a static IP address of 192.168.1.12X, where X is equal to last digit of JACE's serial number.
2) The subnet mask shall be configured to 255. 255. 255.0

C. Security and Authentication
1. Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data.

2. The Owner shall control/set all passwords and security levels for all operators. The Owner shall provide the FMCS and Enterprise Developer with the standard passwords required to be used in the Enterprise Server and the JACE.
3. The FMCS Contractor shall not use any passwords except those provided by the owner. The system administrator shall have the ability to set passwords and security levels for all other operators.
4. The FMCS Contractor shall not leave any default usernames/passwords on the JACE.
5. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object.
6. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected.
7. User Profile templates:
   a. The FMCS Contractor shall program users in the JACE utilizing the following User profiles

User Profile	View Graphics	Operator Setpoints	All Setpoints	Add/Delete Users
Technician	X	X		
View Only	X			
Power User	X	X	X	X

8. SSL requirements
   a. All communications between Niagara devices and the Enterprise server or user interface software, i.e., IDE, shall be secured using SSL encryption.
   b. The following ports shall be used for SSL communications

Software Interface	Protocol	Specified Port
Browser	HTTPS	443
Niagara Station IDE	FOX	4911
Niagara Platform IDE	TLSv1	5011

2.5 Java Application Control Engine (JACE)

A. The FMCS Contractor shall supply one or more Java Application Control Engine (JACE) as part of this contract to manage devices/points in all specification sections with the exception of Division 28 00 00 Security. Security JACEs are provided under Division 28 00 00 and all card access, video and intrusion detection shall be integrated into the existing Enterprise software by the Systems Integrator. The Systems Integrator shall be required to integrate BACnet zone information provided by the Division 28 into the HVAC and Lighting Sequence of Operation. The number of JACEs provided by the FMCS Contractor is dependent on the type/quantity of devices and points. It is the responsibility of the FMCS Contractor to coordinate with all Division contractors to determine the quantity and type of JACEs needed to fulfill the operating sequences.

B. Java Application Control Engine (JACE) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the JACE. It shall be capable of executing application control programs to provide:
   1. Calendar functions
   2. Scheduling
   3. Trending
   4. Alarm monitoring and routing
   5. Time synchronization
   6. Integration of LonWorks controller data and BACnet controller data

7. Network Management functions for all LonWorks based devices.

C. The Java Application Control Engine must provide the following hardware features as a minimum:
   1. Two Ethernet Ports – 10/100 Mbps
   2. One RS-232 port
   3. One LonWorks Interface Port – 78KB FTT-10A (if applicable)
   4. One RS-485 port
   5. Battery Backup or equivalent
   6. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)
   7. The JACE must be capable of operation over a temperature range of 32 to 122°F
   8. The JACE must be capable of withstanding storage temperatures of between 0 and 158°F
   9. The JACE must be capable of operation over a humidity range of 5 to 95% RH, non-condensing.

D. The JACE shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 32 simultaneous users.

E. JACE Alarm Notification and actions:
   1. The JACE shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers. The JACE shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up telephone connection, or wide-area network.
   2. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
      a. To alarm
      b. Return to normal
      c. To fault
   3. Provide for the creation of a minimum of eight of alarm classes (Must contain building name) for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
   4. Provide timed (scheduled) routing of alarms by building name and class, object, group or node.
   5. Provide alarm generation from binary object "runtime" and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
   6. Control equipment and network failures shall be treated as alarms and annunciated.
   7. Alarms shall be annunciated in any of the following manners as defined by the user:
      a. Screen message text
      b. Email of the complete alarm message to multiple recipients. Provide the ability to route email alarms based on:
         1) Day of week
         2) Time of day
         3) Recipient
      c. Graphic with flashing alarm object(s).
   8. The following shall be recorded by the JACE for each alarm (at a minimum):
      a. Time and date
      b. Location (building, floor, zone, office number, etc.)
      c. Equipment (air handler #, access way, etc.)
      d. Acknowledge time, date, and user who issued acknowledgement.
      e. Number of occurrences since last acknowledgement.
   9. Alarm actions may be initiated by user defined programmable objects created for that purpose.

10. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
11. A log of all alarms shall be maintained by the JACE and/or a server (if configured in the system) and shall be available for review by the user.
12. Provide a "query" feature to allow review of specific alarms by user defined parameters.
13. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
14. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

F. JACE Data Collection and Storage.
   1. The JACE shall have the ability to collect data for any property of any object and store this data for future use. See points list for required logs.
   2. The data collection shall be performed by log objects, resident in the JACE that shall have, at a minimum, the following configurable properties:
      a. Designating the log as interval or deviation.
      b. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
      c. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
      d. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
   3. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action. All log data shall be archived to a database in the Enterprise Server and the data shall be accessed from a standard Web browser and the Periscope Dashboard.
   4. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL, BQL & NQL statements.
   5. All log data shall be available to the user in the following data formats:
      a. HTML
      b. XML
      c. Plain Text
      d. Comma or tab separated values.
   6. Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.
   7. The JACE shall have the ability to archive its log data remotely to a server on the network. Provide the ability to configure the following archiving properties, at a minimum:
      a. Archive on time of day
      b. Archive on user-defined number of data stores in the log (buffer size)
      c. Archive when log has reached its user-defined capacity of data stores
      d. Provide ability to clear logs once archive.

G. JACE Audit Log
   1. Provide and maintain an Audit Log that tracks all activities performed on the JACE. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log to a server. For each log entry, provide the following data:
      a. Time and date
      b. User ID
      c. Change or activity: i.e., Change set point, add or delete objects, commands, etc.

H. JACE Database Backup & Storage

1. The JACE shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval. Enterprise Developer shall coordinate with Owner to establish/implement a backup procedure.
2. Copies of the current database and, at the most recently saved database shall be stored in the JACE. The age of the most recently saved database is dependent on the user-defined database save interval.
3. The JACE database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

I. JACE Time Sync
1. Use the NtpPlatformServiceQnx in the Station/Services/PlatformServices/ NtpPlatformServiceQnx. Use Time Servers greenarrow@uncc.edu and greenlatern@uncc.edu

J. JACE Weather Station/ODA Temperature
1. The Web Supervisor has a dedicated weather station that will be available through the Niagara Network. While the Jace is not on the UNCC Network and for backup purposes all buildings are required to have their own Outdoor Air Temperature sensor to be used for economizer and other requirements but also be able to be overridden by the Web Supervisor Outdoor Air Temperature.
2. Also available from the Web Supervisor is Outdoor Humidity, Dew point and Wet Bulb.
3. The weather station in the Services of the Station should also be enable and set for Charlotte NC
4. At this time Air Quality is not enable due to conditions beyond our control. Therefor this property should be set to False.

K. JACE Loading.
1. UNCC desires for the SI to design the system to properly load balance across multiple JACEs. I.e.; UNCC does not want 1 Jace operating at 80% and another is operating at 20%

2.6 INTEGRATED DEVELOPMENT ENVIRONMENT (IDE)

A. It is the intent of UNCC to manage and maintain all Niagara devices on the BAS network to the same Niagara approved version. It is also the intent of UNCC to upgrade the version of Niagara once a year in April. However an upgrade to Niagara may be performed at any time based upon UNCC's discretion. It is the FMCS Systems Contractor's responsibility to check the currently installed/approved version of Niagara campus and to attain and perform any deployment with the current UNCC approved version.

B. An integrated development environment for development of graphic screens, control logic, security, alarm notification and data storage has been established using the Niagara Workbench Tool and currently resides on a Server in the existing data center and several laptops. The successful FMCS Contractor shall utilize its own laptop for all programming and graphical development. The Enterprise Developer shall utilize the IDE at the server via a VPN connection or its own separate laptop IDE. The IDE residing on the central server shall be the most current version of the Niagara Workbench toolset and the FMCS Contractor shall utilize the exact same version when programming JACE s.

C. The server and JACE IDE tools shall be identical; however, it shall be possible to limit views and commands via a unique user profile and password in either. The IDE shall include a quick viewing of, and access to, the hierarchical structure of the database. Menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to,

forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

D. System Diagnostics. The system shall automatically monitor the operation of all workstations, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

E. Alarm Management:
   1. The system will be provided with a dedicated alarm window or console. Refer to Sequence of Operations/Points List for Alarm strategies. The Alarm Console will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator. Alarms shall be created and grouped per the owner's requirements by the FMCS Contractor at the JACE level. The Enterprise Developer shall bring the JACE alarms into the existing Enterprise server and generate the strategies to send alarms to the appropriate city or contractor parties.
   2. Alarms shall be capable of being routed to any of the following:
      a. Local Alarm Console (by FMCS Systems)
      b. Remote Alarm Station (by Enterprise Developer)
      c. Email recipient (multiple if needed) (by Enterprise Developer)
   3. When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable. Alarms shall be able to be mapped into groupings where the groupings have common displays, sounds or hyperlinks. This grouping shall be used to distinguish alarms when alarms are coming in from multiple sites or classes (i.e. buildings, regions, trades, etc) for faster recognition.
   4. The system shall be provided with an alarm database management view. The view shall allow a user with appropriate password to:
      a. Filter or Clear old records before a certain date and time
      b. Clear records older than the currently highlighted record
      c. Clear all records
      d. Modify the alarm table options including which alarm details are displayed, column width, etc.
      e. Export the alarm database records to .pdf, text or CSV formats.
      f. There will be 4 Alarm Classes, Critical Alarms Class, Non Critical Alarms Class, Maintenance Alarms Class and Network Alarm Class. There will be 5 Alarm Consoles one for each Class and a Master where all 4 go to one console. All Alarm classes and console will have the building name included ie; **Friday Critical Alarm Class and Friday Critical Alarm Console.**

2.7 WEB BROWSER CLIENTS

A. The system shall also allow use of an unlimited number of clients using a standard Web browser including Chrome and Firefox™ (preferred). The system shall be capable of providing a rich user experience (including full use of the engineering toolset) through the use of java applets or a simple user interface using only HTML, CSS and JavaScript. Refer to Sequence of Operations for the client side display types that are required on this project.
   1. Acceptable Browsers:
      a. Firefox™
      b. Google Chrome

B. The Web browser shall provide the same view of the graphics, schedules, calendars, logs, etc. as is provided by the Graphical User Interface and match the look and feel of

graphics in the Web Supervisor. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

1. The Web browser client shall support at a minimum, the following functions:
2. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
3. Graphical screens developed for the GUI shall be the same screens used for the Web browser client (unless clearly stated in the sequence of operation). Any animated graphical objects supported by the GUI shall be supported by the Web browser interface. Enterprise Developer shall provide a FMCS Contractor with a basis of performance/expectation for GUI. FMCS Contractor shall use this standard graphic template or modify the graphics slightly to achieve the desired specification requirement/outcome.
4. Storage of the graphical screens shall be in the Java Application Control Engine (JACE) and these graphics shall be "learned" by the Enterprise Server via **Export tagging.**
5. Jace will be set up for Export Tagging to UNCC_AXWS following proper Niagara standards.
6. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
7. Owner shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
    a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
        1) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
        2) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
    b. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
    c. View logs and charts
    d. View and acknowledge alarms
    e. Setup and execute SQL queries on log and archive information.
8. The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide each specific user a defined home page based on their usage requirements. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
9. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.
10. Graphics on JACE shall not have more than 2 tabbed panes and have a "load" time not exceeding 5 seconds.
11. Navigation page will follow this layout;
    a. Home page – Main landing page with menu and a picture of the building.
    b. Floor Plans, under floor plans folder are the individual floor plans and under them the individual VAV's (meters and lighting to be shown on floor plan with layers and a legend.)
    c. Systems
    d. Equipment

e. Alarms
f. Schedules
g. Meters
   1) Power
   2) Water
   3) Gas
h. Documents (PDFs and Visio files)

12. Tagging required on all projects. Points shall be tagged appropriately with Haystack, Niagara, and UNCCs tag libraries. Equipment shall be tagged with the same name as on the drawings. See template for examples.
13. Alarms are required when network or controllers go down.
14. Alarms shall include out of range source information.
15. All PID set point adjustments on a secure/hidden graphic. This file will be restricted by the system administrator.
16. Autotune is not acceptable and will be disabled.
17. Network punchdown blocks are required.
18. Legends to show what the different colors are (See ANNEX L 2.4)
19. All floorplans to in a SVG or Scalable Vector Format.
20. Layouts shall be designed for screen Resolution 1366x800
21. VAV summary Page - Room Temp, Act temp, set point, damp position, reheat valve position, supply air temp, override color
22. Page for Max Terminal Box used for Set Point Calculation to allow for step up or step down of air flow. Ability to disable and enable vav boxes in calculation
23. Show what points are in override, down, stale, in Alarm, and fault. (See proper color scheme in ANNEX L 2.1 Default Colors)
24. Label units (ahu) to show what they feed
25. Network diagram to show jace network inter-connectivity
26. Jaces to use outside air temp and campus weather station for temperatures
27. Valves need to be labeled and position shown.
28. All flow meters and temperatures need to be trended
29. Page to show sequences tcva tcb valves
30. Page definitions with standards - AHU, CHW, Floorplan, VAV pages, DHW summary page, VAV summary page, water and gas meter page, electric meter
31. Insert maps (key plan) when zoomed in floor plans
32. Thermostat box on vav page
33. Lighting floor plan
34. Show where meters are in the building, show icon on floor plan and link back to summary page.
35. Floorplan zones - don't use conflicting colors
36. Control diagram show network addresses for each device
37. Control valve Tuning required on the graphics.
38. DomHW.px water temp, tank name
39. PX page naming convention

C. Navigation on left side of page should have the same look and operation as Web Supervisor. See ANNEX L for more details.
D. JACEs shall be on Niagara 4.1 at a minimum or at the latest version Niagara that UNCC is running on the web supervisor. Check with UNCC Facilities Information Systems.

2.8 SERVER FUNCTIONS & HARDWARE

A. Provide a general, intuitive navigational path from the server to the JACEs. Store all required O&M data sheets, drawings, help files, etc on the server from the UNCC approved Web Supervisor Contractor (Activelogix).

B. All JACEs to be JACE 8000s Vykon only jaces.

2.9 SYSTEM PROGRAMMING

A. The Jace's Graphical User Interface software (GUI) shall provide the ability to perform system programming and graphic display engineering as part of a complete software package. Access to the programming functions and features of controllers need to be accessible through the Jace/GUI through password access as assigned by the system administrator.

B. A library of control, application, and graphic components shall be provided to enable the creation of all applications and user interface screens. Applications are to be created by selecting the desired control components from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display components to the application components to provide "real-time" data updates. Any real-time data value or component property may be connected to display its current value on a user display. Systems requiring a separate software tool to create applications and browser user interface displays shall not be acceptable.

C. Programming Methods:

1. Power Fail Protection - All System set points, proportional band, control algorithms and any other programming parameters shall be stored such that a power failure of any duration does not necessitated reprogramming the ASC or FPC.
2. Provide the capability to copy components from the supplied libraries, or from a user-defined library to the user's application. Component shall be linked by a graphical linking scheme by dragging a link from one component to another. Component links will support one-to-one, many-to-one, or one- to-many relationships. Linked components shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to components on other pages for easy identification. Links will vary in color depending on the type of link; i.e., internal, external, hardware, etc.
3. Configuration of each component will be done through the component's property sheet using fill-in the blank fields, list boxes, and selection buttons requiring the use of custom programming, scripting language, or a manufacturer-specific procedural language for every component configuration will not be accepted.
4. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
5. All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database component s shall not be allowed.
6. The system shall support component duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.
7. All PIDs shall have adjustable set point exposed to the graphics in a secure/hidden page.

D. Network and Device Naming Conventions.
   1. All Network names will not have spaces or underscores. I.e.; BacnetNetwork is acceptable. Bacnet Network is not acceptable.
   2. Device names will not have spaces, underscores are acceptable. VAVs must have a room name associated with it. I.e.; VAV1_1Rm126. The #1 after VAV corresponds with the floor it is on and the digit after the underscore identifies the VAV.
   3. All Network and Device names must be kept to a minimum and subject to UNCC acceptance.

2.10 COMPONENTS LIBRARIES

A. A standard library of components shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
B. The components in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group components created in their application and store the new instances of these components in a user-defined library.
C. In addition to the standard libraries specified here, the supplier of the system shall maintain an on-line accessible (over the Internet) library, available to all registered users to provide new or updated components and applications as they are developed.
D. Contractor will use the Niagara template station file as provided by FM FIS. The template station will be made available to the FMCS Contractor upon request via standard RFI.
E. Contractor shall not use any "non-standard" or OEM JAR files unless approved by FM FIS. A JAR is considered "non-standard" if it is not included in Tridium's "Niagara AX Developer" release made available to developers and to OEM partners. An example of a non-standard JAR is "jcigrahicssmall.jar". A current list of approved JARs will be made available to the FMCS Contractor upon request via standard RFI.
   Source codes made available to FIS to store and use.
F. Any approved non-standard JAR files become property of UNCC with a copy of the source code to store and use
G. All control components shall conform to the control component specified in the BACnet specification.
H. The component library shall include components to support the integration of devices connected to the Java Application Control Engine (JACE). At a minimum, provide the following as part of the standard library included with the programming software:
   1. LonMark/LonWorks devices. These devices shall include, but not be limited to, devices for control of HVAC, lighting, access, and metering. Provide LonMark manufacturer-specific components to facilitate simple integration of these devices. All network variables defined in the LonMark profile shall be supported. Information (type and function) regarding network variables not defined in the LonMark profile shall be provided by the device manufacturer.
   2. For devices not conforming to the LonMark standard, provide a dynamic component that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file, resource file and documentation for the device to facilitate device integration.
   3. For BACnet devices, provide the following components at a minimum:
      a. Analog In
      b. Analog Out
      c. Analog Value
      d. Binary
      e. Binary In

f. Binary Out
g. Binary Value
h. Multi-State In
i. Multi-State Out
j. Multi-State Value
k. Schedule Export
l. Calendar Export
m. Trend Export
n. Device

4. For each BACnet component, provide the ability to assign the component a BACnet device and component instance number.
5. For BACnet devices, provide the following support at a minimum:
   a. Segmentation
   b. Segmented Request
   c. Segmented Response
   d. Application Services
   e. Read Property
   f. Read Property Multiple Write Property
   g. Write Property Multiple
   h. Confirmed Event Notification
   i. Unconfirmed Event Notification
   j. Acknowledge Alarm
   k. Get Alarm Summary
   l. Who-has
   m. I-have
   n. Who-is
   o. I-am
   p. Subscribe COV
   q. Confirmed COV notification
   r. Unconfirmed COV notification
   s. Media Types
   t. Ethernet
   u. BACnet IP Annex J
   v. MSTP
   w. BACnet Broadcast Management Device (BBMD) function
   x. Routing

2.11 LONWORKS NETWORK MANAGEMENT

A. The Graphical User Interface software (GUI) shall provide a complete set of integrated LonWorks network management tools for working with LonWorks networks. These tools shall manage a database for all LonWorks devices by type and revision, and shall provide a software mechanism for identifying each device on the network. These tools shall also be capable of defining network data connections between LonWorks devices, known as "binding". Systems requiring the use of third party LonWorks network management tools shall not be accepted.
B. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.
C. The network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices, and to view health and status counters within devices.
D. These tools shall provide the ability to "learn" an existing LonWorks network, regardless of what network management tool(s) were used to install the existing network, so that existing LonWorks devices and newly added devices are part of a single network management database.

E. The network management database shall be resident in the Java Application Control Engine (JACE), ensuring that anyone with proper authorization has access to the network management database at all times. Systems employing network management databases that are not resident, at all times, within the control system, shall not be accepted.

F. All LonNetworks must be installed to industry standards and are not exceed a max length of 3500 ft. Wire is to be installed in separate conduit if non-plenum and installed in accordance with proper lon specifications, no more than 60 devices and no Lon repeaters, point and trend counts to assure proper polling of devices and points. Plenum cable is allowed without conduit with University approval. All points and devices are required to update correctly and not go into fault, stale or offline. Proof of network reliability by means of but not limited to LonNetwork Scan tool, Oscilloscope and Polling Service. Copies of these operations are to be submitted to UNCC before warranty period begins.

2.12 BACNET/MSTP NETWORK MANAGEMENT

A. The Java Application Control Engine shall support the integration of device data from BACnet TCP/IP or BACnet MSTP system devices. The connection to the BACnet system shall be via an RS485, or Ethernet IP as required by the device prior UNCC approval is required for IP/Ethernet controls and only through the secondary IP port of the Jace.

B. Provide the required components in the library, included with the Graphical User Interface programming software, to support the integration of the BACnet system data into the FMCS. Components provided shall include at a minimum:
   1. Read/Write BACnet AI Points
   2. Read/Write BACnet AO Points
   3. Read/Write BACnet AV Points
   4. Read/Write BACnet BI Points
   5. Read/Write BACnet BO Points

C. Read/Write BACnet BV Points, All scheduling, alarming, logging and global supervisory control functions, of the BACnet system devices, shall be performed by the Java Application Control Engine.

D. The FMCS supplier shall provide a BACnet system communications driver. The equipment system vendor that provided the equipment utilizing BACnet shall provide documentation of the system's interface and shall provide factory support at no charge during system commissioning

E. BACnet Conformance:

F. Logic controllers shall as a minimum support MS/TP BACnet LAN type. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as native BACnet devices. Logic controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:
   1. Files Functional Group
   2. Reinitialize Functional Group
   3. Device Communications Functional Group
   4. 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.

G. All BacNetworks must be installed to BacnetNetwork industry standards with attention to number of devices, routers, and overall length, point and trend counts to assure proper polling of devices and points. All points and devices are required to update correctly and not go into fault, stale or offline. Proof of network reliability by means of

but not limited to BacnetNetwork Scan tool, Oscilloscope and Polling Service. Copies of these operations are to be submitted to UNCC before warranty period begins.

2.13 COMMUNICATING THERMOSTATS

A. The manufacturer of the Thermostat hardware and software components must be primarily engaged in the manufacture of BAS as specified herein, and must have been so for a minimum of five (5) years.
B. The manufacturer shall be ISO 9001:2000 certified. This is to insure that all manufacturing, design and support policies comply with a minimum quality assurance standard. Corporate quality assurance policies should be available for examination upon request by the owner or his agent.
C. The manufacturer of the hardware and software components shall have a technical support group accessible via a toll free number that is staffed with qualified personnel, capable of providing instruction and technical support service for networked control systems.
D. Communicating Thermostats shall be LON or BACnet thermostats. FMCS Contractor shall standardize on a single protocol for all thermostats and IDC/IBCs (if non thermostat controllers are needed) provided, i.e. all controllers provided shall be of the same protocol. This does not necessarily apply to controllers provided in other sections of the specification as there may be limited choices, but when possible, standardize on a single protocol
E. Acceptable providers of the Communicating Thermostat hardware and software components as specified herein are as follows. Acceptance as a product provider does not provide approval to be an acceptable FMCS Systems Integrator.

2.14 LON DEVICES (IDC)

A. The manufacturer of the hardware and software components must be primarily engaged in the manufacture of BAS as specified herein, and must have been so for a minimum of five (5) years.
B. The manufacturer shall be ISO 9001:2000 certified. This is to insure that all manufacturing, design and support policies comply with a minimum quality assurance standard. Corporate quality assurance policies should be available for examination upon request by the owner or his agent.
C. The manufacturer of the hardware and software components shall have a technical support group accessible via a toll free number that is staffed with qualified personnel, capable of providing instruction and technical support service for networked control systems.
D. Acceptable manufacturers of the DDC hardware and software components as specified herein are as follows. Acceptance as a product manufacturer does not provide approval to be an acceptable FMCS Systems Integrator.
E. Communicating Thermostats shall be LON or BACnet thermostats. FMCS Contractor shall standardize on a single protocol for all thermostats and IDC/IBCs (if non thermostat controllers are needed) provided, i.e. all controllers provided shall be of the same protocol. This does not necessarily apply to controllers provided in other sections of the specification as there may be limited choices, but when possible, standardize on a single protocol
F. Acceptable manufacturers of the VFD hardware and software components as specified herein are as follows. Acceptance as a product manufacturer does not provide approval to be an acceptable FMCS Systems Integrator.

2.15 BACNET DEVICES (IBC)

A. The manufacturer of the hardware and software components must be primarily engaged in the manufacture of BAS as specified herein, and must have been so for a minimum of five (5) years.
B. The manufacturer shall be ISO 9001:2000 certified. This is to insure that all manufacturing, design and support policies comply with a minimum quality assurance standard. Corporate quality assurance policies should be available for examination upon request by the owner or his agent.

C. The manufacturer of the hardware and software components shall have a technical support group accessible via a toll free number that is staffed with qualified personnel, capable of providing instruction and technical support service for networked control systems.
D. Acceptable manufacturers of the DDC hardware and software components as specified herein are as follows. Acceptance as a product manufacturer does not provide approval to be an acceptable Systems Integrator.
E. Acceptable manufacturers of the VFD hardware and software components as specified herein are as follows. Acceptance as a product manufacturer does not provide approval to be an acceptable FMCS Systems Integrator.

2.16 LON/BACNET CONTROLLER(S) STANDARDS

A. Where possible provide LON Controllers or BACnet Controllers that can meet the required sequence of operation and can be configured rather that custom programmed. All controllers shall be designed for easy installation and servicing including removable enclosures, removable terminals, and factory applied labels for all I/O. All internal points shall be fully supported by the Graphical User Interface (GUI), allowing the user to easily modify them and monitor them. All of the internal programming points (e.g. variables, constants, PID's, timers, inputs and outputs) shall be exposed to the network on dedicated network variable outputs.
B. Performance Standards for Inputs - Provide software selectable universal inputs. Analog inputs - shall have the following minimum level of performance: 10 bit A to D resolution; manage thermistors with an accuracy of: ±0.9oF, and a Potentiometer. For VAV Applications provide a differential pressure input sensor built in to the controller with an adjustable range of .05" to 2" H20 (125-300PA) static pressure with a minimum accuracy of + or – 3%. Minimum response time shall be 0.5 seconds from input to output time.
C. Performance Standards for Outputs – Analog outputs shall have the following minimum level of performance: Tri-mode Voltage of 0-10 VDC (linear), digital 0-12 VDC (off/on) or PWM. All analog outputs shall be equipped with an auto-reset fuse. Output Resolution shall be a minimum 8 bits digital / analog converter. Digital outputs shall be provided with a minimum of a triac output rated at 24VAC and 1 amp. All analog outputs and power supply shall be fuse protected
D. Application Specific Controllers (ASC) - A controller designed through its I/O configuration and configurable control logic to be used for a specific type mechanical equipment. Typical applications are VAV boxes, Fan Coil Units, Roof Top Units, Unit Ventilators, Split DX Systems, and Heat Pumps. Lighting Controls, etc. All ASC's shall conform to the LonMark or BACnet standards so long as such a standard exists for its intended application. The ASC shall allow the use of its spare I/O as dumb I/O to be shared over the network to JACE where a sequence of operation can be applied to the I/O. Such applications shall include but not be limited to exhaust fan control, heaters, light control, etc. Freely Programmable Controllers (FPC) shall be a controller designed for more complex sequences of operations such as built up AHU's, central plant operations, electrical monitoring, and control and management for chillers, boilers and generators. These FPCs are to allow for the flexibility of custom control programming to meet the needed sequences of operation.

2.17 MODBUS SYSTEM INTEGRATION

A. Java Application Control Engine (JACE) shall support the integration of device data from Modbus RTU, ASCII, or TCP control system devices. The connection to the Modbus system shall be via an RS-232, RS485, or Ethernet IP as required by the device.
B. Provide the required components in the library, included with the Graphical User Interface programming software, to support the integration of the Modbus system data into the FMCS. Components provided shall include at a minimum:
    1. Read/Write Modbus AI Registers
    2. Read/Write Modbus AO Registers
    3. Read/Write Modbus BI Registers
    4. Read/Write Modbus BO Registers
C. All scheduling, alarming, logging and global supervisory control functions, of the Modbus system devices, shall be performed by the Java Application Control Engine.

D. The FMCS supplier shall provide a Modbus system communications driver. The equipment system vendor that provided the equipment utilizing Modbus shall provide documentation of the system's Modbus interface and shall provide factory support at no charge during system commissioning.
E. Provide a Modbus Interface to the following equipment:
   1. switchgear
   2. packaged pumping system
   3. building energy metering
F. A copy of Modbus Registers must be included in HTML format for each device in the files/lib/ModbusReg of the JACE
G. If more than one brand of Modbus devices are on the same Modbus network each brand may need to have its own dedicated Modbus network to avoid Modbus network communication issues. If multiple brands are on the same network Contractor will need to prove proper communications and have UNCC approval before warranty period begins.
H. All ModbusNetworks must be installed to ModbusNetwork industry standards with attention to number of devices, routers, and overall length, point and trend counts to assure proper polling of devices and points. All points and devices are required to update correctly and not go into fault, stale or offline. Proof of network reliability by means of but not limited to ModbusNetwork Scan tool, Oscilloscope and Polling Service. Copies of these operations are to be submitted to UNCC before warranty period begins.

2.18 THIRD PARTY INTEGRATION

A. The Java Application Control Engine shall support the integration of device data from the existing control system. The connection to the existing system shall be via an RS-232 or RS485 connection between the Java Application Control Engine and the existing control system {if applicable on this project}.
B. Provide the required data points from the third party integration per sequence of operations and/or points list.
C. All Third Party Networks must be installed to industry standards with attention to number of devices, routers, and overall length, point and trend counts to assure proper polling of devices and points. All points and devices are required to update correctly and not go into fault, stale or offline. Proof of network reliability by means of but not limited to Scan tool, Oscilloscope and Polling Service. Copies of these operations are to be submitted to UNCC before warranty period begins.

2.19 SENSORS (3 names, remove and/or equal)

A. All control items, except thermostats, sensors and transmitters located in rooms shall be properly identified with engraved plastic nameplates permanently attached. Nameplates shall have white letters on a black background.
B. All sensors shall be provided in NEMA 4X enclosures where exposed to the Pool environment.
C. Room thermostat, sensor and transmitter locations shall be coordinated to align vertically or horizontally with adjacent light switches or other control devices. Room thermostats and sensors shall be mounted with the bottom 5'-0" above the floor. Sensors installed in areas where they are subject to physical abuse (ex: gymnasiums) shall be furnished with protective type aspirating guards. Sensors installed on exterior walls shall be installed on non-conductive (cork) sub-base. Sensors shall have plus or minus local set point control feature.
D. Temperature Sensors: Thermistor type with an accuracy of plus or minus 0.40 degree F over the entire control range. Sensors for pipe installations shall be immersion type,

brass well, and thermistor with integral lead wire. Sensors for duct application shall be insertion probe type, stainless steel probe, integral handibox, and thermistor with integral lead wire. Space temperature sensors shall be compatible with the unit controller and shall be provided in a decorative metal or plastic enclosure (Nema 4X where exposed to pool environment). Space temperature sensors shall be provided with set point and temperature indication only. Outdoor temperature sensors shall be mounted inside a protective weather and sun shield and shall be located on a North wall.

E. Humidity Sensors: Thin-film capacitive type sensor with on-board nonvolatile memory, accuracy to plus or minus two percent (2%), 12 - 30 VDC input voltage, analog output (0 - 10 VDC). Operating range shall be 5 to 95% RH and -40 to 170 degree F. Duct mounted type sensors shall have a stainless steel insertion element, sealed to prohibit corrosion. Sensors shall be selected for wall, duct or outdoor type installation as appropriate.

F. Carbon Dioxide Sensors (CO2): Sensors shall utilize Non-dispersive infrared technology (N.D.I.R.), repeatable to plus or minus 20 PPM. Sensor range shall be 0 - 2000 PPM. Accuracy shall be plus or minus five percent (5%) or 50 PPM, whichever is greater. Response shall be less than one minute. Input voltage shall be 20 to 30 VAC/DC. Output shall be 0 - 10 VDC. Sensor shall be wall or duct mounted type, as appropriate for the application, housed in a high impact plastic enclosure required in all classrooms and labs.

G. Carbon Monoxide and Nitrogen Dioxide Dual Gas Detection System (CO/NO2): (Service Bays):

1. Dual gas detection system:
   a. The detection system shall consist of one integral CO sensor and one remote NO2 sensor.
   b. CO and NO2 sensors shall be electrochemical. Twinset sensors shall be equipped with compensatory circuits for variations in relative humidity and temperature and maintain a high level of accuracy. The Twinset unit will be capable of operating within relative humidity ranges of 15-90% and temperature ranges of 32degF to 104degF (0oC to 40oC) with an optional capacity of operating at extended temperature ranges.
2. The unit is manufactured within an ISO 9001-2000 production environment.
3. The unit alarm levels are to activate fans, dampers and alarms and the unit is to be installed in accordance with the following parameters:
   a. The CO operating levels shall typically be 35 PPM, 100PPM and 100PPM 30 minutes time-delayed (1-60min adjustable) for the LOW, HIGH and ALARM levels respectively.
   b. NO2 operating levels shall typically be 1PPM, 2PPM and 3PPM for LOW, HIGH and ALARM levels respectively.
   c. The sensor shall have typically three SPDT relay contacts to operate at the selected operating levels, visual indicators and an alarm buzzer. The operating levels can also be programmed to have different time delays.

Table of factory default operating levels	FIRST ALARM SET POINT (LOW)	SECOND ALARM SET POINT (HIGH)	THIRD ALARM SET POINT (ALARM)	RADIUS OF COVERAGE
Carbon Monoxide (CO)	35 PPM	100 PPM	100PPM 30Min	50 feet
Diesel (NO_2)	1 PPM	2 PPM	3PPM	50 feet

4. Sensing element shall require no more than a yearly calibration. CO and NO2 sensors shall have a maximum life of 2 years whereas combustible gas sensors shall have a maximum life of 3 years

5. The unit shall be housed in a NEMA 3 robust PVC enclosure.
6. The remote sensor to control unit field wiring shall be done by using 2 x #18 (for CO/NO2) or 3 x # 18 (for combustible gas) low voltage wires.
7. Acceptable:
   a. Base:
   b. Optional:

H. Combustible Gas Detection (Service Bays)
1. Combustible gas detection:
   a. The detection system shall consist of one combustible gas sensor.
2. Combustible sensors shall be catalytic bead (pellistors). Sensors shall be equipped with compensatory circuits for variations in relative humidity and temperature and maintain a high level of accuracy. The UNISET unit will be capable of operating within relative humidity ranges of 15-90% and temperature ranges of 32degF to 104degF (0oC to 40oC) with an optional capacity of operating at extended temperature ranges
3. The unit is manufactured within an ISO 9001-2000 production environment.
4. The unit alarm levels are to activate fans, dampers and alarms and the unit is to be installed in accordance with the following parameters.
5. Combustible Gas operating levels shall typically be 20%, 30% and 40% L.E.L. for LOW, HIGH and ALARM levels respectively. The unit shall have typically three SPDT relay contacts to operate at the selected operating levels, visual indicators and an alarm buzzer. The operating levels can also be programmed to have different time delays.

Table of factory default operating levels	FIRST ALARM SET POINT (LOW)	SECOND ALARM SET POINT (HIGH)	THIRD ALARM SET POINT	RADIUS OF COVERAGE
Combustibles	20% L.E.L.	30% L.E.L.	40% LEL	25 feet

6. Sensing element shall require no more than a yearly calibration. Combustible gas sensors shall have a maximum life of 3 years.
7. The sensor shall be housed in a NEMA 3 robust PVC enclosure. Explosion-proof enclosure is also available.
8. The remote sensor to control unit field wiring shall be done by using 4 x # 18 (for combustible gas) low voltage wires.

I. Differential Air Pressure Switch: Differential pressure switches for proving fan operation or sense dirty air filters shall be SPDT type, UL approved, and selected for the appropriate operating range of the equipment to which it is applied. Sensor shall have ¼" compression type fittings and shall have an adjustable set point. Furnish with ¼" barbed type static pressure tips.

J. Current Switches (Type 1): For proving fan or pump operational status, provide solid or split-core type current status switches with adjustable set point and solid-state internal circuitry. Current switch shall have induced power, trip point set adjustment to plus or minus 1% over a range of 1 to 135 amps, trip and power LED, and field adjustable to indicate both On-Off conditions and loss of load (broken belt, etc.). Units shall have a five-year manufacturer's warranty.

K. Current Switches (Type 2): For proving fan or pump operational status, provide solid or split-core type current switches ("Go/No" type). Current switch shall have induced power, 100 percent solid state with no moving parts. Units shall have a five-year manufacturer's warranty.

L. Low Temperature Sensors: For sensing low temperatures in air handling units, provide SPST type switch, 35 to 45 degree F range, manual reset, vapor charged twenty foot long sensing element, and 120- volt electrical power connection.

M. Pressure Transmitters: For sensing static pressure in a duct system (usually for VAV systems), provide a pressure transmitter with integral capacitance type sensing action, solid state circuitry, accuracy of plus or minus 1% of range, zero and span adjustments, 10 to 35 VDC operating voltage, 4 to 20mA output, and integral inlet port connections. Select pressure range suitable for the application.

N. Line Voltage Thermostats: For control of equipment using line voltage on-off thermostats (exhaust fans, unit heaters, etc.) provide 120 volt UL Listed wall mounted thermostats. Thermostat shall have a range of 50 to 90 degree F with minimum 2 degree F differential, snap acting switch, and dial adjustment for temperature setting.

O. Firestat: For sensing sudden increases in duct temperature (ex: fire condition), provide 120 volt UL Listed SPST switch with adjustable setpoint that breaks the circuit on a rise in temperature above the setpoint and de-energizes the air handling unit fan.

P. Aquastat: For sensing temperature of a fluid within a pipe system, provide 120-volt SPST strap-on type aquastat, temperature control range of 100 to 240 degree F (adjustable).

Q. Air Flow Monitoring Device:
   1. Provide airflow/temperature measurement devices (ATMD) where indicated on the plans. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices indicated on the plans.
   2. Each ATMD shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.
      a. Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
      b. Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.
      c. The airflow rate of each sensor assembly shall be equally weighted and averaged by the transmitter prior to output.
      d. The temperature of each sensor assembly shall be velocity weighted and averaged by the transmitter prior to output.
      e. Each transmitter shall have a 16-character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics.
   3. All Sensor Probes
      a. Each sensor assembly shall independently determine the airflow rate and temperature at each measurement point.
      b. Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).
      c. Airflow accuracy shall be +/-2% of Reading over the entire operating airflow range.
         1) Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
      d. Temperature accuracy shall be +/-0.15° F over the entire operating temperature range of -20° F to 160° F.
      e. The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).
      f. Each sensor probe shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.

g. Each sensor assembly shall not require matching to the transmitter in the field. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.

4. Duct and Probes
   a. Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.
   b. Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:
      1) Insertion mounted through the side or top of the duct
      2) Internally mounted inside the duct or plenum
      3) Standoff mounted inside the plenum
   c. The number of sensor housings provided for each location shall be as follows:
      Total #

Duct Area (sq.ft.)	Sensors / Location
< 2	4
2 to < 4	6
4 to < 8	8
8 to < 16	12
>= 16	16

   d. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

5. Fan Inlet Probes
   a. Sensor assemblies shall be mounted on 304 stainless steel housings.
   b. Mounting rods shall be field adjustable to fit the fan inlet and constructed of nickel plated steel.
   c. Mounting feet shall be constructed of 304 stainless steel.
   d. The operating airflow range shall be 0 to 10,000 FPM unless otherwise indicated on the plans.

6. Transmitters
   a. The transmitter shall have an integral LCD display capable of simultaneously displaying airflow and temperature. The LCD display shall be capable of displaying individual airflow and temperature readings of each independent sensor assembly.
   b. The transmitter shall be capable of field configuration and diagnostics using an on-board pushbutton interface and LCD display.
   c. The transmitter shall have a power switch and operate on 24 VAC (isolation not required).
      1) The transmitter shall use a switching power supply fused and protected from transients and power surges.
      2) The transmitter shall use “watch-dog” circuitry to assure reset after power disruption, transients and brown-outs.
   d. All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.
   e. The operating temperature range for the transmitter shall be -20° F to 120° F. The transmitter shall be installed at a location that is protected from weather and water.
   f. The transmitter shall be capable of communicating with other devices using the following interface option: Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10VDC/4-20mA (4-wire)

7. The ATMD shall be UL listed as an entire assembly.
8. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans.

2.20 DAMPERS AND ACTUATORS (Strip out any brand names)

A. Damper actuators shall be sized by the **FMCS Contractor** for the intended application. Unless noted otherwise, dampers will be furnished by the **FMCS Contractor** for all field installed dampers that are not included as part of the equipment. In general, provide opposed blade type dampers for modulating control and parallel type dampers for two-position control applications.

B. Control Dampers. Provide all automatic control dampers not specified to be integral with other equipment. Frames shall be 5 inches wide and of no less than 16-gauge galvanized steel. Inter-blade linkage shall be within the frame and out of the air stream. Blades shall not be over 8 inches wide nor less than 16-gauge galvanized steel triple V type for rigidity. Bearings shall be acetal, oilite, nylon or ball-bearing with ½ inch diameter plated steel shafts. Dampers shall be suitable for temperature ranges of -40 to 180F. All proportional control dampers shall be opposed or parallel blade type as hereinafter specified and all two-position dampers shall be parallel blade types. Dampers shall be sized to meet flow requirements of the application. The sheet metal contractor shall furnish and install baffles to fit the damper to duct size. Baffles shall not exceed 6". Dampers with dimensions of 24 inches and less shall be rated for 3,000 fpm velocity and shall withstand a maximum system pressure of 5.0 in. wc. Dampers with dimensions of 36 inches and less shall be rated for 2,500 fpm velocity and shall withstand a maximum system pressure of 4.0 in. wc. Dampers with dimensions of 48 inches and less shall be rated for 2,000 fpm velocity and shall withstand a maximum system pressure of 2.5 in. wc. Side seals shall be stainless steel of the tight-seal spring type. Dampers shall be minimum leakage type to conserve energy and the temperature control manufacturer shall submit leakage data for all low leakage control dampers with the temperature control submittal. Maximum leakage for low leakage dampers in excess of sixteen inches square shall be 8 CFM per square foot at static pressure of 1 inch of WC. Low leakage damper blade edges shall be fitted with replaceable, snap-on, inflatable seals to limit damper leakage. Testing and ratings shall be in accordance with AMCA Standard 500. Damper blade width shall be no greater than 8 inches, and dampers over 48 inches wide by 74 inches high shall be sectionalized. Testing and ratings to be in accordance with AMCA Standard 500.

C. Damper Actuators: Damper actuators shall be provided for all automatic dampers. Damper actuators controlled through the DDC system shall be low voltage electronic type, either modulating or two-position, as required to achieve the intended sequence of operation. Provide with spring return when required for fail-safe operation. Modulating dampers shall be positive positioning in response to a 2 – 10 VDC or 4 - 20mA control signal. Actuator shall include the capability of adding auxiliary switches for position indication. Furnish actuators other than spring return type with a release button (clutch) or handle on the actuator to allow for manual override. Power supply to the actuator shall be by 120 VAC, 24 VAC, or 24 VDC and the actuator shall be furnished with a factory installed 3-foot cable with end fitting for field connection. All actuators shall be UL Listed by the manufacturer.

2.21 VARIABLE FREQUENCY DRIVES

A. All Variable Frequency drives including Chilled Water System drives shall be ABB VFD or equivalent. Variable frequency drives shall be UL listed and sized for the power and loads applied. Drives shall include built-in EN 61800-3 Category C2 radio frequency interference

(RFI) filters and be constructed to operate in equipment rooms and shall not be susceptible to electromagnetic disturbances typically encountered in such environments. Similarly, the drives must not excessively disturb the environment within which it is used. All VFDs over 3 horsepower shall be provided with an AC choke. VFDs shall be installed in strict conformance to the manufacturer's installation instructions, and shall be rated to operate over a temperature range of 14 to 104 F.

B. VFD automatic operation shall be provided with a BACnet MSTP, BACNET TCP/IP, Modbus RTU or Modbus TCP/IP communications protocols. Each VFD shall be fan cooled and have an integral keypad and graphical display unit with wizards and built in manuals for user interface.

A. Three types of faults shall be monitored, "FAULT" shall shut the motor down, "FAULT Auto-reset" shall shut the motor down and try to restart it for a programmable number of tries, and "FAULT Trip" shall shut the motor down after a FAULT Auto-reset fails to restart the motor. Coded faults shall be automatically displayed for the following faults:
   1. Over current
   2. Over voltage
   3. Earth ground
   4. Emergency stop
   5. System (component failure)
   6. Under voltage
   7. Phase missing
   8. Heat sink under temperature
   9. Heat sink over temperature
   10. Motor stalled
   11. Motor over temperature
   12. Motor underload
   13. Cooling fan failure
   14. Inverter bridge over temperature
   15. Analog input control under current
   16. Keypad failure
   17. Other product unique monitored conditions

B. In addition to annunciating faults, at the time of fault occurrence the VFD shall capture and make available to the user certain system data for subsequent analysis during fault trouble shooting, including duration of operation (days, hours, minutes, seconds),output frequency, motor current, motor voltage, motor power, motor torque, DC voltage, unit temperature, run status, rotation direction, and any warnings. The last 30 fault occurrences shall be retained as well as the fault data listed in the previous sentence of each fault. New faults beyond 30 shall overwrite the oldest faults.

C. The display unit keypad shall **provide start up wizard and** allow setting operational parameters including minimum and maximum frequency, and acceleration and deceleration times. The display shall offer user monitoring of frequency, unit temperature, motor speed, current, torque, power, voltage, and temperature.

2.22 CONTROL VALVES

A. Control Valves: (Globe Type) Valves shall be 2-way or 3-way pattern as shown constructed for tight shutoff and shall operate satisfactory against system pressures and differentials. Two-position valves shall be 'line' size. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (except as may be noted on the drawings). Two-way water valves shall have equal percentage flow characteristics and three-way valves shall have equal percentage flow characteristics straight through and linear through the bypass. Provide valve position indicator on all valves. Leakage rate shall be no more than 0.05% of Cv.

1. Valves 1/2 inch through 1 1/2 inch shall be screwed pattern except where solder connections are specified for valves 1/2 or 3/4 inches. Three-way valves bypass port shall be of one size reduced Cv to preclude the need for a bypass port balancing valve. Valve and cartridge replacement tool shall be configured for maintenance or replacement without draining the coil to prevent water spill; however, an integral isolation valve on the control valve outlet will also be acceptable. Valves shall close off against 58 psi minimum.
2. Two inch valves shall be "screwed" configuration and 2-1/2 inch and larger valves shall be "flanged" configuration and ANSI-rated to withstand the pressures and temperatures encountered. Valves shall have stainless-steel stems and spring loaded Teflon packaging with replaceable discs.

B. Control Valves: (Characterized Ball Valves) Control valves ½ to 2 inches shall be 2-way or 3-way forged brass screwed pattern as shown constructed for tight shutoff and shall operate satisfactory against system pressures and differentials. Two-position valves shall be 'line' size. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (except as may be noted on the drawings). Two-way water valves shall have equal percentage flow characteristics and three-way valves shall have equal percentage flow characteristics straight through and linear flow through the bypass. Leakage rate shall be ANSI Class IV (no more than 0.01% of Cv). Valves shall be rated for no less than 350 psig at no less than 250 degrees F. provide a removable handle to operate valves manually during actuator power loss or failure.

C. Two-way valves shall close off against 100 psi minimum, and three-way valves shall close off against 40 psi minimum. Valves shall have stainless-steel or chemically nickel-plated brass stem and throttling port. Valves shall be tagged with Cv rating and model number.

D. Butterfly Control Valves: Valves shall be Honeywell or equivalent. Where specified butterfly control valves over 2" in size shall be cast iron body type for 2-way or 3-way applications specified constructed for tight shutoff and shall operate satisfactory against system pressures and differentials. Valves shall have tapped lugs for standard flange connection, and designed for isolation and removal of downstream piping at full rated pressure. Two-position valves shall be 'line' size. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (except as may be noted on the drawings). Valves shall be rated for bubble tight shutoff at no less than 150 psi. Valve disc shall be aluminum bronze. Valve stems shall be stainless steel, with inboard top and bottom bronze bearings, and an external corrosion resistant top bearing to absorb actuator side thrust.

2.23 ELECTRICAL MISCELLANEOUS

A. Panels: All enclosures for DDC controllers and devices shall be fabricated in accordance with UL Standards from code gauge steel. Enclosures shall be provided with a continuous hinge on the door and a flush latching mechanism. Enclosures shall be shop painted with standard grade enamel coating. Back panels shall be furnished when required to facilitate installation of boards or accessories. All enclosures installed outdoors shall be constructed to NEMA 3R standards. All controllers shall be installed within an approved enclosure unless the controller will be installed within the control cabinet section of the equipment that it is intended to control. Enclosures shall facilitate the mounting of gauges, switches, pilot lights, and the like, on the face panel when required. Control devices that are mounted on the face of the panel shall be identified with engraved nameplates.

B. Power Transformers: Step-down power transformers shall be provided for all DDC controllers and associated accessory devices as required. Transformers shall be sized and selected to accommodate all connected accessory items. Transformers shall be UL Listed Class 2 type with 120 VAC primary, 24 VAC secondary.

C. Relays: Miscellaneous control relays shall be provided as required to energize or control equipment and devices within the control system. Relays shall be located as close as practical to the controlled device (motor, motor starter, etc.). Where approved by NC State Building Codes, relays may be installed within starters and equipment control panels where space is available. Relays installed outside of the controlled device shall be provided with a NEMA enclosure suitable for the location where installed.

2.24 ELECTRICAL AND COMMUNICATION WIRING

A. Wiring: All wiring devices and accessories shall comply with the requirements of NC State Building Codes. All wiring shall be installed in a neat and professional manner. Control wiring shall not be installed in power circuit conduits or raceways unless specifically approved for that purpose. All wiring, except plenum wiring (where allowed), shall be run in electrical conduits. Plenum cable will be allowed in concealed locations where accessible. All cable must be installed with 90° angles and strapped according the NC State Building Codes.

B. Provide all interlock and control wiring. Provide wiring as required by functions as specified and as recommended by equipment and device manufacturers to achieve the specified control functions.

C. Low voltage conductors shall be stranded bare or tinned-copper with premium grade polymer alloy insulation. For shielded cable, furnish multi-conductor of overall polyester supported aluminum foil with stranded tinned copper drain wire to facilitate grounding. Coaxial shield shall be copper braided type. Provide shielded cable where recommended by the equipment or device manufacturer, grounded in strict accordance with the manufacture's recommendations.

D. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Terminations for Fire Alarm Control Panel (FACP) interface shall be accomplished by the Electrical Contractor or his designated subcontractor.

E. FMCS Contractor shall provide power for all control devices and components from the closest available power source or as indicated on the power Drawings. When acceptable to the equipment manufacturer, low voltage power may be obtained from the internal equipment power source or transformer. Electrical Power for Systems Contractor's use has been provided at j-boxes located on plans.

2.25 IT or Telecommunication Rooms

A. IT or telecommunication rooms shall be monitored with a minimum of temperature and humidity. Temperature shall be shown on the floor plans. Humidity Alarm - below 30% or above 70% and Temperature Alarm - when over 80°F.

B. HVAC Units/CRAC Units that supply air for rooms with over $100,000 in equipment or supplies conditioned air for over 500 square feet shall be required to have an integration card which shall communicate with the BAS system for alarm monitoring.

PART 3 -EXECUTION

3.1 GENERAL

A. The Facility Management and Control System (FMCS) shall be designed, installed, and commissioned in a turnkey fully implemented and operational manner; including all labor not noted in the "Work by Others" paragraph of Part I of this section of these specifications, and not noted in other sections of these specifications.

3.2 SEQUENCE OF OPERATION

A. General:
   1. HVAC systems shall be controlled with Direct Digital Control (DDC) according to sequence contained in this section of specifications and shall be stand-alone.
      a. Additional points or software programming not listed but which are required to meet following sequences of operation shall be provided.
   2. House controllers, relays, transducers, and other components required for stand-alone control in NEMA 1 enclosure with lockable door.
   3. All VFD's shall be monitored by FMCS for trouble conditions. Signal shall be a set of dry contacts wired to BAS. Operator will use VFD control panel for diagnostics.
   4. Set points:
      a. All set points given in the sequence of operations or in the drawings are for system startup and are preliminary. Optimum operating set points must be determined during actual occupancy and will be affected by many factors. These may include:
         1) Weather conditions.
         2) Building occupancy.
         3) Building utilization patterns.
         4) Variations in building construction.
         5) Variations in operating characteristics of actual installed building equipment.
      b. It is the responsibility of the building operators to determine those settings and operating methods which provide the best balance of operating efficiency and occupant comfort. This is an ongoing process. Optimum settings change as operating conditions change.
      c. Current switches for motor starters shall be set to indicate failure of motor, for motors with VFDs, the setting shall be below normal minimum operating point. For belt driven motors, the setting shall be capable of detecting belt breakage.
   5. The position of all valve and damper actuators shall be communicated to the FMCS.
      a. Modulating actuators: Utilize feedback signal integral to actuator (or equivalent external device).
   6. Two position actuators: Utilize auxiliary contacts integral to actuator (or equivalent external device) to indicate full open position. Full closed position shall also be indicated where specifically required by sequence of operation.
   7. Position feedback shall not be required for air terminal unit, unit heater, or fan coil unit actuators.
   8. Where space temperature sensors have set point adjustment and unoccupied mode override button, the unoccupied mode shall be overridden to occupied mode of operation for one hour (adj.), unless specified otherwise.
   9. Standalone Operation
      a. All DDC controllers that are attached to the FMCS must operate in a "standalone/Occupied" fashion during the loss of communications on any Ethernet network, serial subnetwork, supervisory system, subsystem or peer system

b. All DDC controllers shall revert to the stand-alone mode upon detecting a loss of communication with the relevant system for more than 5 minutes (adj.).
c. If it is not equipped with a RTC
   1) The unit shall default to occupied mode.
d. If equipped with a RTC
   1) The controller shall revert to a default schedule residing in the DDC controllers programming logic.
   2) The FMCS Contractor shall submit the default stand-alone schedule to the owner for approval during the submittal process.
   3) The last value (preferred) or a hardcoded default value shall be used for all set points to maintain acceptable operational levels during communication outages.

10. All Utility Metering History Points: All points that are used for metering and/or are being used in a calculation that is being collected in history shall have the transient flag removed. The Transient Flag Removal program will be provided to installing contractor by FIS Control Dept.
11. Sequence of operation for equipment will be provided by the Universities DOR (Designer of Records)

3.3 OWNER TRAINING

A. General: Owner training shall be executed in four phases. The System Integrator will provide at no cost to the owner, Phase I, Phase II, Phase III and Phase IV training classes. A proposed training agenda will be submitted to the Commissioning Agent in writing, and approved by the Commissioning Agent before the training takes place.

1. The first phase shall take place at the customer job site and will be scheduled at a time preceding owner acceptance. The purpose of the training is to provide an introduction and an overview of the FMS, and ensure owner's laptop is updated with control tools (software and cabling) and functional with installed controllers. (Phase I and Phase II may be combined.)
2. The second phase of training shall be a follow-up training to address specific building system and questions of the operators. Training shall take place at the customer job site and will include a site-specific walk through and hands on site-specific instruction. Completion of this training shall be a condition of system acceptance.
3. Phase III and Phase IV training shall be provided as a follow-up and enrichment to the introductory and site-specific training.

3.4 PHASE I – ON SITE TRAINING

A. This training will be primarily a classroom lecture/demonstration of approximately 1 hour to give the operator with little or no experience an introduction to the FMS. Presentation materials (PowerPoint, handouts) must be provided to the commissioning agent. Phase I may be combined with Phase II.

1. Building automation fundamentals.
2. System architecture and functions as they pertain to the site.
3. System access using the Browser User Interface and FMS software.
4. Example of basic software controller programming and tuning.
5. Editing parameters such as set points and schedules.
6. Developing trends and day to day system monitoring.
7. Troubleshooting tools. (Correlation of graphic display to sequences.)
8. The complete range of hardware and software products.

9. Building walk-thru.

3.5 PHASE II – ON SITE TRAINING

A. The manufacturer and the controls contractor shall provide 6 hours of on-site training in the maintenance and operation of the installed system for up to (4) personnel. The training shall be documented and a syllabus and O&M manuals shall be submitted and approved by the commissioning agent 2 weeks prior to the training. The training should include the following:

1. HVAC systems layout including the locations of air handlers, DDC controllers, VAV boxes, pumps. This will include a walk-thru at the building.
2. Review of O&M manual and control system as-builts:

    a. Using As-Built documentation, Sequences of operation, control drawings, input/output summaries.
    b. Field sensor and actuator location and maintenance.
    c. Field controller location and maintenance.
    d. FMS hardware operation and maintenance.
    e. FMS software site specific capabilities.

3. Sequence of operations for each control loop.

4. Operation and troubleshooting including:

    a. Modification of ASC or FPC setpoints, parameters, etc.
    b. Calibration and adjustment.
    c. Trending.
    d. Hands on training in the troubleshooting and replacement of components including sensors, transmitters, control valves and actuators. Contractor shall have examples of each component and demonstrate measurement of input and output signals, and any operator adjustments available.
    e. DDC controller functions and operation.

3.6 PHASE III – ON SITE TRAINING

A. No later than 6 months and no earlier than 4 months from building acceptance, the SI will repeat Phase I and Phase II training. Training to be consolidated into one 4 hour session.

3.7 PHASE IV – ON THE JOB TRAINING

A. SI and/or controls contractor shall coordinate all site visits and provide opportunity for university personnel to receive OJT during warranty work. Additionally, provide 2 days of OJT control loop tuning with owner utilizing owner laptop.

B. The DDC contractor shall provide an additional 4 hours on-site training session twelve (12) months after project completion. The purpose of the session will be to review any operational problems that have developed. In addition, the contractor will lead Facilities Operations personnel through a comprehensive annual preventative maintenance of the controls system. This shall be scheduled at least one (1) month in advance.

3.8 WARRANTY ACCESS

A. The Owner shall grant the Contractor, reasonable access to the BAS system during the warranty period. The owner shall provide at no cost to the contractor web browser access (VPN) for remote service and troubleshooting during warranty period.