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Construction Engineering Research Laboratory

US Army Corps of Engineers®
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Development of an Open Building Automation System Specification Based on ANSI/ASHRAE 135-2004 (BACnet® Communications Protocol)

A Technical Assessment

David M. Schwenk, Stephen J. Briggs, David M. Underwood, and Joseph Bush

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Abstract: This work assessed the potential for development of a building automation system (BAS) specification (for heating, ventilating, and air conditioning systems, etc.) based on the BACnet® communications protocol. Although BACnet is widely supported, no BAS specification exists that implements BACnet as an Open System. The BACnet protocol is detailed, includes comprehensive requirements, and also provides options in how individual vendors might choose to implement it. Such vendor-specific choices can effectively close the system to future open bid procurements, or result in incompatible systems. This work concluded that implementing BACnet in an Open manner will require extensively prescriptive requirements with a large amount of design and contract documentation. The resulting system may not integrate as tightly as desired and may therefore not be as user friendly to Army installation operations and maintenance (O&M) staff as other equivalent systems due mainly to the need for multiple configuration tools. This work recommends that development of BAS specifications based on BACnet continue and that a source selection process that pre-qualifies BACnet contractors be developed to help obtain open systems in accordance with those specifications.

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Executive Summary

The Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) was tasked by Headquarters, U.S. Army Corps of Engineers (HQUSACE) to assess the potential for development of building automation system (BAS) specifications (for heating, ventilating, and air conditioning systems, etc.) based on the ANSI/ASHRAE 135-2004 – the BACnet® communications protocol (hereafter ASHRAE 135 or BACnet). BACnet enjoys wide industry support; a number of vendors offer related products and services, the Navy uses the protocol, and a limited but growing number of Army installations also use BACnet. However, there is apparently no BAS specification that implements the BACnet protocol in an Open system, where an Open system is defined here as "One (integrated, multi-vendor) system with no future dependence on any one contractor."*

The BACnet protocol is detailed and includes comprehensive requirements, but also provides options in how individual vendors might choose to implement it. However, it does not include requirements for other necessary aspects of an Open BAS. Such vendor-specific choices or lack of requirements can effectively close the system to future open bid procurements (or result in incompatible systems) if not adequately addressed. For example, many BACnet applications make use of and encourage proprietary objects which may result in incompatible systems. Similarly, BACnet does not specify a standard for a "network database" thus necessitating the use and maintenance of multiple configuration tools (from multiple manufacturers), and in some cases the use of multiple tools to replace a single device.

Implementing BACnet in an open manner will require extensive prescriptive requirements (particularly in regard to BACnet "objects" and "properties") and, where defining prescriptive requirements is impractical or impossible, optional BACnet functionality selected by the Contractor will need to be documented via submittal. Overall a significant amount of design and contract documentation will be required.

* Meaning no future dependence on either the specific installing controls contractor or the manufacturer of the controls.

The primary objective of this project was to evaluate the feasibility of creating an Open BAS specification based on BACnet and its associated technology—not to compare the BACnet protocol with the ANSI 709.1 communications protocol Since the Government already has Open BAS specifications based on ANSI 709.1 (and its associated technologies usually referred to as LONWORKS®), it must be careful to continue to advance its open systems goals.

This work concludes that, while it is possible to write "Open-enough" BACnet-based BAS specifications, the effort will be challenging and prescriptive, and will require a greater level of enforcement than an equivalent ANSI-709.1 (LONWORKS) based specification. The resulting system will not integrate as tightly or be as user friendly to installation operations and maintenance staff as a LONWORKS system based on the existing Unified Facility Guide Specification [UFGS]) due mainly to the need for multiple configuration tools and issues in establishing and maintaining device communications.

The Navy intends to publish a "Navy" BACnet BAS specification in the second quarter of FY07. While this assessment concludes that a sufficiently open BACnet-based BAS specification is possible, the authors do not believe the Navy specification achieves this goal, and do not endorse the Navy specification. The Corps intends to continue to work with the Navy towards a unified specification. This work addresses outstanding technical issues/concerns. this involves developing a two-spec (front-end and building level system) approach vis-à-vis the Navy's current single specification. It also involves incorporating control sequences and developing BACnet Points Schedules along with other control system drawings. It also includes developing a source selection procurement methodology that prequalifies BACnet contractors.

Development of unified BACnet-based BAS specifications should proceed in close cooperation with the Navy and Air Force. CERL will continue to meet with the Navy on a periodic basis to proceed to develop these specifications and related criteria. Existing LONWORKS specifications and Unified Facilities Criteria (UFC) will then need to be edited to ensure consistency (not be repetitive) with the new BACnet BAS criteria, primarily in regard to common or overlapping content such as control sequences and hardware specifications).

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Preface

This work was conducted for Headquarters, U.S. Army Corps of Engineers (HQUSACE) under the Standards and Criteria Program (SCP), Work Unit SC60191, "BACnet Criteria," via Funding Authorization Document (FAD) 06-0012-01447. The technical monitor was Gary Bauer, CECW-CE-D.

The project was performed by the Energy Branch (CF-E) of the Facilities Division (CF), Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was David M. Schwenk. David Fisher and Grant Winchenko provided excellent technical consultation. Carl Ruther, formerly of the University of Cincinnati, and Ron Sharpe from Ohio State University, provided valuable end-user perspectives on the implementation of BACnet. The authors also thank the numerous industry representatives from control manufacturers, the BACnet Manufacturers Association, and BACnet International who participated in this effort. Dr. Thomas J. Hartranft is Chief, CEERD-CF-E, and L. Michael Golish is Chief, CEERD-CF. The associated Technical Director was Martin J. Savoie, CEERD-CV-T. The Director of ERDC-CERL is Dr. Ilker R. Adiguzel.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL Richard B. Jenkins, and the Director of ERDC is Dr. James R. Houston.

1 Introduction

1.1 Background

For years, government installations (and other campus-like facilities) have faced the complexities of multi-vendor building automation systems (BAS), where a BAS (for the purposes of this report) includes local building-level direct digital control (DDC) systems along with the hardware and software needed to integrate building level systems at a supervisory level as part of a multi-building campus or base-wide system.

Proprietary[*] BAS hardware, software, and communications protocols present design, installation, and operation/maintenance challenges. Adopting a standard communications protocol can help to overcome some of these challenges by permitting different vendors' building-level DDC systems to interoperate by communicating among themselves and with one or more computer workstations and/or servers. In practice, this consists of the open exchange of data/information between DDC systems and with supervisory system(s). This is particularly important as new devices and systems are added to an existing system and provides benefits at both the base-wide (campus-like) supervisory level and at the sub-system/building level.

There is a great need to identify and assess design and specification requirements for Open building automation systems. Headquarters, U.S. Army Corps of Engineers (HQUSACE) tasked the Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) to assess the potential for development of a BAS specification (for heating, ventilating, and air conditioning systems [HVAC], etc.) based on the BACnet communications protocol.

> NOTE: This report uses the term "BACnet" to refer to the actual BACnet protocol as well as to mean that protocol along with related technologies. While every attempt has been made to distinguish which meaning is intended, in some cases the reader must make the determination from context.

[*] For the purposes of this document, a *proprietary system* is defined as "a system where sole source procurement is required for system modifications or expansions."

1.2 Objective

The specific objective of this work was to identify and assess design and specification requirements for Open building automation systems based on ASHRAE 135.

1.3 Approach

To complete this assessment, the project team:

1. met with multiple BACnet manufacturers* including; Alerton, Automated Logic, Cimetrics, Delta Controls, Siemens, and Trane
2. met with the BACnet Manufacturers Association (BMA),† and BACnet Testing Laboratories (BTL)
3. reviewed a draft Navy controls specification based on BACnet
4. met with Navy representatives, BACnet consultants, end users (Ohio State University, University of Cincinnati), and BACnet International
5. met with Navy representatives and BACnet consultants
6. submitted two sets of (e-mail) surveys to industry and BMA/BI representatives, and reviewed and analyzed their responses
7. met at HQUSACE with Navy representatives
8. analyzed the input from these many sources to identify and assess design and specification requirements for an Open BAS that will best serve the needs of the user community.

1.4 Scope

This work includes an assessment of the feasibility of creating an Open BAS specification using the BACnet protocol. It identifies issues and actions required to address those issues to develop criteria for Open BACnet-based BAS systems. The intent is that the resultant criteria will be tri-service (i.e., adopted by the Army, Navy, and Air Force).

This assessment goes beyond simply identifying BACnet-based BAS guide specification requirements. It includes an investigation of BAS requirements that meet the goals of an Open system, defined here as “One (integrated, multi-vendor) system with no future dependence on any one contractor.” Although this work emphasizes HVAC and central

* Manufacturers who implement ASHRAE 135 in their products.

† BMA has since merged into BACnet International (BI).

heating/cooling plants, it is not intended to exclude other mechanical, electrical, and utility systems.

While this work focused on identifying open systems criteria based on the use of the BACnet protocol comparisons were made between BACnet- and LONWORKS-based systems to illustrate Open systems concepts and related specification requirements.

1.5 Mode of Technology Transfer

This report will be made accessible through the World Wide Web (WWW) at URL: http://www.cecer.army.mil

2 Developing a BAS Specification

2.1 Early BAS Development

At the supervisory level, the purpose of the BAS is to perform overall supervisory management, monitoring, and certain control functions. These functions might include remote alarm reporting, remote scheduling (on/off control), trending and trend reports, load shedding/load management, remote setpoint adjustment, initial diagnosis of a service call and other maintenance management functions, load and utility monitoring/measurement for the purpose of performance monitoring and reporting. At the building or sub-system level, the goal is to support interoperability with the base-wide/supervisory system while also communicating and sharing building-specific operational data such as on/off scheduling commands, setpoints, and outside air temperature.

With help from several other agencies and industry, the U.S. Army Corps of Engineers began developing specifications based on LONWORKS technology in 2001. That effort resulted in Unified Facilities Guide Specifications (UFGS) 13801 and 15951 (also referred to as UFGS 25 10 10 and UFGS 23 09 23, respectively), which have been adopted for use by the Army, Navy, and Air Force. These specifications are available through the Corps of Engineers' *TechInfo* website or the *Whole Building Design Guide* ("Construction Criteria Database") website, which are accessible through URLs:

http://www.hnd.usace.army.mil/techinfo/engpubs.htm

http://www.wbdg.org/ccb/

Draft Unified Facilities Criteria (UFC) are available through URL:

https://kd.erdc.usace.army.mil/projects/besc/ufc/

BACnet is a standard communications protocol for building automation systems that enjoys wide industry support; a number of vendors offer products and services based on it, the Navy uses the protocol, and a limited number of Army installations also use BACnet. Its use will likely continued to grow. The Navy and GSA (among others) have developed BAS specifications for the implementation of the BACnet protocol. The Navy specifiation is in draft form and CERL has been working with the Navy to identify the needs and requirements for unified (multi-service) BACnet BAS specifications in coordination with the Air Force.

2.2 The Future of BAS Specifications

The Corps will be de-emphasizing the use of UFGSs in favor of the Military Construction (MILCON) design/build request for proposal (RFP) on a majority of projects. However, the Navy design/build approach uses "specs" for both controls, and for HVAC test, adjust, and balance (TAB) requirements. This is the same approach that was advocated by many within the Corps for our MILCON RFP, but to no avail. There are also a substantial number of controls retrofit projects funded by means other than MILCON that require specifications and where it is assumed that non-proprietary (open) systems should/will be procured thus suggesting an ongoing need for UFGSs.

2.3 The Open System Goal

Early in this effort, CERL defined a baseline goal and related sub-goals to help define Open System needs and subsequent requirements. Some of these goals may not be achievable in the near term. At this point, it may be best to trade "bells and whistles" and sophisticated sequences for a less complicated, more open system, e.g., accept a simpler economizer to get a configurable application-specific controller instead of a programmable controller. The resulting central focus of this work was to obtain an Open system characterized by:

1. *One system*. Multiple buildings with controls installed by multiple vendors are integrated into one system.
2. *One common front-end* that provides users with the capability to interface with all buildings (monitoring, supervisory control, etc.).
3. *One common tool for network management*. For management/configuration. One common tool for device configuration.
4. *No future need for the original (installing) contractor*. Additions, modifications, and retrofits can be easily (without significant additional cost) made to the system without dependence on the original contractor nor require substantial engineering or other technical development.

The effort to obtain an Open system must:

1. Minimize the number of software interface packages
2. Provide one interface for monitoring
3. Provide one interface for device/system management/configuration
4. (Optimally) provide one interface for device programming
5. Allow no Gateways. The following should be permitted only as exceptions:

   a. A supervisory interface to legacy systems
   b. Specialized applications. It may be necessary to define specialized applications such as fume hood monitoring, and cases where a single packaged unit, single chiller, or single boiler, etc. may need to be connected to the control network, but the manufacturer's packaged controller is not Open Systems compatible.
6. Allow no use of "jellynet" (i.e., the use of some proprietary communication between different "islands" of openness). This is closely related to the stipulation to "allow no Gateways."
7. Provide device interchangeability. Must be able to remove a device from one manufacturer and, without adding any other networking hardware, replace it with a device from another manufacturer.
8. Create a system that DOES work together, not one that CAN work together.
9. Limit the number of options. More options generally equates to more ways to close the system.
10. Provide good system documentation. The system must be documented so that future contractors or the Government can understand what has been done.
11. Use industry standards where possible, but be willing to extend them by specifying in a prescriptive manner exactly how to do things that are not done in a standard way.
12. Be performance-based when possible, but be prescriptive where needed to ensure interoperability. (Experience with LONWORKS indicates that, to get an open system, it will be necessary to be prescriptive about nearly all issues related to communication between devices)

2.4 Number of Specifications

Minimally, in addition to a building-level BACnet BAS specification, a BACnet-based system integration specification is needed to specify front-end/supervisory, building-to-building networking, and network management. This will be similar to the LONWORKS Utility Monitoring Control System (UMCS) UFGS-13801. In the extreme case as many as eight (but more likely only four or five) specifications could be needed to accommodate both BACnet and LONWORKS.

The issue here is how best to package the specifications to ensure practical application of the criteria including ease of use, specification maintenance, and integration with other specifications. There are presently two LONWORKS specifications. The Navy originally suggested the need to investigate coordination between the LONWORKS and BACnet BAS specifica-

tions as part of a BACnet BAS specification development effort. Eight fundamentally different topics must be addressed (conceivably through separate specifications):

1. *Hardware*. Sensors, valves, dampers, actuators, wire and cabling, enclosures, and other miscellaneous hardware. These things are (largely) protocol and vendor independent, e.g., a Johnson Controls valve can work fine on a Honeywell system. This might even include common DDC hardware requirements that are protocol independent (e.g., the requirement that the controller not loose its program in case of a power failure). As a result, it will be wise to consider using the same Hardware requirements in both the LONWORKS and BACnet specifications.
2. *Building-level system performance verification test (PVT), Training, and other execution items*. Again, these elements are largely protocol and vendor independent (although some requirements/submittals may be unique to LONWORKS or BACnet).
3. *Control Sequences*. Sequences should be protocol and vendor independent.
4. *LONWORKS requirements inside the building*. This will cover network requirements, protocol specific issues, and DDC hardware requirements unique to LONWORKS systems. This will be a subset of the existing UFGS-15951.
5. *BACnet requirements inside the building*. This will cover network requirements, protocol specific issues, and DDC hardware requirements unique to BACnet systems.
6. *UMCS Workstation requirements*. This will cover protocol independent requirements of a base-wide (or, multi-vendor integrated) system. This would include computer hardware requirements and installation, as well as any IP network requirements common to either LONWORKS or BACnet. It could include sections on M&C functionality (such as demand limiting), graphical user interface (GUI) requirements, access/authentication requirements, and optionally requirements for web-based GUIs. It would also include PVT, training, and possibly submittals as well.
7. *LONWORKS requirements outside the building as part of a base-wide (or, multi-vendor integrated) system*. This would cover system integration and Monitoring and Control (M&C) software/hardware requirements unique to LONWORKS systems (e.g., the requirement to use an LonWorks® Network Services (LNS) database).
8. *BACnet requirements outside the building on the base-wide (or, multi-vendor integrated) system*. This would cover system integration and M&C requirements unique to BACnet systems.

Clearly, it is not desirable to have eight specifications. On the other hand, to ensure that any building can communicate openly with a UMCS, it is desirable to keep the UMCS contractor at "arms length" from the building contractor. This suggests a separation of building-level specifications from UMCS-level specifications.

Another factor to consider is the desire to avoid repetition. If, for example, a temperature sensor is specified in three different places in three different specifications, then any later change necessitates changing the specification in three places. This invites inconsistency in the future when different sections of the specifications have different requirements for identical hardware. For this reason, it might be desirable to have all the common (protocol independent) requirements in a separate document. For example, the hardware requirements (#1), building-level execution (#2) and control sequences (#3) could be combined into one specification. The protocol-dependent portions might be better located in a division 17 or the new division 25 (Integrated Automation) specification.

Finally, there is a packaging issue: contractors do not want to be given a large number of specifications that are irrelevant to the job, nor do they want to have related specifications scattered out among multiple documents. The better the guide specification breakout matches the contractor requirements, the easier the designer's job will be. Consequently, this simplified approach recommends five specifications:

1. HVAC controls specification: includes elements 1, 2, and 3
2. LonWorks building specification (UFGS 15951): element 4 above
3. LonWorks UMCS specification (UFGS 13801): elements 6 and 7
4. BACnet building specification: element 5 above
5. BACnet UMCS specification: elements 6 and 8.

This separation of specifications helps to ensure that any building installed under the building specification can be integrated under the UMCS specification. This is because the building contractor has no guidance on what is to be done at the UMCS level other than what is in the building specification – there is less potential for the contractor to close the system.

There is general agreement, primarily with the Navy, that separate specifications are needed. Existing UFGS-13801 and 15951 will need to be edited to relocate portions to a new HVAC Controls Specification and two BACnet UFGSs will need to be developed.

3 Required Level of Detail

3.1 Issue Categories

BACnet-related BAS specification issues are categorized here based on the follow-up necessary for criteria development, as an:

1. **Open issue:** an issue requiring additional investigation prior to concluding its impact on or necessity of being addressed in the specifications or design guidance (UFC),
2. **Resolved issue**: an issue which has been the overall impact on the specification has been determined to be substantial and which requires significant effort to address in the specificification.
3. **Closed issue:** an issue that either has little to no bearing on the creation of a specifications or that requires minimal effort to address in the specification. These issues are included here for completeness.

3.2 BACnet BAS Guide Specifications

While the designer need not be intimately familiar with the intricacies of BACnet (such as PICS, BIBBS, Objects, Properties, Services, etc.), some level of understanding is required for designer selections and subsequent field-level implementation/verification of specified system. The intent of writing BACnet BAS guide specifications is to pre-assess and pre-define key open system requirements so as to minimize the time and effort required on the part of the designer and to potentially assist those who are responsible for accepting the installed system. There are a number of details related to these elements that, left unspecified, can result in proprietary and or non-interoperable multi-vendor systems.

The BACnet protocol is very functional and flexible, but complex in part due to its many options (such as protocol options and media types). While these options are described in more detail below, it will be necessary to restrict options to get openness and interoperability as this helps to ensure compatibility between pre-existing systems and those procured later. In addition there are some requirements of an Open system not covered by the BACnet protocol that must be addressed in a BACnet-based BAS specification. A performance-based specification alone will not work due to the absence of a means to verify third party interoperability (as is the case with how Government procurement contracts are issued). This is further addressed under in the “Contracting Issues/Approaches“ section (p 25). Suf-

fice it to say that even a performance-based specification would need to define how to implement the various options in BACnet so as to provide a level playing field for contract bidders, which brings us back to the need for detailed requirements. Therefore it is desirable to be performance based and use industry standards when possible, but also to extend those standards and be prescriptive as necessary.

For many of the following issues, there is a concern that BACnet is not prescriptive enough. In these cases there is usually an obvious, simple way to extend the specification to ensure openness, but the problem is that these extensions can potentially be too restrictive and thus limit competition because some or many vendors may not be able to meet the restrictions/requirements. The challenge, then, is to find the appropriate balance between ASHRAE 135, a "blanket" prescriptive clause, and a (possibly) painful detailed mix of performance based and prescriptive requirements.

This issue is **resolved;** a great deal of detail is needed, but the actual details required in the specifications still need to be determined.

3.3 Objects

3.3.1 BACnet Proprietary Objects

BACnet defines Proprietary Objects as those having a type value outside the range 0 to 128. While BACnet defines a number of standard objects and their underlying properties, it also permits the use of proprietary objects. This allows information that does not fit into standard objects to be made accessible via BACnet events and services, which can be a very good thing. However, because they are unique to that vendor, proprietary objects present a concern in that other devices/systems may not be able to interoperate with these objects. In the extreme case, proprietary objects can potentially close a system. To help ensure interoperability, the specifications should require Contractors to provide interoperability details for Proprietary Objects. This might best be accomplished by requiring that this detail be shown in a "Points Schedule" drawing submitted by the Contractor.

This issue is **resolved;** proprietary objects need to be addressed in the specifications and the requirements for their use need to be defined and coordinated with industry as part of the specification development process.

3.3.2 Inappropriate Property Usage

Object properties can potentially be used inappropriately. For example the analog input Min_Present_Value might be used to communicate data/information "other" than the minimum present value. While this is not common practice, it remains a concern. The representation of the same information in different object types and properties is a greater concern. For instance, analog values (AV) can be mapped as a binary value (BV).

This issue is **closed;** a simple requirement will be included in the specifications: "Properties shall not be used for other than their intended use as defined in ASHRAE 135."

3.3.3 BIBBS / PICS and Points Schedule Drawings

To help facilitate interoperability, ASHRAE 135 describes BACnet Interoperability Building Blocks (BIBBs) and device profiles, and vendors document compliance through Protocol Implementation Conformance Statement (PICS) data sheets for their devices. Neither appears to be sufficient to define interoperability requirements because needed properties in a given device may not be documented in either the BIBBs or PICS. Neither contains a sufficient level of detail or thoroughness to ensure that a device meets interoperability requirements.

For example, ASHRAE 135 permits a vendor to indicate that their controller supports the BACnet object "Analog Input" and that their "Analog Input" object supports the write property without requiring *every* analog input on the controller to meet the requirements of a BACnet "Analog Input" object and without requiring every BACnet "Analog Input" object on the controller to support the write property. BACnet only requires that at least one analog input be a BACnet Analog Input object and that at least one of those Analog Input objects support the write property. This is less than satisfying particularly when desired functionality that the Government may expect (and pay for) may or may not be provided. In contrast, LONWORKS criteria addressed this by showing this type of expected functionality in a Points Schedule drawing.

To resolve this, the specification could potentially include a blanket statement such as; "all AI objects shall support xxx optional property." This is probably not practical primary because it would restrict the number of

vendors who can meet this requirement and would be overkill resulting in unneeded functionality in some applications.

Alternatively, in theory, the specification could require that all BACnet Object Types support BACnet required properties along with a list of BACnet optional properties. For example, the spec could require that "all analog inputs shall be BACnet Analog Input Object Types and shall support the optional COV_Increment property." Based on our discussions with and survey of industry, a number of vendors would not be able to meet this requirement either.

Instead, a more practical approach seems to be where the designer shows what objects AND properties each device will support in specific applications. Given a sequence of control for a specific application and its associated input/output points list, CERL intends to develop specific requirements for specific points on a device. It seems essential to present/show this in the form of a Points Schedule drawing. For each of the points, requirements for support of BACnet services, objects, and object properties need to be developed. For example, for a given air handler, Return Air Temperature (RA-T) might be shown as an Analog Input (AI) BACnet object with the following properties: Description (read/writeable) and COV Increment (read/writeable). At the same time it may not be practical to show all object properties on a drawing because objects can include a large number of properties (both optional and required).

This issue is **open**. While it appears object and property detail is needed it is not clear how much can/should be addressed via specification and how much needs to be shown in a Points Schedule drawing. Points Schedules for several example applications need to be developed to make a determination.

3.3.4 Overrides

In support of fundamental functionality, it will be necessary that the BAS have the capability to perform overrides of setpoints and device outputs. There are several ways of accomplishing overrides, some proprietary. AIs and BIs require that they be taken out of service before being put in override, but the specification likely will not include a requirement to override AIs and BIs because this functionality is over and above that considered to be fundamental.

Advanced override functionality would include the capability to (easily) determine what points are currently in an override status. The best way to perform functions such as finding out how many devices are in override is to use the ReadPropertyConditional, but this is poorly supported.

This issue is **resolved;** it must still be determined how to specify overrides of setpoints and device outputs as well as the viewing and managing of overrides.

3.3.5 (COV, Intrinsic, Algorithmic) Event Reporting

To transfer data between devices, it seems like change of value (COV) event reporting is required. However, vendors do not recommend (i.e., they oppose) it being required. Many smaller (low level of functionality) devices simply do not have the functionality and memory to support it. Intrinsic alarming may be more useful for alarming. ReadProperty is the understood fallback to COV. This is an informal agreement amongst vendors where if a controller/device does not support/subscribe to COV it fall backs to polling (ReadProperty). COV must be specified such that if the COV subscription fails the device automatically reverts to polling. There is some uncertainty regarding how and what values to specify for various subscriptions to services such as COV subscription renewal interval. Initial concerns were that algorithmic reporting might be used to close systems. Our discussions with industry and BACnet experts indicate that this is not the case. They also indicated that it is powerful and therefore very useful.

This issue is **open**. The capability to transfer data (such as an alarm condition) between controllers is obviously needed, but it is not clear if it should be accomplished by polling or based on COV. If COV is the preferred approach it must also be determined whether COV should be required or if controllers should attempt COV, but revert to polling if COV is not available.

3.4 Network Management and Device Configuration

3.4.1 Central Database

This is a critical issue. In a multi-vendor system certain base-wide supervisory functions such as alarm handling and system scheduling (Occupied/Unoccupied/WarmUp-CoolDown) should be managed through a single vendor's system or a single software package. This common interface should also provide for display of selected monitored points ideally to include a graphical display. With LONWORKS technology a de-facto data-

base standard exists (LNS™) and the LONWORKS -based UFGS-13801 requires the use of LNS resulting in a centralized or standardized database that provides for 3rd party access to the control system network/devices. BACnet neither specifies nor requires a standard database.

In a BACnet system, vendors create their own proprietary database(s). This is accomplished using a tool that queries the network to obtain BACnet device data (including third party BACnet device data). This process is called *discovery* and uses the "Who-Is" and "Who-Has" service requests and the associated responses "I-am" and "I-Have." Discovery relies on the ability of controllers to be addressed via their Device ID and to respond to a "Who-Is" query.

Discovery of devices and their associated Objects on MS/TP (the most common media type) network are problematic because a Slave device on MS/TP cannot (by BACnet definition) respond to the "Who Is" query and therefore cannot be discovered on the network. In particular, a BACnet Application Specific Controller (B-ASC) is not required by BACnet to have the ability to become a Master on the MS/TP network (and thus is a slave) and may not be able to be discovered. A brute force method exists to identify/discover slave devices, but appears to be inefficient and time consuming.

Part of our concern about this issue stems from the potential situation where the government wants to let a Contract to replace existing Vendor A (or renew the Vendor A contract). If Vendor C wants to bid on the Contract, vendor C is at a competitive disadvantage if the system contains slave devices known only to Vendor A.

Specifying the use of a proxy device is a possible way to deal with discovery (where a master device serves as a proxy for the slave device). As a proxy, the master device responds to a "who-Is" query for the slave device. Requiring detailed submittal documentation, when slave devices are used, is another option where this documentation would serve to facilitate slave device discovery.

This issue is **open**. Prohibiting the use of slave devices could potentially exclude many low-cost BACnet controllers, and industry seems opposed to our prohibiting the use of slave devices. The possible use of proxies and/or detailed documentation needs to be investigated.

3.4.2 System Integration

In a multi-vendor system these different vendors' systems (particularly as part of separate projects/contracts) need to be (readily) integrated. As discussed under "Number of Specifications" (p 6) and "Contracting Issues/Approaches" (p 25) sections, system integration in an Army installation environment consists of integrating building-level systems with a single-vendor front-end (UMCS) where this single-vendor UMCS (which may include multiple client workstations) is used to monitor/manage all (multi-vendor) building-level systems so that functions such as device scheduling (on/off), energy management, and other related actions are performed from a single user interface. It is not our intent to procure a new front-end with every newly installed building-level system. (This approach is not unusual, but seemed foreign to some.)

The following two questions were posed to BACent consultants and to industry:

Consider a situation with an existing "Vendor A" front-end where "Vendor B" is hired to install a building-level DDC system.

1. Will "Vendor B" be comfortable providing a "working" system and walking away from it (turning it over as complete) confident that is ready-to-be-integrated to the "Vendor A" front-end?
2. Will "Vendor A" be comfortable being required to integrate the Vendor B system in the absence of Vendor B?

The industry responses indicate that it is likely that vendor cooperation is required although with adequate documentation cooperation will not be required. (Note – this is also the case with LONWORKS and part of the intent of the Points Schedules specified in UFGS-13801 and 15951). Therefore, it appears there are no technical barriers, but a BTL listed BACnet Operator Workstation (B-OWS) may help ensure that integration is not a problem. This listing is not yet available, but should be included in the specification once it is.

As a related issue, building-level Contractors can be expected to perform limited integration at a 3rd party UMCS front-end. (i.e., where "Vendor B" works on the "Vendor A" front-end). For example Vendor B can be expected to set up graphics on the "Vendor A" front-end. Still, a systems integration contract is advisable (as is the case with the LONWORKS UFGSs) where "Vendor A" is responsible for integration of building-level systems

to Vendor A's front-end. The use of a separate integration contract is in the Governments best interest because the SI provides a quality control service by helping to ensure that that building-level contractor provides and meets open system requirements.

This issue is **resolved**. Appropriate specification requirements (including documentation) will be defined.

3.4.3 Multiple Configuration Tools for Network Communication Settings

The ASHRAE 135 standard does not specify or require that devices expose all network communication parameters in an open, standard manner. Industry implementations do not expose this information in a standard manner, which means that use of multi-vendor BACnet will require the use of proprietary configuration tools from multiple vendors. This is in sharp contrast to LONWORKS, where the use of a single network configuration tool which interacts with the LNS database helps to reduce the need for proprietary tools from multiple vendors.

For example, a VAV box may have a Binary Object representing its occupancy status which supports a ReadProperty on its PresentValue (the VAV box is a data server and supports the BIBB DS-RP-B). Furthermore, an AHU controller may wish to read that occupancy in order to turn itself on as needed (the AHU controller is a data client and supports DS-RP-A). While the VAV box does not need to know which device is reading its data, the AHU needs to know where to read the data from. The AHU controller must contain the device ID, object ID, and property ID of the VAV box's occupancy present value. ASHRAE 135 does not require that this information be exposed on the network.

While this means that installation of a new device containing network addresses for remote devices will require the use of a vendor-specific configuration tool, the issue becomes even worse when controller replacement within a building is contemplated. In this case, not only the replaced device, but other devices will probably need to be reconfigured as well using their vendor-specific configuration tools. In the example of a VAV box and the AHU controller, replacement of the VAV box will likely require* that

* * If you replace a device and use the same identifiers (Device/Object/Property identifiers) then the bindings in the client device will still work and networkcommunication will be maintained. However, ASHRAE 135 does not require that Device/Object/Property identifiers be field assignable, and this is not well supported by industry. Another possibility is to reinitiate the binding, if the device supports dy-

(footnote continued on next page)

the network configuration information in the AHU controller be changed to point to the new Device/Object/Property in the new VAV box controller. If the VAV controller is from a different manufacturer than the AHU controller, the VAV installer be required to use the proprietary tool belonging to the AHU controller manufacturer. Furthermore, lack of a central database of network bindings makes it difficult to even know what other devices (bindings) need to be updated; there is no way to query the network (or a database) to determine which controllers talk to which.

One industry expert suggested requiring network communication parameters be settable via Writeable properties of (presumably proprietary) BACnet Objects. A Graphical User Interface (GUI) could then be developed to serve as a network configuration tool for these properties. This GUI would serve as a common/single network configuration tool that could then be used to identify and thus re-establish bindings and network communications upon replacement of a controller or device. A major obstacle is that there are no standards/requirements in place (defined) for such a tool suggesting that detailed specification requirements would need to be developed. Neither does this approach seem to be supported by industry; ASHRAE 135 does not define such an object and we are not aware of any proprietary object by any vendor that supports this. The BACnet 'Structured View Object', although not yet available, might serve as part of the solution to this problem.

The need for multiple tools will complicate O&M for Army maintenance staff due to the amount of training and higher skill levels required. Additionally, the large number of tools that O&M staff will need to be familiar with will make it very difficult to become proficient with all of the required tools. Finally, requiring the use of proprietary tools may give a competitive advantage to vendors already established on the installation since subsequent vendors may have to use the first vendor's tool during a retrofit, replacement, upgrade, or expansion project.

This issue is **resolved**. It appears that needed network communication and binding requirements will require the use of a vendor-specific proprie-

namic object binding by Name. However, dynamic binding is also not required by ASHRAE 135, and its use and level of support is left up to the implementer. The result is that in general one cannot replace a device and ensure that the replacement will not "break" communication links. In general, the client controller (the one containing the identifiers of the remote device/object/property) must be reconfigured.

tary tool. Specification requirements for the documentation of inter-device communications will be developed.

3.4.4 Device Application Configuration

Device configuration, in the sense of internal device programming and parameters needed to execute a sequence of operation (note in this case stand-alone operation is discussed, where the network aspects of device configuration were covered above) is absent from ASHRAE 135 and is left to individual vendors to implement as they see fit.

BACnet systems, as implemented by industry, do not support the single-tool concept. In contrast, with LONWORKS the use of a single network configuration tool, vendor-specific plug-ins, and the requirement to use SNVTs, SCPTs, or UCPTs under UFGS-15951 and 13801 helps to reduce the need for proprietary tools from multiple vendors. While it is true that when programmable controllers are used, both BACnet and LONWORKS systems will require use of a proprietary programming tool, BACnet systems appear to have a higher percentage of programmable controllers and owners/maintainers of BACnet systems will be more likely to suffer the problems associated with using and maintaining multiple proprietary programming tools than owners/maintainers of a LONWORKS based system in accordance with UFGS-13801 and 15951.

A BACnet system based solely on ASHRAE 135 (i.e., a system where the only requirement was compliance with ASHRAE 135) and using products commonly available from industry would most likely have different proprietary programming tools (for programmable controllers) and different proprietary configuration tools (for non-programmable controllers, that is configurable or application specific controllers). Such a system will complicate O&M for Army maintenance staff due to the amount of training and higher skill levels required. Plus the large number of tools that O&M staff will need to be familiar with will make it very difficult to become proficient with all of the required tools.

A further limitation of a system based solely on ASHRAE 135 will be a reduced ability to perform remote configuration. This is due to the fact that ASHRAE 135 does not require a standard communications protocol between the configuration software and the device being configured. Ideally, a user would wish to use Vendor A's tool while sitting at Vendor B's workstation (front end) and configure Vendor A's device that resides on a building network accessible via Vendor C's BACnet router. Based on industry

response to a questionnaire, configuration through a third party BACnet router may or may not work depending on the vendor. Instead, the user may need to "plug in" directly to the LAN on which Vendor A's device resides. Others advised us that by-and-large it can be done and will work although Telnet/VPN may be needed. This is because vendors have not agreed on a standard manner to perform this communication. In comparison, UFGS-15951 and UFGS-13801 provides for configuration tool use from anywhere on the network.

One possible workaround that was suggested by industry experts is to require that all devices* have the capability to be fully configured for the intended application via Writeable properties of BACnet objects. Device vendors would then provide documentation of the mapping between object/properties and configuration parameters (e.g., Analog_Value 7, Present_Value is the Set_Point; Binary_Value 5, Present_Value is the flag that indicates whether the VAV box has a series fan or not; etc.). This could then be extended to require that the contractor performing integration of the device to the front end provide a page providing these descriptions and bindings to the object/properties to facilitate changes to them. From a functional perspective, this is perfectly acceptable and largely duplicates the capabilities of LNS plug-ins for device configuration. What is unclear at this point is how widely supported this is by industry or how much this capability will cost. For example, will this requirement force vendors to use all programmable controllers because their application specific controllers cannot be configured via Writeable properties of BACnet objects?

This issue is **open**. There is uncertainty about how industry will view this requirement, how much it will cost, and whether it will force the use of programmable controllers exclusively.

3.4.5 Addressing and Naming convention

This is extremely important. For the discovery tools to be effective, a logical and consistent addressing and naming convention, which also results in globally unique Device Identifiers, is needed. Addresses consist of a

* This discussion originated with the need to configure application specific controllers, however it is also applicable to programmable controllers, where the term "fully configurable for the application" would not imply reprogramming, but would only refer to parameters (setpoint, PID settings, etc.) shown on the Points Schedule and normally changed by the operators.

network number (up to 65,535) and a device media access control (MAC) address. Device MAC addresses are unique within a network, but not globally. For ARCNET and MS/TP networks (up to 255 devices per network number), the specification should require vendors to obtain address assignments from the owner if there is any chance that several vendors are connecting devices to the same network and therefore could repeat addresses. In any case, future management of the inter-network will be made simpler if some logical address scheme is used for all buildings. Similarly, the device object identification property must be managed uniformly by the owner of a large system; no duplication is permitted in the same network domain.

This issue is **resolved**. Designers will need to specify network number and MAC address. The specifications will provide addressing requirements and related submittals (such as showing the addressing in a Points Schedule).

3.5 Network Miscellaneous

3.5.1 Network Access and DOIM Coordination

A UMCS ordinarily if not always requires access to and use of the base-wide IP LAN. At Army Installations, this can be challenging because systems that use the IP network must be verified to operate at an acceptable level of security risk. This verification calls for DITSCAP/Networthiness accreditation/certification. Obtaining the required certifications can be painful, time consuming, and expensive in part because designers, Installations, and/or Contractors sometimes do not foresee the need to coordinate with the DOIM as part of BAS/UMCS projects. Certification is also painful because the involved parties (DOIM and UMCS project implementers) seem to be unfamiliar with each others needs and intent; overall there seems to be confusion about the certification “process.” This issue is not unique to BACnet, but needs to be addressed as part of the design and implementation process.

This issue is **open** in that the extent to which the designer (versus others) needs to address and be responsible for accreditation/certification is unclear.

3.5.2 Media Types

BACnet allows multiple media types, specifically ARCNET. The problem with ARCNET is that there is ONLY one major vendor who supports it; it

is essentially a proprietary media type. In the interest of standardizing on widely supported media, media will be required to be either MS/TP or BACnet/IP over Ethernet. The one major BACnet vendor who uses ARCNET may object to this requirement. This vendor argues that ARCNET is faster than MS/TP, therefore performance will be better and that media converters can be used to accommodate ARCNET and MS/TP. On the other hand, the instant a particular LAN becomes mixed-media (ARCNET and MS/TP with a media converter), the speed drops to that of the slowest media; the performance advantage of ARCNET vanishes. Media converters may require sole source procurement

This issue is **resolved**. Although there is some slight industry objection, the consensus seems to be that requiring MS/TP (or IP only) is reasonable. There may be special cases for other media types, but as with the LONWORKS specification there is no need to deal with special cases right now. In addition, MS/TP may eventually be phased out in lieu of IP.

3.5.3 MS/TP Baud Rate

BACnet allows a variety of MS/TP communication rates, all the way down to 9.6 Kbps. The network needs to be able to respond in a timely manner to alarms and other real-time control requirements while simultaneously supporting near-worst-case activities such as trending and other data/network intensive activities. Another consideration is compatibility of different vendors' devices that operate at different speeds while connected to a common network bus.

This issue is **closed**. The requirement will be 38.4 Kbps. It is supported by most, if not all, vendors and it is reportedly the best speed for use with legacy network cabling. Some applications may require faster polling and will be a designer option.

3.5.4 Confirmed Text Messages

The BACnet standard defines Confirmed Text Messages. Although its use could be used to Close a system, response to our industry questionnaire indicated that some vendors would object to prohibiting them. Industry does not however seem to object to prohibiting them for "interoperable" communications (sharing information between devices or between a device and the front end).

This issue is **resolved**. The specifications will restrict the use of Confirmed Text Messages; language must be developed to specify what is meant by "interoperable" communications.

3.6 Miscellaneous

3.6.1 BTL Listing

BACnet Testing Laboratories (BTL) provides a "listing" service whereupon completion of laboratory testing a device becomes listed (and posted at the BTL website). BTL listing is, via industry consensus, a necessary but not sufficient specification requirement. The one exception is the B-OWS, because there is no test available for this yet (as of Aug 06), but may be by the time BAS specifications are developed.

This issue is **closed**. The specifications will require BTL listing where there is a BTL test available although none is presently available for B-OWS.

3.6.2 Source Code

BACnet vendors' controllers are primarily of the programmable type (as opposed to application specific). Our specification needs to make it clear that the customer "owns" all the control programs, graphics, configuration database, and other site-specific data including source code for programmable controllers. The vendor may copyright or patent the programming tools, workstation software, hardware, firmware (including patented control algorithms), and other features common to their product line, but the customer should have the right to edit, copy, or otherwise manage the site-specific system applications. In general, industry appears to agree with this (and in one vendor's case strongly recommends it).

This issue is **closed**. The specification will require source code submittals as described above.

3.6.3 Mode Scheduling

At a minimum, according to the BTL Device Implementation Guidelines,* scheduling should be able to be accomplished using BACnetBinaryPV

*BACnet Testing Laboratories. 23 March 2006. *Device Implementation Guidelines*.

enumeration (a BACnet property data type which essentially is a logical binary state value).

This issue is **resolved**. Functional and implementation requirements need to be defined.

3.6.4 Segmentation

Segmentation is the breaking up of messages into multiple smaller messages. This is a limitation on message size imposed by the transport layer (layer 2). It appears as if the specification should segmentation. Some devices do not support it, making them incompatible with devices that do.

This issue is open. It must be determined if segmentation is required and how to address this in the specifications.

3.6.5 Smart Sensors/Actuators

BTL does not "list" any BACnet smart sensors (B-SS) and only two vendors' BACnet smart actuators (B-SA), where a smart sensor/actuator is defined here as one that communicates digitally. At present, due to limited B-SS and B-SA device availability, permitting the use of these devices may restrict/limit competition particularly in the case of device replacement. This may not be a sufficient rationale to prohibit their use, but the previously discussed problem with discovery of slave devices may warrant not permitting these devices.

This issue is **open**.

3.6.6 Trending

Trending requirements may need to be specified, such as where trending data should be stored and required sampling rates. One vendor indicated that they can trend at a minimum sampling interval of only 10 seconds.

This issue is **resolved;** specification requirements must be developed.

3.6.7 Units

BACnet defines an object property "Units" of type BACnetEngineeringUnits, which has both SI and IP enumerations. This is a required object property for object types Analog Input, Analog Output, and Analog Value.

BACnet does not require that a device reading a value from another device also read the units and/or convert units as needed. (These are considered application requirements outside of the scope of the protocol).

One solution would be to require that all devices that read information from another device automatically check units and convert. This solution, however, may prove infeasible for many controllers and can also lead to user confusion since not all controllers would be using the same units. An alternative solution is to require that all devices use specific units for specific values, either through the specification of a units system (i.e., "all controllers shall us SI units") or through the specification of units for each type of measurement (i.e., "temperatures shall have units of degrees farenhiet [°F], pressures shall have units of PSI" etc).

It appears that the specifications should standardize units.

This issue is **resolved**; units will be standardized, but the method of standardization has to be determined and specified.

3.6.8 Web-Based Graphics

The possible use of and requirements for web-based graphics needs to be investigated.

This issue is **open**. Further investigation is required to determine if web-based graphics should be required or allowed by the specification.

3.6.9 XML

BACnet use of Extensible Markup Language (XML) appears to be on the horizon. This will have to be monitored and the specification edited when it becomes implemented as part of the BACnet standard.

This issue is **closed** until a standard is released.

3.6.10 Structured View Object

The Structured View Object is currently being defined by BACnet (ASHRAE). This work must be monitored to determine its impact on the specifications.

This issue is **open**.

3.7 Contracting Issues/Approaches

Base-wide implementation of a multi-vendor building automation system (BAS) entails the integration of numerous building-level systems where the building-level systems are constructed individually as part of separate/individual construction/renovation projects. The integration aspect requires connection of the individual building-level systems to a common front-end platform (FEP) in an interoperable manner using a standard/open communications protocol where the FEP usually consists of one or more operator workstations (OWS) running a single software package including related server(s), networking, OWS software, etc. The FEP, via OWS permits monitoring, management, and supervisory control (alarm management, trend data capture, on/off scheduling, load shedding, etc.) of the many building-level systems. The UMCS likely may need to be a single-source vendor/contractor to supply workstation and related hard/software along with system integration services on a long term (IDIQ) contract, **or**, it may need to require the contractor for each building-level project to perform system integration (to the existing UMCS workstation/hardware/software).

In addition to obtaining/contracting system integration services, the preselection of building-level contractors will be helpful (if not necessary) to support base-wide implementation of a multi-vendor BAS that uses an open/standard protocol. At various trade shows, the BACnet community has advocated and demonstrated the concept of a plug-fest where vendors demonstrate system/equipment interoperability. The Navy proposed using this same plug-fest approach as part of a source selection contracting process to pre-qualify vendors/contractors. This idea shows great potential. The Navy may need help devising the contracting mechanism/approach. This may be done on a base, regional, and/or national (CONUS) level. A regional or national level approach seems most pragmatic. At the regional level individual contractors/vendor_branchs could be evaluated. At the national level broader (vendor HQ) support could be anticipated. The intent is to limit the controls vendors at each base to those who meet the open system “requirements.” Ideally this would limit the number of contractors/manufacturers to a “few,” but there is some concern about the break point between acceptable and non-acceptable vendor qualifications.

4 Conclusions and Recommendations

This work identified and assessed design and specification requirements for Open building automation systems based on ANSI/ASHRAE 135-2004 focusing on an assessment of BACnet. It identified issues in the development of specification for an Open BACnet-based BAS as well as subsequent actions required to address those issues.

This project concludes that implementing BACnet in an Open manner will require extensively prescriptive specifications (particularly in regard to BACnet "objects" and "properties"), which would entail a large design and contract documentation effort.

Although the primary objective was to evaluate the feasibility of creating an Open BACnet BAS specification and not to compare the BACnet protocol with ANSI 709.1 communications protocol, the Government already has Open BAS specifications based on ANSI 709.1 (and LONWORKS technology), and must be careful to continue to advance its open systems goals. For this reason comparisons between an Open BACnet BAS specification and the Open LONWORKS specifications of UFGS-13801 and 15951 are included.

This work concludes that, while it is possible to write "Open-enough" BACnet BAS specifications, the effort would be challenging and prescriptive, and would require a greater level of enforcement than an equivalent LONWORKS-based specification. The resulting system would not integrate as tightly or be as user friendly to installation operations and maintenance staff as a LONWORKS system based on the existing UFGS due mainly to the lack of a standard "network database" and the need for multiple configuration tools.

It is recommended that, to support the existing widespread use of BACnet, development of BACnet BAS specifications should proceed in close cooperation with the Navy and Air Force. CERL will continue to meet with the Navy on a periodic basis as development of BACnet BAS criteria proceeds, consisting of a building-level specification, front-end (base-wide) specification, Points Schedule drawings, and a source selection methodology. As part of this, in the near term, the Army, Navy and Air Force need to agree on control sequences and control system diagrams (drawings) as a precursor to the development of BACnet BAS specifications. Existing LONWORKS

specifications and UFCs will then need to be edited to ensure consistency (not be repetitive) with the new BACnet BAS criteria, primarily in regard to potentially common/overlapping content such as control sequences and hardware specifications. To obtain open systems in accordance with the specifications, development of a procurement methodology is recommended, most likely via a source selection process that pre-qualifies BACnet contractors.

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Abbreviations and Definitions

Term	Spellout / Definition
BACnet	Building Automation and Control Networking Protocol
BAS	Building Automation System
BI	BACnet International (or binary input)
BIBB	BACnet Interoperability Building Block
BMA	BACnet Manufacturers Association
BTL	BACnet Testing Laboratories
CONUS	Continental United States
COV	Change of value
DDC	Direct Digital Control
DITSCAP	DoD Information Technology Security Certification and Accreditation Process
DOIM	Directorate of Information Management
ERDC-CERL	Engineer Research Development Center, Construction Engineering Research Laboratory
GUI	Graphical User Interface
HQUSACE	Headquarters, U.S. Army Corps of Engineers
ID	Identifier
IDIQ	Indefinite delivery Indefinite quantity
IP	Internet Protocol
LNS	LonWorks Network Services. A network operating system including an image (database) of the network and devices.
M&C	Monitoring and Control (software)
MS/TP	Master-slave / token-passing
OWS	Operator Workstation
PICS	Protocol Implementation Conformance Statement
PVT	Performance Verification Test
SCPT	Standard Configuration Parameter Type. (LonWorks term)
SNVT	Standard Network Variable Type. (LonWorks term)
UCPT	User Configuration Parameter Type. (LonWorks term)
UFC	Unified Facilities Criteria. (Design guidance) Unified = Army, Navy, and Air Force.
UFGS	Unified Facilities Guide Specification. Unified = Army, Navy, and Air Force.
UMCS	Utility Monitoring Control System. (As specified in UFGS-13801).
XML	Extensible Markup Language

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14. ABSTRACT

This work assessed the potential for development of a building automation system (BAS) specification (for heating, ventilating, and air conditioning systems, etc.) based on the BACnet® communications protocol. Although BACnet is widely supported, no building automation system (BAS) specification exists that implements BACnet as an Open System. The BACnet protocol is detailed, includes comprehensive requirements, and also provides options in how individual vendors might choose to implement it. Such vendor-specific choices can effectively close the system to future open bid procurements, or result in incompatible systems. This work concluded that implementing BACnet in an Open manner will require extensively prescriptive requirements with a large amount of design and contract documentation. The resulting system may not integrate as tightly as desired and may therefore not be as user friendly to Army installation operations and maintenance (O&M) staff as other equivalent systems due mainly to the need for multiple configuration tools. This work recommends that development of BAS specifications based on BACnet continue and that a source selection process that pre-qualifies BACnet contractors be developed to help obtain open systems in accordance with those specifications.

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