



**Procurement**

300 Turner Street NW  
North End Center, Ste 2100  
Blacksburg, Virginia 24061  
P: (540) 231-6221 F: (540) 231-9628  
[www.procurement.vt.edu](http://www.procurement.vt.edu)

February 3, 2025

Automated Logic  
Jeff Smidler  
4948 Dominion Blvd  
Glen Allen, VA 23060-6766

Dear Jeff,

Subject: Contract Renewal Letter

Virginia Tech Contract #: VTM-2035-2023  
Commodity/Service: Building Automation Systems  
Renewal Period: 6/1/25 - 5/31/26  
Renewal #: (2 of 9) one-year renewal

In accordance with the renewal provision of the original contract, the university would like to renew the contract for an additional term. Please advise concerning your intention by signing in the appropriate space below. A signed copy of this letter should be received in Procurement by ASAP.

If allowed by the contract, price adjustments must be requested at the time of renewal in accordance with the contract documents. Price adjustments are not automatic or retroactive and are only implemented upon request by the vendor at the time of renewal.

In addition, review the attached form which shows your company information as listed in the university's vendor database. If any of this information has changed, make corrections directly on the form, and return with this letter. It is essential this information be accurate for payments to be processed in a timely manner.

Virginia Tech recommends that our vendors utilize the Wells One AP Control Payment System for payment of all invoices and strongly encourages all vendors under contract with the university to participate in this program. If your firm is not enrolled in the program, refer to our website: <http://www.procurement.vt.edu/Vendor/WellsOne.html> or contact me directly for more information.

Sincerely,

Chad Dalton  
Systems and Contracts Lead  
(540) 231-9129

Automated Logic **agrees** to renew the contract under the terms and conditions of the subject contract.

Signed by:  
Authorized Signature: Jeff Smidler Date: 2/4/2025  
Name: Jeff Smidler Title: Area Sales Manager  
(please print)

**We currently participate in the Wells One Program:** X

**We would like to participate in the Wells One Program:** \_\_\_\_\_

Approved: Amy Sebring  
Date: 4/1/2025  
Executive Vice President and Chief  
Operating Officer



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April 9, 2024

Automated Logic  
John Adams  
4948 Dominion Blvd  
Glenn Allen, VA 23060-6766

Dear John,

Subject: Contract Renewal Letter

Virginia Tech Contract #: VTM-2035-2023  
Commodity/Service: Building Automation Systems  
Renewal Period: 6/1/2024 - 5/31/2025  
Renewal #: (1 of 9) one-year renewal

In accordance with the renewal provision of the original contract, the university would like to renew the contract for an additional term. Please advise concerning your intention by signing in the appropriate space below. A signed copy of this letter should be received in Procurement by 5/1/2024.

If allowed by the contract, price adjustments must be requested at the time of renewal in accordance with the contract documents. Price adjustments are not automatic or retroactive and are only implemented upon request by the vendor at the time of renewal.

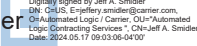
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Virginia Tech recommends that our vendors utilize the Wells One AP Control Payment System for payment of all invoices and strongly encourages all vendors under contract with the university to participate in this program. If your firm is not enrolled in the program, refer to our website: <http://www.procurement.vt.edu/Vendor/WellsOne.html> or contact me directly for more information.

Sincerely,

Chad Dalton  
Procurement Contract Support Specialist  
(540) 231-9129

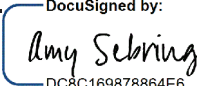
Automated Logic **agrees** to renew the contract under the terms and conditions of the subject contract.

Authorized Signature:   
Name: Jeff A. Smidler  
(please print)

5/17/2024  
Date: ~~Area Sales Manager~~  
Title: \_\_\_\_\_

**We currently participate in the Wells One Program:** \_\_\_\_\_

**We would like to participate in the Wells One Program:** \_\_\_\_\_

Approved:   
DC8C169878864E6...  
Executive Vice President and Chief Operating Officer

Date: 5/30/2024



COMMONWEALTH OF VIRGINIA

STANDARD CONTRACT

Contract Number: VTM-2035-2023

This contract entered into this 1st day of June 2023 by Automated Logic Contracting Services, Inc., DBA Automated Logic, hereinafter called the "Contractor" and Commonwealth of Virginia, Virginia Polytechnic Institute and State University called "Virginia Tech."

WITNESSETH that the Contractor and Virginia Tech, in consideration of the mutual covenants, promises and agreements herein contained, agree as follows:

SCOPE OF CONTRACT: The Contractor shall provide Building Automation Systems (BAS) services to Virginia Tech as set forth in the Contract Documents.

PERIOD OF CONTRACT: From June 1<sup>st</sup>, 2023 through May 31<sup>st</sup>, 2024, with the option of Nine (9) x One (1) year renewals.

COMPENSATION AND METHOD OF PAYMENT: The Contractor shall be paid by Virginia Tech in accordance with the Contract Documents.

CONTRACT DOCUMENTS: The Contract Documents shall consist of this signed contract, Request for Proposal (RFP) number 218672306 dated November 1<sup>st</sup> 2022, the proposal submitted by the Contractor dated December 2<sup>nd</sup>, 2022 and the Summary of Negotiations, all of which Contract Documents are incorporated herein.

ELECTRONIC TRANSACTIONS: If this paragraph is initialed by both parties, to the fullest extent permitted by Code of Virginia, Title 59.1, Chapter 42.1, the parties do hereby expressly authorize and consent to the use of electronic signatures as an additional method of signing and/or initialing this contract and agree electronic signatures (for example, the delivery of a PDF copy of the signature of either party via facsimile or electronic mail or signing electronically by utilizing an electronic signature service) are the same as manual executed handwritten signatures for the purposes of validity, enforceability and admissibility.

sh / LS  
(Initials)

In WITNESS WHEREOF, the parties have caused this Contract to be duly executed intending to be bound thereby.

Contract By: Stanley Horton  
(Signature)  
Stanley Horton, Business Manager  
Name and Title  
July 12, 2023

Virginia Tech By: Amy Sebring  
DocuSigned by:  
B61A5FA226E94C5...  
Amy Sebring  
Executive Vice President and Chief Operating Officer



**REQUEST FOR PROPOSAL 218672306**

**FOR**

**BUILDING AUTOMATION SYSTEMS (BAS) PROGRAM**

**November 1<sup>st</sup>, 2022**

**Note: This public body does not discriminate against faith-based organizations in accordance with the *Code of Virginia*, § 2.2-4343.1 or against a bidder or offeror because of race, religion, color, sex, sexual orientation, gender identity, national origin, age, disability, or any other basis prohibited by state law relating to discrimination in employment.**

**RFP # 218672306, Building Automation Systems (BAS) Program**

**INCLUDE THIS PAGE WITH YOUR PROPOSAL, SIGNATURE AT SUBMISSION IS REQUIRED  
GENERAL INFORMATION FORM**

**DUE DATE:** Proposals will be received until December 2<sup>nd</sup>, 2022 at 3:00 PM. Failure to submit proposals to the correct location by the designated date and hour will result in disqualification.

**INQUIRIES:** All inquiries for information regarding this solicitation should be directed to Bryan Holloway, Phone: (540) 231-8545; e-mail: [bryanh91@vt.edu](mailto:bryanh91@vt.edu). All inquiries will be answered in an addendum. Inquiries must be submitted by 3:00PM on November 14<sup>th</sup>, 2022. Inquiries must be submitted to the procurement officer identified in this solicitation.

**OPTIONAL PRE-PROPOSAL CONFERENCE:** A non-mandatory virtual pre-proposal conference will be held via Zoom on Thursday, November 10th, 2022 at 10:00AM. See RFP Section IX, Pre-proposal Conference for additional information.

**PROPOSAL SUBMISSION:**

**Proposals may NOT be hand delivered to the Procurement Office.**

Virginia Tech has partnered with Bonfire Interactive to create a new procurement portal that will allow you to access business opportunities and submit bids and proposals to Virginia Tech digitally.

**Proposals must be submitted electronically at:**

<https://procurement-vt.bonfirehub.com/>.

Vendors are requested to visit the new Procurement Portal then follow the link to the Bonfire vendor registration page to register your company. Registration is easy and free. If you have any challenges with the registration process, please contact Bonfire Interactive Support at [support@gobonfire.com](mailto:support@gobonfire.com).

**It is encouraged for all vendors to register prior to the proposal submission deadline to avoid late submissions.** Log into your Bonfire Vendor account to access the opportunity and begin preparing your submission. Upon completion you will be directed to your Submission Receipt. Virginia Tech will not confirm receipt of proposals. It is the responsibility of the offeror to make sure their proposal is delivered on time.

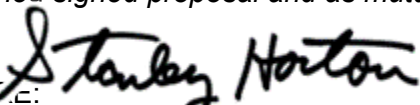
For a quick tutorial on how to upload a submittal, visit: [https://support.gobonfire.com/hc/en-us/articles/360011034814-Creating-and-Uploading-a-Submission-for-Vendors-?\\_ga=2.42375717.1472165071.1588110542-997330893.1585332052](https://support.gobonfire.com/hc/en-us/articles/360011034814-Creating-and-Uploading-a-Submission-for-Vendors-?_ga=2.42375717.1472165071.1588110542-997330893.1585332052)

Hard copy or email proposals will not be accepted. Late proposals will not be accepted, nor will additional time be granted to any individual Vendor.

**Attachments must be smaller than 1000MB in order to be received by the University.**

*In compliance with this Request For Proposal and to all the conditions imposed therein and hereby incorporated by reference, the undersigned offers and agrees to furnish the goods or services in accordance with the attached signed proposal and as mutually agreed upon by subsequent negotiation.*

AUTHORIZED SIGNATURE:



Date: July 12, 2023

**[INCLUDE THIS PAGE]**

**I. PURPOSE:**

The purpose of this Request for Proposal ("RFP") is to solicit proposals to establish a contract through competitive negotiations for Virginia Polytechnic Institute and State University ("Virginia Tech"), an agency of the Commonwealth of Virginia.

Virginia Tech seeks to procure one or more experienced firms to provide Building Automation Systems ("BAS") for 1) future, yet-to-be determined projects in various locations at the University and 2) on-demand maintenance and repair services of existing BAS systems. Details describing the scope of the services required can be found in Section VII of this request for proposal.

This request does not intend to describe all aspects of the BAS. Descriptions of the software, hardware, and services associated with the BAS are outlined within this request to ensure that the overall goal of Virginia Tech is achieved. This request therefore, serves only as a guideline to solicit proposals from qualified firms.

For ease of reference, each firm receiving this RFP is referred to as a "Firm" or collectively as "Firms." The Firm(s) selected to provide the BAS for Virginia Tech is referred to as the "Selected Firm(s)." This RFP states the instructions for submitting proposals, the procedure and criteria by which a Firm may be selected, and the contractual terms by which Virginia Tech proposes to govern the relationship between it and the Selected Firm(s).

**II. SMALL, WOMAN-OWNED AND MINORITY (SWaM) BUSINESS PARTICIPATION:**

The mission of the Virginia Tech supplier opportunity program is to foster inclusion in the university supply chain and accelerate economic growth in our local communities through the engagement and empowerment of high quality and cost competitive small, minority-owned, women-owned, and local suppliers. Virginia Tech encourages prime suppliers, contractors, and service providers to facilitate the participation of small businesses, and businesses owned by women and minorities through partnerships, joint ventures, subcontracts, and other inclusive and innovative relationships.

For more information, please visit: <https://www.sbsd.virginia.gov/>

**III. CONTRACT PERIOD:**

The term of this contract is for one (1) year(s), or as negotiated. There will be an option for nine (9) one (1) year renewals, or as negotiated.

If Virginia Tech elects to exercise the option to renew the contract for any additional one-year period, the contract price(s) for the additional year shall not exceed the contract prices of the previous contract year costs increased/decreased by no more than the percentage increase/decrease of the All Items category of the CPI-W section of the Consumer Price Index of the United States Bureau of Labor Statistics for the latest twelve months for which statistics are available or 2.5%, whichever is less, or as negotiated. Price increases will be permitted only at the time of renewal.

**IV. EVA BUSINESS-TO-GOVERNMENT ELECTRONIC PROCUREMENT SYSTEM:**

The eVA Internet electronic procurement solution streamlines and automates government purchasing activities within the Commonwealth of Virginia. Virginia Tech, and other state agencies and institutions, have been directed by the Governor to maximize the use of this system in the procurement of goods and services. *We are, therefore, requesting that your firm register as a vendor within the eVA system.*

There are transaction fees involved with using eVA. These fees must be considered in the provision of quotes, bids and price proposals offered to Virginia Tech. Failure to register within the eVA system may cause the quote, bid or proposal from your firm being rejected and the award made to another vendor who is registered in the eVA system.

Registration in the eVA system is accomplished on-line. Your firm must provide the information. Please visit the eVA website portal at <http://www.eva.virginia.gov/pages/eva-registration-buyer-vendor.htm> and **register both with eVA and Ariba**. *This process needs to be completed before Virginia Tech can issue your firm a Purchase Order or contract.* If your firm conducts business from multiple geographic locations, please register these locations in your initial registration.

For registration and technical assistance, reference the eVA website at: <https://eva.virginia.gov/>, or call 866-289-7367 or 804-371-2525.

**V. CONTRACT PARTICIPATION:**



It is the intent of this solicitation and resulting contract to allow for cooperative procurement. Accordingly, any public body, public or private health or educational institutions, or Virginia Tech's affiliated corporations and/or partnerships may access any resulting contract if authorized by the contractor.

Participation in this cooperative procurement is strictly voluntary. If authorized by the Contractor, the resultant contract may be extended to the entities stated above to purchase at contract prices in accordance with contract terms. The Contractor shall notify Virginia Tech in writing of any such entities accessing the contract, if requested. No modification of this contract or execution of a separate contract is required to participate. The Contractor will provide semi-annual usage reports for all entities accessing the Contract, as requested. Participating entities shall place their own orders directly with the Contractor and shall fully and independently administer their use of the contract to include contractual disputes, invoicing and payments without direct administration from Virginia Tech. Virginia Tech shall not be held liable for any costs or damages incurred by any other participating entity as a result of any authorization by the Contractor to extend the contract. It is understood and agreed that Virginia Tech is not responsible for the acts or omissions of any entity, and will not be considered in default of the contract no matter the circumstances.

Use of this contract precludes no participating entity from using other contracts or competitive processes as the need may be.

**VI. STATEMENT OF NEEDS/SCOPE OF WORK:**

**A. Overview**

Virginia Tech intends to select one or more Firms to provide Building Automation System ("BAS") engineering/installation and/or material on 1) an as-needed basis for new buildings and systems, and 2) on-demand repair and preventive maintenance services of existing or

newly installed systems. The work related to this procurement could be located at any Virginia Tech site. Currently, Virginia Tech's Blacksburg campus has over 200 buildings, of which, over 130 have DDC BAS installed and controlling various mechanical and HVAC systems. Several buildings utilize a combination of pneumatic and electronic controls while a few are completely pneumatic or standalone. Our current building automation system (BAS) consists of several servers for both Siemens Insight and Desigo CC, 700+ field panels, 7000+ terminal unit controllers, 400+ fume hood controllers, 375,000+ points, and over 3,000 graphics. We currently operate our BAS on a private network housed and maintained by Virginia Tech's Facilities Instrumentation, Controls, and Metering ("ICM") shop.

Virginia Tech does not guarantee a minimum volume of work to the Selected Firm(s) due to the nature of when projects take place and when equipment may need maintenance or repair and undetermined future maintenance budgets.

If the Firm can offer tiered pricing for material based on annual quantities purchased, Virginia Tech will consider this approach upon review of the Firm's proposal. The Selected Firm(s) will provide these services:

1. Provide Virginia Tech the capability of having pre-qualified BAS contractors under agreement to submit written proposals, or bids, on an "as-needed basis" for new construction or renovations that include replacing existing BAS.
2. Be available, upon request, to perform minor BAS work, promptly, to ensure that Virginia Tech's peak workload and high priority requirements for controls can be maintained in good working order.
3. Provide on-demand maintenance and repair work on BAS systems in a competent manner to maintain the quality of educational services and business operations of Virginia Tech and minimize the interruption of such services. See Service Level standards for additional details on response times and expectations.
4. Provide readily available BAS products/ material and software/ licenses to Virginia Tech for in-house design, installation, configuration, and programming.

## **B. Price Proposals and Future Awards**

Specific project price proposals are not part of this RFP because future projects are yet to be determined. However, the Firm is to provide material costs and labor rates per hour within its proposal as listed in **Attachment B – Price Proposal/ Labor Rates & Material Pricing ("Attachment B")**. The rates identified in **Attachment B** shall be the maximum allowed, for both service and construction work, however, Selected Firm may utilize lower rates when pricing work. In addition, the Selected Firm(s) should include any other costs it deems necessary to complete the project when submitting a proposal

Following the conclusion of the selection process and award of Agreements resulting from this RFP, Virginia Tech may periodically issue requests for quotation or Invitations for Bids (IFB) for BAS projects. The Selected Firm(s) may be requested to submit a Proposal/Bid in response to the IFB or request for quotations.

For purposes of construction, including capital construction or renovations, being priced by third-party CM/GCs, Virginia Tech also reserves the right to list the Selected Firm(s) for BAS work in the respective construction project drawings and specifications. Only Selected Firm(s) may provide a proposal to the CM/GCs or mechanical contractors competing for the

project. Alternatively, Virginia Tech may procure the work and assign the work to the CM/GC.

Virginia Tech may use any procurement type (e.g. fixed fee, guaranteed maximum price, etc.) for the procurement of on-demand services contemplated herein. Virginia Tech's designated representative will issue an IFB or request for quotations for each project. The Selected Firm(s) shall submit a written Proposal/ Bid within the time requested. Virginia Tech will base the award on its evaluation process of the Proposal(s)/Bid(s). However, Virginia Tech reserves the right to complete any project with its own forces; reject any proposal; cancel the procurement at any time; or take any action deemed to be in Virginia Tech's best interest. If time for completion of the work is to be a determining factor of award, Virginia Tech will establish the completion date. Once an agreement for the Work has been reached, and the procurement is approved by the Virginia Tech Procurement Department, Virginia Tech will issue a Project Order to the Selected Firm with the agreed upon completion date. The Selected Firm may be required to attend meetings relating to work which they are selected to provide.

Decisions related to awards under capital projects shall be made by the respective capital construction procurement and project staff managing the work.

**C. Preventive Maintenance, On-Demand and Construction Scope of Service**

The Selected Firm(s) shall provide high quality BAS work. This includes prompt response to requests for quotations and completion of projects in a timely fashion (as determined by Virginia Tech) once schedules are established. Virginia Tech will inspect Work in progress, periodically, for adherence to Virginia Tech's quality standards and compliance with project specifications. If Virginia Tech's standards conflict with project specifications or industry best practice, the Selected Firm shall make this known to Virginia Tech, via a written request for clarification to Virginia Tech's procurement office, project manager and/or the Virginia Tech Automation Services group, as applicable.

The Selected Firm shall identify a contract lead that shall be responsible for the day-to-day performance of the Contract ("Contract Lead"). This Contract Lead will have 24 hour per day responsibility for the work performed. Responsibility includes, but is not limited to supervision, scheduling, maintenance, and repair of the BAS and associated controls.

The Selected Firm's Contract Lead shall meet with Virginia Tech representatives at a location directed by Virginia Tech, every month to review reports, maintenance progress, maintenance schedule, repairs and any other topics requested by Virginia Tech. The Selected Firm's Contract Lead shall maintain communication with Virginia Tech representatives, and shall provide the aforementioned responsibilities for all shifts.

Virginia Tech reserves the right of approval and acceptability of the Selected Firm's Contract Lead and any other personnel, including but not limited to, technicians, project managers, engineers, etc. for the duration of the contract. The Selected Firm shall present to Virginia Tech, its candidate for Contract Lead for consideration by Virginia Tech no less than three weeks prior to the start of the Contract.

1. **Equipment Performance Requirements.** All equipment and systems under this contract shall meet the following requirements:
  - a. Shall be installed, maintained and/or repaired as originally specified, designed, manufactured and upgraded.

- b. Materials and parts required for the performance of installation, repair and/or maintenance of this Contract must be of equivalent material, strength and design as originally designed and installed or as specified by Virginia Tech.
- c. All work and materials supplied under this Contract shall be guaranteed against defects for a minimum of one (1) year from the date of final acceptance by Virginia Tech. Any work that is required to be corrected due to the Selected Firm's faulty workmanship, equipment, tools, or materials, shall be done at no additional expense to Virginia Tech.

2. **BAS Preventive Maintenance and Repair Services.** The Selected Firm shall provide all supervision, labor, materials, tools, equipment, insurance and expertise required for the maintenance, service, repair, and testing of the BAS system on a regularly scheduled basis to ensure proper operating condition.

For the purpose of this document, Preventative Maintenance work is defined as the maintenance tasks required to be performed on a regular basis to maintain the BAS in proper operating condition. Preventive Maintenance includes but is not limited to the following:

- Maintaining BAS private network and or provide network support where NI&S maintains the network;
- Perform routine server maintenance and install updates in a timely manner;
- Provide parts and labor for the repair and replacement of electronic components of the BAS;
- Verify panel communication with front-end and field level devices;
- Check/replace panel battery and or UPS where applicable;
- Perform a backup of panel database;
- Check for failed points;
- Check for active alarms;
- Confirm program execution;
- Verify control devices (AOP's, PxP's, etc.); and
- Document all findings in a report provided to appropriate VT representative;
- Inspection, testing, repair, adjustment and replacement of component parts on a regularly scheduled basis, in order to maintain the operating efficiency for the Building Automation System and its components.

The Selected Firm shall perform all preventative maintenance between the hours of 6:00 AM to 6:00 PM, Monday-Friday unless specifically directed otherwise by Virginia Tech. All working hours shall be approved by Virginia Tech in advance. All labor, materials, supplies, tools, equipment, transport, permits, and all incidental items not specified, but reasonably necessary for Preventative Maintenance services, shall be included in the lump sum pricing.

The Selected Firm will be responsible to work with Virginia Tech to identify items that require preventative maintenance on a Monthly, Quarterly and Semi-Annual or other basis.

Once the Selected Firm and Virginia Tech agree to the proposed preventive maintenance items, a preventative maintenance schedule will be created in conjunction with both the Selected Firm and the corresponding department. All Preventative Maintenance work shall be scheduled with Virginia Tech department representatives in coordination with each academic calendar. Preventative



Maintenance shall be scheduled and a copy of the schedule dates shall be provided by the Selected Firm for each year.

During the performance of the preventative maintenance, the Selected Firm will be required to complete preventative maintenance work orders and to produce and complete checklists, for the work, as part of their preventative maintenance process. Checklists and reports are to be furnished to Virginia Tech representatives as preventative maintenance is completed. Checklists shall be approved by Virginia Tech; reviewed annually; and updated to reflect changes in the BAS. All changes to the schedule, preventative maintenance items or check-lists must be approved by Virginia Tech, in writing.

The Selected Firm will also be required to note and report to Virginia Tech any repairs that are needed or made. The Selected Firm shall notify the department designee of any needed repairs and the representative shall generate a work order to document those repairs. Repairs that exceed sixty (60) minutes shall not be completed by the preventative maintenance technician, instead it will be addressed as a Routine Repair (defined below) and repaired by a qualified technician as scheduled with Virginia Tech. If the preventative maintenance technician discovers a repair that does not exceed the sixty (60) minute threshold, but the technician is not qualified to conduct the repair, this repair will be treated as a Routine Repair and scheduled accordingly with Virginia Tech. (Defined below).

The intent of the sixty (60) minute cap is only to differentiate between who completes the repair and not whether the repair is covered under the Contract. A repair that is covered by the Contract and is anticipated to last less than sixty (60) minutes should be completed by the Preventive Maintenance Technician. Otherwise, all Routine Repairs anticipated to 1) last longer than sixty (60) minutes; or 2) is less than sixty minutes and is above the skillset of the preventative maintenance technician shall be handled by an alternate technician so as not to hamper the daily preventative maintenance schedules/requirements.

- a. **Routine Repairs.** Routine repairs, as specified herein, include repairs for all items except those considered non-routine as defined in Paragraph 3 below. Routine repairs shall be performed on a 24-hour, 365-day basis at the discretion of Virginia Tech. Regular working hours are defined as 6 AM to 6 PM Monday-Friday, excluding established Virginia Tech Holidays.

Selected Firm shall provide all labor, supervision, materials, replacement parts, supplies, tools, equipment, transport, travel, shipping, permits, expenses, and incidental items not specified but reasonably necessary for all repairs, replacements and adjustments defined as routine per this specification but necessary to maintain the operation and condition of the BAS included in this contract.

The Selected Firm shall provide documentation to the appropriate designated Virginia Tech Management team at the time any repair is needed.

Virginia Tech's personnel shall confirm the work with a work order number or by email anytime service is needed and in advance of any work performed. If a shutdown is required, the schedule of said work shall be approved by Virginia Tech prior to commencement.

When a repair is complete, the Selected Firm's project manager shall submit a work ticket that includes the time required for the repair and a detailed itemized list of parts used. The work ticket must include the names of the technicians performing the required work along with the confirming work order number.

The Selected Firm shall make every effort possible to complete all repairs within 24 hours. If any repairs cannot be made within 24 hours, the Selected Firm shall notify Virginia Tech's representative within the initial 24-hour period.

In the event of repetitive failures, Virginia Tech reserves the right to bring in another contractor to perform repairs and deduct charges from the contract amount.

Labor and materials provided under "Routine Repairs" shall not be deemed part of the hours per year, per unit required for Preventative Maintenance, unless the need for the repair is discovered during Preventative Maintenance, and that repair takes no longer than 60 minutes. All labor and material costs shall be included in the Preventive Maintenance pricing since there is full coverage and labor is required to be available.

**b. Spare Parts Inventory.** Selected Firm shall provide and maintain a sufficient inventory of genuine original manufacturer's spare parts and components, in order to provide effective maintenance, service and repair under the terms of this RFP. Spare parts are the property of the Selected Firm and as such, the Selected firm is expected to carry the cost of all components and will provide a replacement part for each type of system at their own cost. Spare parts provided by the contractor as specified will be returned to the Selected Firm(s) at the conclusion of the contract. Inventory should include spare parts and components, failure of which could result in extended down time or loss of which could require extended time period for replacement. This inventory of spare parts shall be kept on campus or at a nearby location so that, in the event an immediate need arises, the spare part is available without delay. In order to support the provision of spare parts, Selected Firm shall:

- 1) Store spare parts at a location or locations directed by Virginia Tech. A separate inventory is to be provided for each site. This would currently include Virginia Tech's main campus in Blacksburg, Virginia as well as the Alson H. Smith, Jr. Agricultural Research and Extension Center in Winchester, Virginia and the Marion duPont Scott Equine Medical Center in Leesburg, Virginia.
- 2) Provide approved parts cabinets for the orderly storage of replacement parts.
- 3) Selected Firm shall provide approved UL rated storage cabinet for storage of any combustible materials.
- 4) Provide Virginia Tech with a monthly inventory report of parts. Inventory report should include:
  - i. Location of part(s);

- ii. Quantity on hand;
- iii. Quantity on order; and
- iv. Quantity used.

Report shall be reconciled monthly to assure accuracy.

### 3. **Emergency, On-Demand/Non-Routine Repairs and Upgrades.**

1. **Emergency Services.** Emergency Services, as specified herein, are for responses to emergency calls. Emergency services shall be provided for all BAS including new installations and systems that may be under warranty by others. Any emergency service provided to any system will be billable at the rates outlined in the price schedule.

The Selected Firm(s) shall provide BAS work to meet the needs of Virginia Tech with minimum disruption to the educational, operational, and research mission of Virginia Tech. The Selected Firm(s) should normally plan their work between 7:00 a.m. and 5:00 p.m., Monday through Friday, except established holidays observed by Virginia Tech. Virginia Tech may require work to be performed during off-hours, which will be separately coordinated.

The Selected Firm(s) shall provide emergency service, to include after-hours, as needed and as determined by Virginia Tech Facilities Management. Selected Firm(s) shall respond by phone within thirty (30) minutes and if needed, be on-site within two (2) hours of receiving an emergency call from Facilities Management.

The Selected Firm(s) shall furnish contact information for qualified service personnel who can be reached to respond to an emergency call. Virginia Tech generally defines emergency service as response to failure of the BAS or any of its components where such failure may cause hazard to life or property or have significant business impact as determined by Virginia Tech. Such service may include, but is not limited to Failure of the system to communicate, monitor or control, etc.

The above emergency service shall apply to projects where the Selected Firm has been procured through a CM/GC and/or Virginia Tech-assigned work. Determining an emergency rests solely with the Virginia Tech and the Selected Firm(s) shall respond accordingly.

- b. **On-Demand/Non-Routine Repairs and Upgrades.** On-demand/Non-routine repairs, as specified herein, are repairs made:

- 1) As a result of Virginia Tech's request to modernize or upgrade equipment;
- 2) Repairs necessary due to Acts of God or vandalism; and

All non-routine repairs shall be authorized in advance by Virginia Tech, as negotiated. Non-routine repairs shall be scheduled at the discretion of Virginia Tech. Service shall be available on a 24-hour, 365-day basis. All

non-routine repairs shall be billable at the rates established in the price schedule.

The Selected Firm:

- i. Shall notify the appropriate Virginia Tech Management team, in writing, at the time of any non-routine repair is required;
- ii. May be requested to furnish photos documenting any damage resulting in charges to Virginia Tech; and
- iii. Shall provide Virginia Tech with estimates for repairs.

Upon approval, the Virginia Tech representative shall confirm the work with an email or work order number provided to the Selected Firm in advance of any work being performed. The email or work order number shall serve as verification that authorization for repairs has been received. Failure of the Selected Firm to obtain the required approval, prior to start of work, will constitute unauthorized work and shall release Virginia Tech from responsibility to pay for the repair.

When a repair is complete, the Selected Contractor's project manager shall submit a work ticket that includes the time required for the repair and a detailed itemized list of parts used. The work ticket must include the names of the technicians performing the required work along with the confirming work order number.

Transportation, travel time, and other expenses shall not be paid for separately, but must be included in the hourly rate.

All labor, materials, parts and supplies required in the performance of non-routine repairs shall be provided by the Selected Firm and billed to Virginia Tech per rates established in this contract.

#### **4. Construction**

Virginia Tech reserves the right to list the Selected Firm(s) for BAS work in future construction project drawings and specifications. Only Selected Firm(s) may provide a proposal to the CM/GCs or mechanical contractors competing for the project. Alternatively, Virginia Tech may procure the work and assign the work to the CM/GC. See Paragraph VI.B.

- D. Work Conditions.** The Selected Firm(s) will have to work under the same conditions as does Virginia Tech's Facilities Management. This includes, but is not limited to: information technology (IT) policies; building/ room access requirements; immunization requirements; parking arrangements arranged through Virginia Tech's Transportation Services/Parking Services; adhering to Commonwealth of Virginia and Virginia Tech building or safety codes and standards, and scheduling work around Virginia Tech special events and holidays.
- E. Inferred Quality.** On many projects, drawings and specifications may be limited. Under these circumstances, the quality of materials and workmanship should conform with the highest quality control standards and the total scope of work would be that which can be reasonably implied and inferred from the bid/construction documents.

All work performed on Virginia Tech facilities shall meet the standards specified by the equipment manufacturer, all applicable local, state, and federal standards, applicable

building and safety codes, Virginia Tech's Design and Construction Standards Manual ("DCSM"), and Virginia Tech BAS Standards. At the time of installation, all parts furnished under this contract shall be new and genuine manufacturer's recommended or authorized replacement parts. Virginia Tech strictly prohibits the use of used parts. Virginia Tech may authorize the use of manufacturer-rebuilt parts and components, provided these parts and components carry the same warranty and meet the current specification for new parts. Before using manufacturer-rebuilt parts, approval by Virginia Tech is required on a case-by-case basis

- F.** The Selected Firm(s) shall furnish all necessary labor, supervision, travel, tools, supplies, parts, and materials to provide a complete and functional system.
- G.** The Selected Firm(s) shall maintain a sufficient quantity of material or repair parts on hand or have ready access to material and parts to prevent unnecessary downtime.
- H.** Any changes to Selected Firm's personnel during the term of this contract shall be submitted in writing no less than five (5) days prior to any change. Any changes in personnel are subject to approval by Virginia Tech.
- I.** Virginia Tech reserves the right to inspect Firm's audited financial statements or other financial information which may be requested by Virginia Tech prior to making an award to Firm.
- J.** At Virginia Tech's discretion, the Selected Firm(s) may have to provide a plan of operation on future projects to demonstrate to Virginia Tech how it plans to accomplish the respective projects. This should include, but not be limited to, personnel that the Selected Firm(s) will allocate to the project, inspection by the Selected Firm(s), provisions for warranty and maintenance integrity, and a schedule.
- K.** The Selected Firm(s) shall provide a competent and well-trained workforce that exhibits professionalism, demonstrated experience and service excellence.
- L.** The Selected Firm(s) shall maintain a clean worksite. Virginia Tech may inspect the ongoing work and finished project and approve or disapprove the completed work. If Virginia Tech does not approve the completed project or any portion thereof, Virginia Tech may withhold final payment or a portion of final payment until the Selected Firm(s) finishes the project in a manner acceptable to Virginia Tech.
- M.** The Selected Firm(s) shall work with Virginia Tech to clarify plans and/or specifications provided to the Selected Firm(s) by Virginia Tech. Virginia Tech will endeavor to supply the Selected Firm(s) with the most complete documents possible. Virginia Tech may request Selected Firm(s) to make site visits and schedule meetings to obtain clarifications on the scope of work on projects.
- N.** The Selected Firm(s) should provide sufficient representation in the Blacksburg area to adequately meet Virginia Tech's needs. Representatives from the Selected Firm(s) will have to provide aid, expedite work, correct deficiencies, and handle many other miscellaneous problems that may occur during work-in-progress. "Representation" is not intended to imply a requirement of a local office to be considered for award. Virginia Tech will be looking for each Firm to show they can provide adequate and sufficient representation/manpower to satisfy the obligations listed in the request for proposal at all of our statewide locations. By way of example, having sufficient manpower to respond to the emergency service response time requirements.

- O.** All employees of the Selected Firm(s) must wear uniforms or other appropriate attire at all times to designate their affiliation with the Selected Firm(s). Virginia Tech requires such identification for security purposes and may prohibit access if Virginia Tech personnel do not recognize the identification provided.
- P.** After completion of a project, the Selected Firm(s) shall supply Virginia Tech, in electronic format, all necessary documents, drawings, databases, and software/ licenses for record keeping or other purposes as deemed necessary by Virginia Tech. Drawings shall be provided in portable document format (PDF) and electronic editable format, such as Microsoft Visio or CAD, to allow Virginia Tech to edit the drawings for future work.

At a minimum, this shall include:

1. Control drawings,
  2. Points lists,
  3. Sequence of operations,
  4. Letter of warranty,
  5. Confirmation that appropriate alarms have been put in place,
  6. Confirmation that appropriate trends have been put in place,
  7. Confirmation that system graphics have been put in place,
  8. Confirmation that training has been provided to Systems Control Center operators and Instrumentation Technicians, and
  9. A list of any outstanding (punch list) items.
- Q.** The Selected Firm(s) shall take proper safety and health precautions to protect at a minimum, students, faculty, staff, construction workers, and visitors to Virginia Tech, and the Selected Firm's work and the property of others.
  - R.** All projects shall be performed in a manner that will not adversely affect the integrity of a building's structural, mechanical, electrical, fire protection, and life safety systems, or any other building systems or utilities that may overload or render useless any portion of the building without first seeking approval by Virginia Tech's designated representative.

Building and utility shutdowns/ outages must be coordinated in advance with Virginia Tech's designated representative. Shutdowns generally require notice a minimum of five (5) days in advance.
  - S.** The Selected Firm(s) must supply Virginia Tech with all warranty and other manuals after the completion of each project. Additionally, the Selected Firm(s) shall guarantee all material and workmanship for a period of at least one (1) year or the Manufacturer's warranty period, whichever is longer. For purposes of new construction (either renovations or capital construction), the one (1) year period shall begin at Beneficial Occupancy regardless of whether the equipment was used prior to Substantial Completion. For all other work including preventative maintenance services, the warranty period shall occur after approval of the final payment by Virginia Tech.

- T. The Selected Firm (s) shall provide Virginia Tech with current manuals and other documentation as required to ensure that all personnel operate equipment and software in accordance with appropriate manufacturers' recommendations.
- U. The Selected Firm(s) shall provide the name and contact information for the individual who will act as the single point of contact for Virginia Tech for each Project.
- V. The Selected Firm(s) shall provide Virginia Tech with all hardware, software, licenses, and access rights to fully modify and maintain any system installed at Virginia Tech by the Selected Firm.
- W. Virginia Tech expects that any proposals submitted for construction projects will be valid for the time specified in Selected Firm's Proposal or as required by the bid documents. Cost increases will be handled per the terms of the procurement and associated contract for the work.
- X. The Selected Firm(s) shall be required to participate in a pilot demonstration during the negotiation phase of this solicitation. The purpose of this demonstration is to allow the prospective vendor(s) the opportunity to prove their integration capabilities across various platforms. More information about this demonstration will be provided at a later date.

## **VII. PROPOSAL PREPARATION AND SUBMISSION:**

All Proposals will consist of a technical proposal ("Technical Proposal") and a price proposal ("Price Proposal") (the Technical Proposal and the Price Proposal may be referred to collectively as "Proposal"). Descriptions of these can be found below. Proposals should be as thorough and detailed as possible so that Virginia Tech may properly evaluate your capabilities to provide the required goods or services. Firms are required to submit the following information/items as a complete proposal. If the Firm(s) fail to submit all information requested herein, Virginia Tech may require prompt submission of missing information after the receipt of Proposals or deem the proposal as non-responsive.

### **A. Price Proposal:**

- 1. The Firm shall provide **Attachment B**. Virginia Tech recognizes that not all Firms may be able to provide support for existing systems. To the extent this is the case, Virginia Tech requests Firms, to the extent possible, to describe how preventive maintenance pricing would be developed for a location or project if a BAS project is completed using the specific manufacturer's control equipment.

### **B. Technical Proposal:**

- 1. **Proposed Contractual Provisions.**
  - a. State the Firm's acceptance of the **Contractual Provisions**.
  - b. State the Firm's acceptance and understanding, with any proposed modifications, of **Section VII – Statements of Needs / Scope of Work**. Any proposed modifications shall be conspicuously identified in the proposal.
  - c. Provide the Contractor's Class A license number.
- 2. **The Firm and Its Proposed Operations.**

- a. Describe the Firm, its size, number of employees, and annual sales. This should include:
  - 1) An organizational chart indicating which individuals or positions would have knowledge of an Agreement with Virginia Tech, and the degree to which each person would be responsible to the Virginia Tech's account, including names of project managers and superintendents;
  - 2) The Firm's commitment to the Virginia Tech in terms of resources, personnel, investment, etc.; and
  - 3) Submit a copy of the Firm's most recent price catalog along with the discount that Virginia Tech will receive.
- b. Provide, at minimum, a list of three (3) of the Firm's clients comparable to Virginia Tech indicating the length of service contract and the nature of each effort. Include and identify clients where you were required to integrate into a pre-existing system.
  - 1) The following reference information shall be provided for no less than three (3) of the comparable clients:
    - a) Name of Client Contact;
    - b) Title of Client Contact;
    - c) Address;
    - d) Phone number; and
    - e) Email address.
- c. Provide, at minimum, a list of three (3) of the Firm's clients comparable to Virginia Tech describing work on new capital (or major) construction and the nature of each effort.
  - 1) The following reference information shall be provided for no less than three (3) of the comparable clients:
    - a) Name of Client Contact;
    - b) Title of Client Contact;
    - c) Address;
    - d) Phone number; and
    - e) Email address.
- d. The Firm represents that the prices, terms, warranties, and benefits specified in its proposal are comparable to or better than the equivalent terms being offered by the Firm to any present customer.



- e. Provide the Firm's plan for utilization of Small, Women-owned, and Minority-owned businesses.

3. **BAS Preventive Maintenance Technicians Experience**. The importance of maintaining the BAS and associated equipment in line with its original design and upgraded performance requires the service to be performed by an experienced and competent Firm who has satisfactorily maintained equipment of this type and to the degree included in these specifications

- a. Any technician used by the Selected Firm for the performance of this work shall be experienced and trained in the maintenance and repair of BAS systems and associated equipment, and shall be capable and qualified in performing the repair and service work.
- b. The Selected Firm shall have and maintain technical support assistance for the assigned technicians and be available at all times.
- c. Any technician, or other personnel, proposed by the Selected Firm shall be subject to approval by Virginia Tech.

4. **Software Tools**

The Firm shall provide a plan for allowing Virginia Tech personnel direct access to all software components and licenses necessary for Virginia Tech personnel to design, engineer, configure, and maintain projects or work using the Firm's products. Software components include, but are not limited to, engineering software for developing live and interactive engineering drawings of controllers, programming software, server configuration software, graphics software, database configuration software, web applications, and field utility applications for maintenance of controllers/ components.

5. **BAS Integration**

The Firm shall provide a detailed plan for how it intends to integrate their system into the existing BAS infrastructure and operational processes currently in place at Virginia Tech as well as a detailed explanation of all required hardware/ software components for a long-term fully functional system. This should include a list and description of any necessary servers, software, licenses, software contracts, service contracts, etc. A description of the existing BAS infrastructure on Virginia Tech's main campus can be found in Section VI.A - Overview.

6. **Technical Support**

The Firm shall provide a plan for allowing Virginia Tech personnel direct access to technical support information, including but not limited to, technical support cases, product briefings, and software updates.

7. **Training**

Provide the Firm's plan for providing ongoing training to Virginia Tech staff, including specific training topics and costs.

8. **Research and Development**

The Firm's proposal shall include a section detailing the research and development efforts of the company regarding technology innovation in the field of BAS. This section should describe the firm's upcoming product releases, and a description of how the Firm will communicate technological advancements to Virginia Tech.

9. **Cybersecurity**

- a. The Firm's proposal shall include a section detailing the cybersecurity features of their material and software/ application. This section should include a description of logging capabilities of the software/ application as well as recommended cybersecurity best practices for their system.
- b. The Firm's proposal shall list the system's information technology hardware and software (firmware, operating systems, and applications) components and the expected lifespan of each component.
- c. The Firm's proposal shall detail how the Firm, across the entire expected lifespan of the system:
  - 1) Will provide firm or third-party supported firmware, operating systems, and applications for the system;
  - 2) Will deliver application, operating system and firmware security updates and patches as they are released by the supporting party (e.g. the firm, Microsoft, etc.) and tested by the firm; and
  - 3) Will install antivirus or antimalware on systems that are capable of running such software.
- d. The Firm's proposal shall describe the process by which they ensure removal/ disablement of all unnecessary network-available services from the system; default passwords are changed on the system; and the types of system security alerts that are available for configuration and use.
- d. The Firm's proposal shall describe what data the system generates or handles, where the data travels, and how it secures the data in processing, in transit, and at rest.
- e. The Firm's proposal shall describe options regarding on-premises components of the system and components of the system that reside or communicate with hosts external to the Virginia Tech network, including any "cloud" infrastructure. Systems that involve cloud infrastructure (vs. only on-premises infrastructure) shall require detailed justification and additional security screening.

10. **Other Information**

Provide any other information that Virginia Tech should consider in evaluating the Firm's proposal. This should include information relating to Virginia Tech's stated interest in self-performance of BAS projects.

11. **Participation of Small, Women-owned and Minority-owned Business ("SWAM") Business**

If your business cannot be classified as SWaM, describe your plan for utilizing SWaM subcontractors if awarded a contract. Describe your ability to provide reporting on SWaM subcontracting spend when requested. If your firm or any business you plan to subcontract with can be classified as SWaM, but has not been certified by the Virginia Department of Small Business and Supplier Diversity ("SBSD"), it is expected that the certification process will be initiated no later than the time of the award. If your firm is currently certified, you agree to maintain your certification for the life of the contract. For assistance with SWaM certification, visit the SBSD website at <http://www.sbsd.virginia.gov/>

The Firm(s) must submit all information requested by this RFP on the ownership, utilization, and planned involvement of SWaM firms in accordance with this SWaM **Form DGS-30-360** ([https://dgs.virginia.gov/globalassets/business-units/bcom/documents/forms/dgs-30-360\\_06-20\\_small-and-diverse-businesses-participation.xlsx](https://dgs.virginia.gov/globalassets/business-units/bcom/documents/forms/dgs-30-360_06-20_small-and-diverse-businesses-participation.xlsx)) including any source list of SWaM equipment and material vendors and construction subcontractors that may be suitable to participate in the construction of BAS.

## 12. **General Information and Addenda**

The return of the General Information Form and addenda, if any, signed and filled out as required.

## C. **General Requirements**

1. **RFP Response**: In order to be considered for selection, Firms shall submit a complete response to this RFP to include;
  - a. A signed **Technical Proposal** and **Price Proposal**.
    - 1) The Technical Proposal [one (1) original digital submission] and Price Proposal (Labor Rates & Material Pricing) [one (1) digital submission] shall be prepared as two separate packages, and identified and appropriately marked as "Technical Proposal" and "Price Proposal," respectively.
  - b. Summary of Offeror's Proposal and proposed team on a double-sided place mat type 11" X 17" format.
  - c. Proposals shall be uploaded through the Bonfire online submission portal. Refer to page 2 for instructions.
    - 2) Any proprietary information should be clearly marked in accordance with 2.c. below.
  - d. Should the proposal contain **proprietary information**, provide **one (1) redacted electronic copy** of the proposal and attachments **with proprietary portions removed or blacked out**. This redacted copy should follow the same upload procedures as described on Page 1 of this RFP. This redacted copy should be clearly marked "*Redacted Copy*" within the name of the document. The classification of an entire proposal document, line item prices and/or total proposal prices as proprietary or trade secrets is not acceptable. Virginia Tech shall not be responsible for the Firm's failure to exclude proprietary information from this redacted copy.

No other distribution of the proposals shall be made by the Firm.

2. **Proposal Preparation:**

- a. Proposals shall be signed by an authorized representative of the Firm. All information requested should be submitted. Failure to submit all information requested may result in Virginia Tech requiring prompt submission of missing information and/or giving a lowered evaluation of the proposal. Proposals which are substantially incomplete or lack key information may be rejected by Virginia Tech at its discretion. Mandatory requirements are those required by law or regulation or are such that they cannot be waived and are not subject to negotiation.
- b. Proposals should be prepared simply and economically providing a straightforward, concise description of capabilities to satisfy the requirements of the RFP. Emphasis should be on completeness and clarity of content.
- c. Proposals should be organized in the order in which the requirements are presented in the RFP. All pages of the proposal should be numbered. Each paragraph in the proposal should reference the paragraph number of the corresponding section of the RFP. It is also helpful to cite the paragraph number, subletter, and repeat the text of the requirement as it appears in the RFP. If a response covers more than one page, the paragraph number and subletter should be repeated at the top of the next page. The proposal should contain a table of contents which cross references the RFP requirements. Information which the Firm desires to present that does not fall within any of the requirements of the RFP should be inserted at an appropriate place or be attached at the end of the proposal and designated as additional material. Proposals that are not organized in this manner risk elimination from consideration if the evaluators are unable to find where the RFP requirements are specifically addressed.
- d. Ownership of all data, material and documentation originated and prepared for Virginia Tech pursuant to the RFP shall belong exclusively to Virginia Tech and be subject to public inspection in accordance with the Virginia Freedom of Information Act. Trade secrets or proprietary information submitted by a Firm shall not be subject to public disclosure under the Virginia Freedom of Information Act. However, to prevent disclosure the Firm must invoke the protections of Section 2.2-4342F of the Code of Virginia, in writing, either before or at the time the data or other materials is submitted. The written request must specifically identify the data or other materials to be protected and state the reasons why protection is necessary. The proprietary or trade secret material submitted must be identified by some distinct method such as highlighting or underlining and must indicate only the specific words, figures, or paragraphs that constitute trade secret or proprietary information. The classification of an entire proposal document, line item prices and/or total proposal prices as proprietary or trade secrets is not acceptable and may result in rejection of the proposal.

3. **Oral Presentation:** Firms who submit a proposal in response to this RFP may be required to give an oral presentation of their proposal to Virginia Tech.-This will provide an opportunity for the Firm to clarify or elaborate on the proposal but will in no way change the original proposal. Virginia Tech will schedule the time and

location of these presentations. Oral presentations are an option of Virginia Tech and may not be conducted. Therefore, proposals should be complete.

## **VIII. SELECTION CRITERIA AND AWARD:**

### **A. Selection Criteria**

Proposals will be evaluated by Virginia Tech using these criteria:

<b><u>Maximum Point Criteria</u></b>	<b><u>Value</u></b>
1. Quality of products/services offered and suitability for the intended purposes	30
2. Qualifications and experiences of Firm in providing the goods/services	20
3. Specific plans or methodology to be used to provide the Services	30
4. Cost (or Price)	10
5. Participation of Small, Women-Owned and Minority (SWAM) Business	10
Total	100

### **B. Award**

Selection shall be made of two or more Firms deemed fully qualified and best suited among those submitting proposals based on the evaluation factors in the Request for Proposal, including price, if so stated in the Request for Proposal. Negotiations shall then be conducted with the Firms so selected. Price shall be considered, but need not be the sole determining factor. After negotiations have been conducted with each Firm so selected, Virginia Tech shall select the Firm(s) which, in its opinion, has made the best proposal, and shall award the contract to that Selected Firm(s). Virginia Tech may cancel this Request for Proposal or reject proposals at any time prior to an award. Should Virginia Tech determine in writing and in its sole discretion that only one Firm has made the best proposal, a contract may be negotiated and awarded to that Firm. The award document will be a contract incorporating by reference all the requirements, terms and conditions of this solicitation and the Contractor's proposal, as negotiated.

Virginia Tech reserves the right to award multiple contracts as a result of this solicitation.

## **IX. OPTIONAL PRE-PROPOSAL CONFERENCE:**

An optional pre-proposal conference will be held virtually via Zoom on November 10<sup>th</sup>, 2022 at 10:00AM. In order to receive an invitation for this teleconference, please email Bryan Holloway directly at [bryanh91@vt.edu](mailto:bryanh91@vt.edu). The purpose of this conference is to allow potential Offerors an opportunity to present questions and obtain clarification relative to any facet of this solicitation.

While attendance at this conference will not be a prerequisite to submitting a proposal, offerors who intend to submit a proposal are encouraged to attend.

Bring a copy of this solicitation with you. Any changes resulting from this conference will be issued in a written addendum to this solicitation.

**It is strongly recommended that you obtain a Virginia Tech parking permit for display on your vehicle prior to attending the conference. Parking permits are available from the Virginia Tech Parking Services Department located at 505 Beamer Way, phone: (540) 231-3200, e-mail: [parking@vt.edu](mailto:parking@vt.edu).**

**X. INVOICES:**

Invoices for goods or services provided under any contract resulting from this solicitation shall be submitted by email to [vtinvoices@vt.edu](mailto:vtinvoices@vt.edu) or by mail to:

Virginia Polytechnic Institute and State University ("Virginia Tech")  
Accounts Payable  
North End Center, Suite 3300  
300 Turner Street NW  
Blacksburg, Virginia 24060

**XI. METHOD OF PAYMENT:**

Virginia Tech will authorize payment to the contractor as negotiated in any resulting contract from this Request for Proposal.

Payment can be expedited through the use of the Wells One AP Control Payment System. Virginia Tech strongly encourages participation in this program. For more information on this program please refer to Virginia Tech's Procurement website: <http://www.procurement.vt.edu/vendor/wellsone.html> or contact the procurement officer identified in the RFP.

**XII. ADDENDUM:**

Any addendum issued for this solicitation may be accessed at <http://www.apps.vpfin.vt.edu/html.docs/bids.php>. Since a paper copy of the addendum will not be mailed to you, we encourage you to check the web site regularly.

**XIII. COMMUNICATIONS:**

Communications regarding this solicitation shall be formal from the date of issue, until either a Contractor has been selected or the Procurement Department rejects all proposals. Formal communications will be directed to the procurement officer listed on this solicitation. Informal communications, including but not limited to request for information, comments or speculations regarding this solicitation to any University employee other than a Procurement Department representative may result in the offending Firm's proposal being rejected.

**XIV. CONTROLLING VERSION OF SOLICITATION:**

The posted version of the solicitation and any addenda issued by Virginia Tech Procurement Services is the mandatory controlling version of the document. Any modification of/or additions to the solicitation by the Firm shall not modify the official version of the solicitation issued by Virginia Tech Procurement Services. Such modifications or additions to the solicitation by the Firm may be cause for rejection of the proposal; however, Virginia Tech reserves the right to decide, on a case by case basis, in its sole discretion, whether to reject such a proposal.

**XV. TERMS AND CONDITIONS:**

This solicitation and any resulting contract/purchase order shall be governed by the attached terms and conditions, see **Attachment A**.

**XVI. CONTRACT ADMINISTRATION:**

- A. A Contract Administrator shall be identified by Virginia Tech and such Contract Administrator and shall use all powers under the contract to enforce its faithful performance.
- B. The Contract Administrator, or their designee, shall determine the amount, quantity, acceptability, fitness of all aspects of the services and shall decide all other questions in connection with the services. The Contract Administrator, or their designee, shall not have authority to approve changes in the services which alter the concept or which call for an extension of time for this contract. Any modifications made must be authorized by the Virginia Tech Procurement Department through a written amendment to the contract.

**XVII. ATTACHMENTS:**

**Attachment A** – Terms and Conditions

**Attachment B** – Price Proposal / Labor Rates and Material Pricing

**Attachment C** – Virginia Tech BAS Standards

## ATTACHMENT A

### TERMS AND CONDITIONS

#### RFP GENERAL TERMS AND CONDITIONS

See: [http://procurement.vt.edu/content/dam/procurement\\_vt\\_edu/docs/terms/GTC\\_RFP\\_09242021.pdf](http://procurement.vt.edu/content/dam/procurement_vt_edu/docs/terms/GTC_RFP_09242021.pdf)

#### ADDITIONAL TERMS AND CONDITIONS

1. **ADDITIONAL GOODS AND SERVICES:** The University may acquire other goods or services that the supplier provides other than those specifically solicited. The University reserves the right, subject to mutual agreement, for the Contractor to provide additional goods and/or services under the same pricing, terms and conditions and to make modifications or enhancements to the existing goods and services. Such additional goods and services may include other products, components, accessories, subsystems, or related services newly introduced during the term of the Agreement.
2. **AUDIT:** The Contractor hereby agrees to retain all books, records, and other documents relative to this contract for five (5) years after final payment, or until audited by the Commonwealth of Virginia, whichever is sooner. Virginia Tech, its authorized agents, and/or the State auditors shall have full access and the right to examine any of said materials during said period.
3. **AVAILABILITY OF FUNDS:** It is understood and agreed between the parties herein that Virginia Tech shall be bound hereunder only to the extent of the funds available or which may hereafter become available for the purpose of this agreement.
4. **CANCELLATION OF CONTRACT:** Virginia Tech reserves the right to cancel and terminate any resulting contract, in part or in whole, without penalty, upon 60 days written notice to the Contractor. In the event the initial contract period is for more than 12 months, the resulting contract may be terminated by either party, without penalty, after the initial 12 months of the contract period upon 60 days written notice to the other party. Any contract cancellation notice shall not relieve the Contractor of the obligation to deliver and/or perform on all outstanding orders issued prior to the effective date of cancellation.
5. **CONTRACT DOCUMENTS:** The contract entered into by the parties shall consist of the Request for Proposal including all modifications thereof, the proposal submitted by the Contractor, the written results of negotiations, the Commonwealth Standard Contract Form, all of which shall be referred to collectively as the Contract Documents.
6. **IDENTIFICATION OF PROPOSAL EMAIL:** Virginia Tech will only be accepting electronic submission of proposals. All submissions must be submitted to <https://procurement-vt.bonfirehub.com/>. Upon completion you will be directed to your Submission Receipt. Virginia Tech will not confirm receipt of proposals. It is the responsibility of the Firm to make sure their proposal is delivered on time. **Attachments must be smaller than 1000MB in order to be received by the University.** Proposals may **NOT** be hand delivered to the Procurement Office.
7. **NOTICES:** Any notices to be given by either party to the other pursuant to any contract resulting from this solicitation shall be in writing via email.
8. **SEVERAL LIABILITY:** Virginia Tech will be severally liable to the extent of its purchases made against any contract resulting from this solicitation. Applicable entities described herein will be severally liable to the extent of their purchases made against any contract resulting from this solicitation.



9. **CLOUD OR WEB HOSTED SOFTWARE SOLUTIONS:** For agreements involving Cloud-based Web-hosted software/applications refer to link for additional terms and conditions: [http://www.ita.vt.edu/purchasing/VT\\_Cloud\\_Data\\_Protection\\_Addendum\\_final03102017.pdf](http://www.ita.vt.edu/purchasing/VT_Cloud_Data_Protection_Addendum_final03102017.pdf)
10. **ADVERTISING:** In the event a contract is awarded for supplies, equipment, or services resulting from this solicitation, no indication of such sales or services to Virginia Tech will be used in product literature or advertising. The contractor shall not state in any of the advertising or product literature that the Commonwealth of Virginia or any agency or institution of the Commonwealth has purchased or uses its products or services.
11. **AS-BUILT DRAWINGS:** The Contractor shall provide Virginia Tech a clean set of reproducible "as built" drawings and wiring diagrams, marked to record all changes made during installation or construction. The Contractor shall also provide Virginia Tech with maintenance manuals, parts lists and a copy of all warranties for all equipment. All "as built" drawings and wiring diagrams, maintenance manuals, parts lists and warranties shall be delivered to Virginia Tech upon completion of the work and prior to final payment.
12. **ASBESTOS:** Whenever and wherever during the course of performing any work under this contract, the Contractor discovers the presence of asbestos or suspects that asbestos is present, he shall stop the work immediately, secure the area, notify the Building Owner and await positive identification of the suspect material. During the downtime in such a case, the contractor shall not disturb any surrounding surfaces but shall inform all employees that the suspect material is not to be disturbed, and shall vacate and secure the area until an identification has been made if suspect debris is present. In the event the contractor is delayed due to the discovery of asbestos or suspected asbestos, then a mutually agreed extension of time to perform the work shall be allowed the contractor but without additional compensation due to the time extension.
13. **MATERIALS CONTAINING ASBESTOS:** The contractor shall not incorporate any materials into the work containing asbestos. The contractor shall not incorporate any material known by the contractor to contain a substance known to be hazardous to health when the building is occupied unless specifically approved by Virginia Tech or required by the specifications. If the contractor becomes aware that a material required by the specifications contains asbestos, it shall notify Virginia Tech immediately and shall take no further steps to acquire or install any such material
14. **OPTIONAL PERFORMANCE AND PAYMENT BONDS:** The University reserves the right in its own discretion to require performance and payment bonds prior to execution of the Contract. The successful Firm/bidder shall be prepared to deliver executed Commonwealth of Virginia Standard Performance and labor and Material Payment Bonds if so requested each in the sum of the contract amount, with the Commonwealth of Virginia, Virginia Polytechnic Institute and State University as obligee. The surety shall be a company or companies approved by the State Corporation Commission to transact surety business in the Commonwealth of Virginia. No payment shall be due and payable to the contractor, even if the contract has been performed in whole or in part, until the bonds have been delivered to and approved by the procurement office. Standard bond forms will be provided by the procurement office if the University does so request a performance and payment bond.

Determination of the requirement to submit performance and payment bonds will be made by the University at its sole discretion based on the following:

- Complexity of the project
- Timeline of the project
- Evaluation of the contractor's references provided
- Past history of work performance at the University

All Firms/bidders shall be prepared to provide said bonds upon request. If requested, cost to obtain these bonds will then be added to the contractor's base price.

15. **CONTRACTOR/SUBCONTRACTOR LICENSE REQUIREMENT:** By my signature on this solicitation, I certify that this firm/individual and/or subcontractor is properly licensed for providing the goods/services specified

Contractor Name: \_\_\_\_\_ Subcontractor Name: \_\_\_\_\_

License #: \_\_\_\_\_ Type: \_\_\_\_\_

16. **CONTRACTOR'S TITLE TO MATERIALS:** No materials or supplies for the work shall be purchased by the Contractor or by any Subcontractor subject to any chattel mortgage or under a conditional sales or other agreement by which an interest is retained by the seller. The contractor warrants that he has clear title to all materials and supplies for which he invoices for payment.
17. **CRIMINAL CONVICTION CHECKS:** All criminal conviction checks must be concluded prior to the Contractor's employees gaining access to the Virginia Tech Campus. Employees who have separated employment from Contractor shall undergo another background check prior to re-gaining access to the Virginia Tech campus. Contractor shall ensure subcontractors conduct similar background checks. Virginia Tech reserves the right to audit a contractor's background check process at any time. All employees have a duty to self-disclose any criminal conviction(s) occurring while assigned to the Virginia Tech campus. Such disclosure shall be made to Contractor, which in turn shall notify the designated Virginia Tech contract administrator within 5 days. If at any time during the term of the contract Virginia Tech discovers an employee has a conviction which raises concerns about university buildings, property, systems, or security, the contractor shall remove that employee's access to the Virginia Tech campus, unless Virginia Tech consents to such access in writing. Failure to comply with the terms of this provision may result in the termination of the contract.
18. **ELECTRICAL INSTALLATION:** All equipment/material shall conform to the latest issue of all applicable standards as established by National Electrical Manufacturer's Association (NEMA), American National Standards Institute (ANSI), and Underwriters' Laboratories, Incorporated (UL) or other Nationally Recognized Testing Laboratories (NRTL) currently listed with the US Department of Labor. All equipment and material, for which there are NEMA, ANSI, UL or other NRTL standards and listings, shall bear the appropriate label of approval for use intended.
19. **FINAL INSPECTION:** At the conclusion of the work, the contractor shall demonstrate to the authorized owner's representatives that the work is fully operational and in compliance with contract specifications and codes. Any deficiencies shall be promptly and permanently corrected by the contractor at the contractor's sole expense prior to final acceptance of the work.
20. **INSTALLATION:** All items must be assembled and set in place, ready for use. All crating and other debris must be removed from the premises.
21. **INSURANCE PROVISIONS:** The insurance requirements identified below are the minimum requirements. Individual projects may require additional insurance coverage and/or limits. By signing and submitting a Proposal/Bid under this solicitation, the Firm/bidder certifies that if awarded the contract, it will have the following insurance coverages at the time the work commences. Additionally, it will maintain these during the entire term of the contract and that all insurance coverages will be provided by insurance companies authorized to sell insurance in Virginia by the Virginia State Corporation Commission.

During the period of the contract, Virginia Tech reserves the right to require the contractor to furnish certificates of insurance for the coverage required.

**INSURANCE COVERAGES AND LIMITS REQUIRED:**

- A. Worker's Compensation - Statutory requirements and benefits.
- B. Employers Liability - \$100,000.00
- C. General Liability - \$2,000,000.00 combined single limit. Virginia Tech and the Commonwealth of Virginia shall be named as an additional insured with respect to goods/services being procured. This coverage is to include Premises/Operations Liability, Products and Completed Operations Coverage, Independent Contractor's Liability, Owner's and Contractor's Protective Liability and Personal Injury Liability.
- D. Automobile Liability - \$500,000.00
- E. Builders Risk – For all renovation and new construction projects under \$100,000 Virginia Tech will provide All Risk – Builders Risk Insurance. For all renovation contracts, and new construction from \$100,000 up to \$500,000 the contractor will be required to provide All Risk – Builders Risk Insurance in the amount of the contract and name Virginia Tech as additional insured. All insurance verifications of insurance will be through a valid insurance certificate.
- F. The contractor agrees to be responsible for, indemnify, defend and hold harmless Virginia Tech, its officers, agents and employees from the payment of all sums of money by reason of any claim against them arising out of any and all occurrences resulting in bodily or mental injury or property damage that may happen to occur in connection with and during the performance of the contract, including but not limited to claims under the Worker's Compensation Act. The contractor agrees that it will, at all times, after the completion of the work, be responsible for, indemnify, defend and hold harmless Virginia Tech, its officers, agents and employees from all liabilities resulting from bodily or mental injury or property damage directly or indirectly arising out of the performance or nonperformance of the contract.

- 22. MAINTENANCE MANUALS:** The contractor shall provide with each piece of equipment an operations and maintenance manual with wiring diagrams, parts list, and a copy of all warranties.
- 23. SUBCONTRACTS:** No portion of the work shall be subcontracted without prior written consent of Virginia Tech. In the event that the contractor desires to subcontract some part of the work specified herein, the contractor shall furnish Virginia Tech the names, qualifications and experience of their proposed subcontractors. The contractor shall, however, remain fully liable and responsible for the work to be done by his subcontractor(s) and shall assure compliance with all requirements of the contract.
- 24. SAFETY:** The contractor bears sole responsibility for the safety of its employees. The contractor shall take all steps necessary to establish, administer, and enforce safety rules that meet the regulatory requirements of the Virginia Department of Labor and Industry (VDLI) and the Occupational Safety and Health Administration (OSHA). The contractor shall take steps as necessary to protect the safety and health of university employees, students, and visitors during the performance of their work. In addition, the contractor must also provide the university with a written safety program that it intends to follow in pursuing work under this contract. By entering into a contract with Virginia Tech, the contractor and its subcontractors agree to abide by the requirements described in Safety Requirements for Contractors and Subcontractors located on Virginia Tech's Environmental, Health and Safety Services (EHSS) web site at this URL [http://www.ehss.vt.edu/programs/contractor\\_safety.php](http://www.ehss.vt.edu/programs/contractor_safety.php). A copy of the publication may also be obtained by contacting EHSS at 540/231- 5985. No work under this contract will be permitted until the university is assured that the contractor has an adequate safety program in effect.

25. **SPECIAL OR PROMOTIONAL DISCOUNTS:** The Contractor shall extend any special promotional sale prices or discounts immediately to Virginia Tech during the term of the contract. Such notice shall also advise the duration of the specific sale or discount price.
26. **TURF POLICY:** Parking or driving on campus turf or sidewalk is strictly prohibited, except as specifically directed or otherwise allowed by the Physical Plant Grounds Department. In this case, a turf permit must be obtained from Virginia Tech Parking Services and displayed by the vehicle. Turf parking is not allowed under the canopy of any tree on campus. Any vehicle parked illegally on turf or sidewalks shall be subject to ticketing and fines.
27. **TRANSPORTATION AND PACKAGING:** By signing their Proposal/Bid the Firm/bidder certifies and warrants that the Proposal/Bid price offered for FOB destination includes only the actual freight rate costs at the lowest and best rate and is based upon the actual weight of the goods to be shipped. Except as otherwise specified herein, standard commercial packaging, packing and shipping containers shall be used. All shipping containers shall be properly and legibly marked or labeled on the outside with the commodity description and number, size and quantity of the contents.
28. **WARRANTY (COMMERCIAL):** The contractor agrees that the supplies or services furnished under any award resulting from this solicitation shall be covered by the most favorable commercial warranties the contractor gives any customer for such supplies or services and that the rights and remedies provided therein are in addition to and do not limit those available to Virginia Tech by any other clause of this solicitation. A copy of this warranty must be furnished with the Proposal/Bid.
29. **WORK SITE DAMAGES:** Any damage to existing utilities, equipment or finished surfaces resulting from the performance of this contract shall be repaired to the Owner's satisfaction at the contractor's expense.

## ATTACHMENT B

### PRICE PROPOSAL/ LABOR RATES & MATERIAL PRICING

#### A. Preventive Maintenance

Initial Term - \$ \_\_\_\_\_

#### B. Labor

Firm's must provide the net labor rates in the "Price per hour" column, and in the "Other expenses" column to include: other associated labor costs, bond costs, insurance costs, all general and administrative expenses, benefits, supervision, and overhead and profit per hour. Tradesperson tools and equipment shall be included as part of overhead. The Firm should provide a price for each discipline listed. It is acceptable for the Firm to edit the discipline/ labor categories to match the Firm's organization. Firms shall supply these rates for the first three (3) years of the contract:

Labor	Price per Hour	Overtime (if applicable)	Other Expenses	Extended Labor Rate
Technician	\$ _____	\$ _____	\$ _____	\$ _____
Assistant Technician	\$ _____	\$ _____	\$ _____	\$ _____
Project Manager	\$ _____	\$ _____	\$ _____	\$ _____
Engineer	\$ _____	\$ _____	\$ _____	\$ _____
Other (List)	\$ _____	\$ _____	\$ _____	\$ _____

#### B. Material Pricing

1. All Material in Firm's Price Catalog  
Discount off of List Price \_\_\_\_\_ %

All Shipping shall be at cost. Material discount is the percentage discount Virginia Tech shall receive that will be deducted from published list prices. **Selected Firms shall provide within their proposal a copy of the commonly used vendor's most recent price catalog.**

## **ATTACHMENT C**

### **BUILDING AUTOMATION SYSTEM**

#### **General Notes**

1. The A/E shall coordinate specific project requirements with the VT PM and with VT Instrumentation, Controls, and Metering (ICM).
2. All materials shall be new, the best of their respective kinds, without imperfections or blemishes, and shall not be damaged in any way, and shall consist of the manufacturer's latest proven technology that is compatible with the existing building controls infrastructure at the time of equipment submittal. Used equipment shall not be used in any way for the permanent installation except where drawings or specs specifically allow existing materials to remain in place.
3. The installation of all equipment shall be in strict accordance with manufacturer's instructions and installation manual. All equipment shall be rated for the intended use.
4. The University reserves the right to make changes to the BAS during the warranty period. Such changes do not constitute a waiver of warranty. The installer shall warrant parts and installation work regardless of any such changes made by the University, unless the installer provides clear and indisputable evidence that a specific problem is the result of such changes to the BAS. Any disagreement between the University and the installer on such matters shall be subject to resolution through the contract 'disputes' clause.

#### **Required Submittals**

1. Project specifications shall have detailed instructions on owner training. A/E shall define which systems need training, how much training is needed, and how the training should be delivered, including videography of training if requested by Virginia Tech.
2. Project specifications shall have detailed instructions to make clear the expectations of the BAS vendor. These specifications shall require the BAS vendor to provide the following information in their submittal package:
  - a. Describe system operation, functions and control techniques.
  - b. Migration strategies to protect owner's investment in BAS system. This includes detailing existing-to-remain controls and the compatibility for all controllers in the building to seamlessly communicate.
  - c. Technical data to support the information on the hardware and software proposed for this solution including any integrated systems and/or solutions.
  - d. Integration information from third-party controllers including manufacturer passwords, Modbus or BACnet point maps, instance numbers is the responsibility of the BAS contractor. BAS contractors must gather this information and provide along with their submittal.
  - e. Line-by-line specification conformance statement.
  - f. Provide submittals for fast-track items that need to be approved and released to meet the schedule of the project.
  - g. Valve schedule and product data
  - h. Damper schedule and product data
  - i. Mounting and wiring diagrams for factory-installed control components
  - j. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices
  - k. Wiring diagrams: Power, signal, and control wiring. Detail the wiring of the control devices and the panels. Show point-to-point wiring from field devices to the control panel. Show point-to-point wiring of hardwired interlocks. Show a ladder diagram or schematic of wiring internal to the panels,

including numbered terminals. Clearly designate wiring that is done at a factory, at a panel shop or in the field.

- l. Details of control panel faces, including panel size, control component layout, instrument layout, and labeling. The intent here is to ensure that panels are not overcrowded and allow sufficient room for future improvements.
  - m. Schedule of valves, dampers and actuators including size, leakage, and flow characteristics. If dampers are furnished by other, submit a damper actuator schedule coordinating actuator sizes with the damper schedule.
  - n. Written description of the sequence of operations.
  - o. Network riser diagram showing wiring types, network protocols, locations of floor penetrations and number of control panels. Label control panels with network addresses and BACnet device instance numbers. Show all routers, switches, hubs and repeaters.
  - p. Point list for each system controller including both inputs and outputs (I/O), point numbers, controlled device associated with each I/O point, and location of I/O device.
  - q. Starter and variable frequency drive wiring details of all automatically controlled motors.
3. Product data: Include manufacturer's technical literature for each control device indicated, labeled with setting or adjustable range of control. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated. Submit a write-up of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.
4. Submit BACnet protocol implementation conformance statements (PICS) for all direct digital controllers, software and other system components that will communicate on the BAS utilizing BACnet.
5. After the BAS system components have been approved for construction, submit standard operator workstation graphics for approval. Electronically submit the graphics that the operator will use to view the systems, change setpoints, modify parameters and issue manual commands. Graphics must be approved by the ICM shop prior to final commissioning.
6. Project record documents including, at a minimum, as-built versions of shop drawings, O&M manual, startup, and commissioning reports. BAS record documents shall clearly convey the physical design of the system, network layouts, as well as materials and devices used therein. As-built shop drawings must be inclusive of all field changes to system configuration and sequences of operation.
  - a. Each unique type of equipment shall have an equipment schematic showing hardware layout, a module or panel detail showing layout and connection, a bill of materials and a concise written sequence describing each mode of operation.
  - b. A network diagram shall be provided for each project, indicating the physical layout, including the routing of network wire, as well as the location of each node and the equipment it serves. This diagram should include all BAS modules, as well as any network devices such as gateways, routers and third-party devices.
  - c. A power riser, power layout, including electrical panel/circuit number.
  - d. Record documents shall include equipment schedules detailing the specification and application of control valves, control dampers and any other equipment provided by the BAS contractor.
  - e. All record documents are subject to the approval of the project management and/or engineer of record.

- f. Upon completion of the project, an electronic copy of the as-builts, in pdf format, shall be provided to the ICM department and stored on the BAS server in the as-builts folder (G:/ drive).
- g. The controls installer shall provide the University with all product line technical manuals and technical bulletins, including new and upgraded products, throughout the warranty period of the project.

### **Coordination with Other Trades**

1. Power and raceways for the BAS system shall be procured in the most cost-effective method possible. BAS building level network panel locations shall be shown on the A/E's contract documents. Power circuiting for these field panels and conduit between field panels shall be included on the A/E's contract documents.
2. The BAS vendor shall actively coordinate with the electrical contractor or any other contractors that are impacted by their work.

### **BAS Commissioning**

1. It is imperative that the BAS contractor actively support commissioning activities that are critical to successful operation of the building once occupied.
2. Provide complete submittal package as described above with sequences of operations and BAS graphics.
3. Attend commissioning planning meetings .
4. Certify that instrumentation and control systems are installed according to the contract documents and complete all required checklists from the commissioning agent.
5. Certify that instrumentation and control systems have been completed and calibrated; are operating according to contract documents; and that pretest set points have been recorded prior to functional performance testing. Complete all required test checklist documents.
6. Test systems and intersystem performance after approval of test checklists for systems, subsystems, and equipment.
7. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shut down, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
8. Verify each operating cycle after it has been running for a specified period and is operating in a steady-state condition.
9. Inspect and verify the position of each device and interlock identified on checklists. Sign off each item as acceptable or failed. Repeat this test for each operating cycle that applies to system being tested.
10. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
11. Annotate checklist or data sheet when a deficiency is observed.
12. Verify proper responses of monitoring and control system controllers and sensors to include the following:
  - a. For each controller or sensor, record the indicated monitoring and control system reading and the test instrument reading. If initial test indicates that the test reading is outside of the control range of the installed device, check calibration of the installed device and adjust as required. Retest malfunctioning devices and record results on checklist or data sheet.
  - b. Report deficiencies and prepare an issues log entry.
13. Verify integrity of all control wiring to ensure continuity and freedom from shorts and grounds prior to commencing the startup and commissioning procedures.
14. Test all operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.



15. The BAS contractor is required to participate in seasonal post occupancy setpoint optimization for energy efficiency for a minimum of four seasons after acceptance. This shall include optimization of pressure setpoints, temperature setpoints, PID gains, and general review of system operation to identify equipment with unusual run times, unusual cycling, etc.

### **Access to the BAS**

1. Access to the BAS shall be by approval only. The request shall be submitted to the ICM shop and ultimately approved by the Campus Energy Manager.
2. The system shall have the follow user access permissions at a minimum
  - a. Administrator
  - b. Owner
  - c. Power user
  - d. Support user
  - e. Read only
3. The BAS contractor shall be responsible for setting up user access permissions prior to project closeout. Virginia Tech will provide a list of users and their user access category so proper system access associated with the project is completed at the time the project is implemented and any access related issues are resolved prior to the end of commissioning activities.

### **Notification Management**

1. The system shall have configurable alarming notification ability for different users. Virginia Tech will provide a list of users, their user access category, and desired alarm notification level so that this function is set up at the time the project is implemented and any alarming related issues are resolved prior to the end of commissioning activities.
2. See Appendix J: BAS Standards: Sequence of Operations for more detail on alarm reporting actions.

### **Approved Products**

1. One approved BAS vendor is Siemens. The new BAS shall utilize electronic sensing, microprocessor-based direct digital control, and electronic actuation of dampers, valves, and devices to perform control sequences and functions specified.
  - a. All new capital projects shall utilize Desigo or other approved vendor as the BAS front-end.
  - b. Non-capital projects consisting of less than 50% of the building shall be tied into the existing network residing on Insight. Renovation projects consisting of more than 50% of the building shall be migrated into the native front end of the newly installed controllers and include the migration of exiting, to remain, BAS infrastructure into this front end as well. In no instance shall there be two or more BAS systems within the same facility.
2. Energy metering
  - a. Accuracy: +/- 0.2% FS
  - b. Power meters shall have hardwired pulse and analog output capability for the kW demand output. Additional monitoring points shall be available via BACnet.
3. Lab controls
  - a. Fume hood controllers, lab supply air valves, lab general exhaust air valves, and fume hood exhaust air valves shall be directly controlled by the BAS without an integration to a third party laboratory control valve system. Third-party lab controls are not acceptable.

4. Hydronic differential pressure transmitters
  - a. 5-port manifold with remote transducer type (rather than integrated transducers). Each transducer shall include a 5-port manifold necessary to isolate, bleed, and test the individual sensor.
  - b. Accuracy:  $\pm 0.25\%$  FS
5. Space temperature and humidity sensors
  - a. All space and humidity sensors shall be located at or near the door, the light switch, and at 60 inches to center. An exception shall be made when adjustable sensors are required by a LEED credit, and shall be mounted 44" to center.
  - b. Accuracy: Temperature  $\pm 0.4^\circ\text{F}$
  - c. Accuracy: Humidity  $\pm 2\%$  (20-80% RH)
  - d. Classrooms, offices, and other occupied spaces shall use a sensor with a setpoint adjust and occupied override functionality. Occupant override functionality will be disabled during the commissioning process to allow for the 60-inch height requirement.
  - e. Non-display sensors shall be used in public spaces (hallways, bathrooms, etc.).
  - f. Include thermostat guards for obvious hazardous locations (gyms, mechanical rooms, etc.).
6. Damper actuators
  - a. Dampers and actuators shall be designed to provide adequate airflow controllability at minimum flow and economizer situations.
  - b. The basis of design for automatic control damper actuators serving central systems shall be Belimo. This includes central air handling units and central exhaust systems.
  - c. The basis of design for automatic control damper actuators on terminal equipment shall be Siemens or Belimo. These systems include heat pumps, VAV boxes, fan coil units, unit ventilators, cabinet unit heaters, and other terminal systems serving rooms and common areas.
  - d. The basis of design for control of all automatic damper actuators shall be Siemens or Belimo DDC controllers.
7. Control valves
  - a. The basis of design for control valves shall be Siemens or Belimo. Control valves shall be provided by the BAS contractor but installed by the mechanical contractor.
  - b. Terminal units shall use pressure independent control valves with testing ports sized for the designed flow rate for the coil. Actuators for terminal equipment coils shall be fully modulating. Floating point actuators are acceptable.
  - c. In renovation applications where pressure independent valves are installed, existing balancing valves shall be removed, and manual isolation valves shall be included.
  - d. Where pressure independent valves are not feasible, units shall use characterized control valves sized for the designed pressure drop across the coil. Actuators for terminal equipment coils shall be fully modulating. Floating point actuators are acceptable.
  - e. Coils that are exposed to outside air or other freezing conditions shall have failsafe actuators. Hot water and steam valves shall fail open in most applications. Chilled water valves shall fail closed. Terminal equipment valves shall not require failsafe actuators.
  - f. Energy valves with a built-in flowmeter shall be considered for central systems such as air handling units, chilled water systems, and hot water systems shall
  - g. Automatic isolation valves shall be 2-position ball or butterfly valves where appropriate.
  - h. Control valves shall be selected with appropriate valve authority to provide adequate flow controllability with a minimum authority coefficient of 0.25 but no higher than 0.5.

- i. High performance butterfly valves shall be considered for modulating applications larger than 3" in lieu of modulating globe valves.
- 8. Hydronic thermal energy meters
  - a. Flowmeters for energy monitoring and utility billing shall be electromagnetic or ultrasonic flowmeters with matched temperature sensors. Hot tap kits shall be provided for insertion meters.
    - i. Accuracy: +/- 0.5% full span
    - ii. Range: Selected for each application based on anticipated flow.
  - b. Hydronic flowmeters
  - c. Flowmeters for central plant systems used for energy monitoring and control applications shall be insertion style electromagnetic flowmeters. Hot tap kits shall be provided.
    - i. Accuracy: +/- 1.0% full span
    - ii. Range: Selected for each application based on anticipated flow.
  - d. Flowmeters for domestic water and make-up water applications shall be impellor style insertion flowmeters. Hot tap kits shall be provided.
    - i. Accuracy: +/- 1.0% full span
    - ii. Range: Selected for each application based on anticipated flow.
  - e. Flowmeters shall be provided by the BAS contractor but installed by the mechanical contractor.
- 9. Airflow measurement stations
  - a. Thermal dispersion style
    - i. Accuracy: +/- 3% of full scale
    - ii. Range: Selected for each application based on anticipated flow.
- 10. Air quality monitoring systems
  - a. Space CO<sub>2</sub> sensor: Accuracy: +/- 50 ppm (0-2000 ppm) or +/- 30 ppm (400-1250 ppm).
  - b. Space volatile organic compound (VOC): Accuracy +/- 100 ppm (0-2000 ppm)
  - c. Duct CO<sub>2</sub> sensor: Accuracy: +/- 30 ppm (0-2000 ppm) or +/- 30ppm (400-1250 ppm)
  - d. Duct VOC sensor: Accuracy: +/- 50 ppm (0-2000 ppm)
- 11. General metering requirements
  - a. Thermal energy meters shall be provided with internal communication card that supports BACnet IP and BACnet MSTP. These should be tied directly to the BAS system controller.
  - b. A hardwired connection to the BAS shall be provided for steam, chilled and hot water rate flow.

### **VT Point Naming Standard**

- 1. All point names for the BAS shall follow the VT BAS point naming convention which follows the CSAL point naming convention.
- 2. All fully qualified point names, where applicable, shall include the respective building number, equipment/system identification number, and the appropriate point abbreviation, each separated by a period. For example, B0101.AH01.SAT would represent a supply air temperature associated with air handler one in building 101.
- 3. Terminal equipment controllers shall be named by the associated room number that they serve. For example, B0101.RM201.VAV would represent building 101, room 201, served by a variable air volume (VAV) terminal.
  - a. Rooms that are served by multiple terminal equipment, will have the terminal equipment name RMXXX.VAV1, RMXXX.VAV2, etc.

- b. Terminal equipment that serves multiple rooms shall be named by the room number that the T-stat is located in. Other rooms that are served by the terminal equipment shall be listed in the point descriptor.
- 4. Field panel naming convention: B0101 CAB 01
- 5. ALN naming convention: Sandy Hall — B0101

## **Graphics Standards**

All BAS projects/renovations shall include new or updated graphics. These graphics will be created in accordance with the following:

1. A main menu for the building with graphic links to all associated system graphics. Include the energy dashboard with the building graphic.
2. One graphic per system (air handling system, exhaust system, hot water system, chilled water system, domestic hot water system, lighting system, energy metering, etc.) shall be included. Each graphic will specify the system's location and what the system serves.
3. Individual terminal equipment will be associated with the correct standard application graphic.
4. Any lab or room with HVAC equipment that is more complex than a standard application graphic can support (e.g., multiple supply terminals, exhaust terminals, and fume hoods in a single lab) will have its own individual graphic with the correct equipment and points shown.
5. Detailed floor plan graphics shall be created. Floor plan graphics must show the following item:
  - a. All terminal equipment (VAVs, FCUs, UHs, HPs, etc.) with associated equipment and T-stat locations.
  - b. All field panel locations.
  - c. The floor plan will also specify which AHU and exhaust system serves which space.
  - d. Floor plan graphics shall show thermal mapping
  - e. Locations of field panels, terminal equipment, transformers, airflow stations, 2/3-down duct sensors, differential pressure sensors, and major equipment (chillers, AHUs, HWS, etc.) shall be shown.
6. All graphics shall be sized to fit the monitors in the ICM department.
7. Dashboarding – Energy meters and calculated energy values shall still be integrated into the BAS as described in Appendix J: BAS Standards: Sequence of Operations to assist with troubleshooting building issues.
8. Sequence of operation graphics - Provide a written “sequence of operation” graphic for every system to make it easy to read the logic for users that do not have the expertise to read the code embedded within the control system.

## **Building Level Graphics**

The building level graphic shall include a high-quality picture of the building with quick links to the following at a minimum:

1. Main floor plan graphic and links to each floor plan
2. Primary equipment including all primary water systems and airside systems
3. Links to critical equipment

## **Floor Plan Graphics**

The main floor plan graphic shall have either a floor plan overview with all zones shown and links to each floor plan, or a picture of the building with hotspots and links to each floor plan graphic.

Individual floor plans shall include the following at a minimum:

1. An architectural floor plan with all zones to scale. Publishing the scale is not necessary.
2. Room numbers and room names, if available.
3. Links to all primary equipment serving spaces in that floor plan. AHUs serving multiple spaces shall be color coded with the corresponding color highlighting areas served by the AHU.
4. Links to primary central equipment
5. Links to all other floor plans
6. Zones that are outside of their controlled setpoints shall be highlighted
7. Outside air temperature and humidity
8. All room temperatures shall be placed on the floor plan beside correct T-stat, where they can be dragged and dropped to pull up the individual room graphic.
9. T-stat icons on floor plans shall be blue; humidity icons shall be dark grey; and CO2 icons shall be light grey. Terminal equipment shall be shown on the floor plan graphic as close to the actual location as possible.

Figure 6-1. Example Floor Plan with Equipment Locations and Sensors

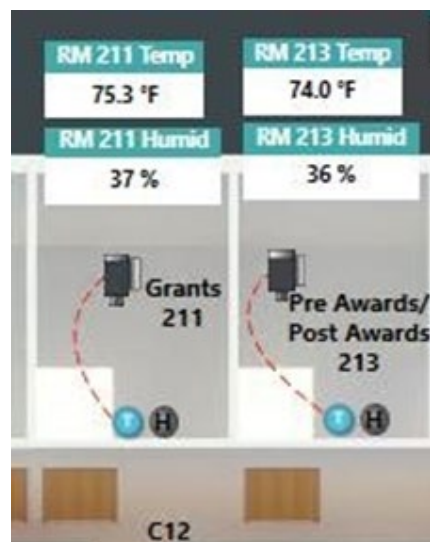


Figure 6-2. Example Floor Plan Graphic



## Equipment Graphics

Individual floor plans shall include the following at a minimum:

1. Links to any parent equipment supplying air or water
2. Links to all other floor plans
3. Zones that are outside of their controlled setpoints shall be highlighted
4. Outside air temperature and humidity
5. All equipment graphics shall have a section designated to show system mode points and key performance indicators for the associated equipment. All HVAC equipment graphics shall show the building's primary broadcast outside air and humidity.
6. Points with the ability to be commanded (digital outputs, analog outputs, virtual setpoints, etc.) shall be indicated on the graphic as an editable text box or graphical control icon.
7. Monitoring points (digital inputs, analog inputs, etc.) shall be displayed for all physical inputs and any key calculated values (energy demand, etc.) along with the point name.
8. Points with source equipment like coil valves and supply ductwork shall show the incoming condition of that source (chilled water supply temperature, AHU-1 supply temperature, etc.) along with a link to the source equipment.
9. Include application notes and startup guide links on the graphic.

Figure 6-3. System Mode Points and Key Performance Indicators

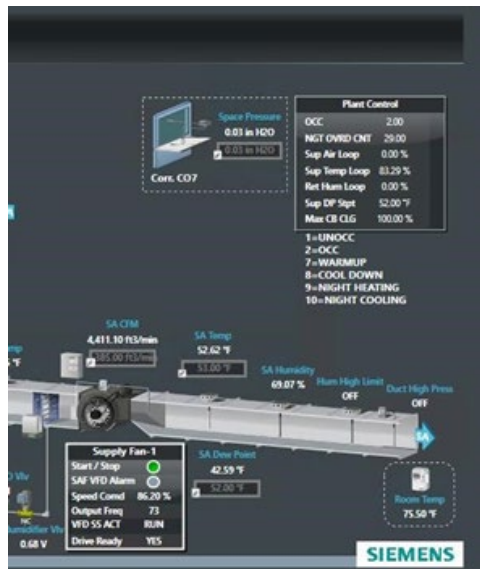
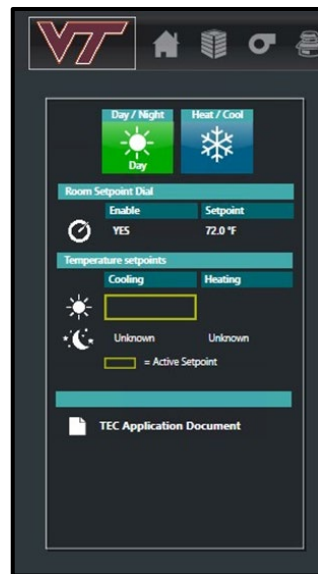


Figure 6-4. Terminal Equipment Mode Points and Key Performance Indicators



## Geographic Trees

Building geographic trees shall be laid out with all zones included under their respective floor plans. Primary and central equipment shall reside at the building level as a peer to floor plans. Terminal equipment and single zones shall reside within their respective floor plans.

Figure 6-5. Geographic Tree Example



### Third-Party Integration

1. The BAS vendor shall be responsible for directly connecting and controlling all HVAC equipment and associated systems with the building automation system. Equipment controls provided by the equipment manufacturer (i.e., “packaged control”) are not acceptable. Any exception shall require a design waiver per DCSM section 1.3.5.
2. All third-party integration, if approved, shall be accomplished via BACnet with native BACnet controls. Integration utilizing alternative protocols (non-BACnet such as Modbus, Lon, etc.) must have additional pre-approval from the VT ICM department.
3. Where a third-party interface is approved for the equipment control and sequencing, the interface shall be native BACnet as provided by the manufacturer.
4. Where a third-party interface is approved, the equipment provider shall provide a factory trained startup technician certified to configure the BACnet device.
5. All BACnet instance numbers, network IDs, MAC addresses, and port numbers, shall be coordinated with the VT ICM department and requested during the wavier application.
6. Refer to required submittals section for point mapping information required for all equipment provided with third-party packaged controls.

### BAS Network Configuration

1. Please contact the ICM Department for next available BACnet addresses and instance numbers.
2. Any IP address requests associated with the BAS shall be made through the ICM department.
3. BACnet broadcast management devices (BBMDs) are assigned by the ICM department. When a new network controller is connected to the BAS network, the BAS installer shall coordinate with the ICM department to configure any necessary BBMDs. Automatic management of the BBMDs shall be disabled.
4. All default/generic user accounts and passwords shall be changed prior to placing any controller online in the production environment. All device username and password information shall be turned over to the ICM department.

### Trending and Reporting

Trends shall be enabled on all hard-wired points, setpoints, and calculated variables to record for a minimum of 48 hours. Points specified for historical archival shall be maintained for a minimum of 365 days. The



engineer of record, commissioning authority, or other authority may request, with the owner's approval, historical trend archives longer than the minimum period. If a temporary server, or other field device is used, all historical trends shall be migrated to the final archive database.

1. Interval trending, unless otherwise specified, shall be in 15-minute intervals with 48 hours samples collected in the field panel.
2. Change of value (COV) trending shall be for binary (on/off) points and shall be for a minimum of 48 hours of data.

All critical equipment and spaces shall have scheduled reports created in coordination with VT Facilities' BAS management and/or as listed in the job specification. Typical critical spaces include but are not limited to the following:

1. Vivariums (animal holding)
2. Critical labs (BSL)
3. Food storage (freezers and coolers)

All trend collections to the BAS front end shall be created in coordination with CPIX BAS management and/or as listed in the job specification.

### **Low Voltage and Communications Wiring**

1. The wire basis of design is Anixter wire. Equivalent products may be used, provided their specifications meet or exceed the basis of design.
2. The term "control wiring" is defined to include the providing of wire, conduit, and miscellaneous materials as required for mounting and connecting.
3. All exposed control wiring and control wiring in the mechanical, electrical, telephone, and similar rooms shall be installed in conduit. All other wiring shall be installed neatly and inconspicuously above ceilings, anchored to the permanent building structure, with supports no more than 6 feet apart. Any exposed wiring shall be plenum rated cable.
4. Critical safety interlocks, such as low temperature detection, high limit protectors, end switches, etc., shall be directly connected through wire, so as not to depend on any digital control system "sequence of operation" to perform their safety function. Contacts shall be provided so the safety can be monitored by the BAS. Low temperature detection and static pressure switch contacts shall be mechanically latching and only reset manually.
5. All Ethernet wiring shall be CAT6.
6. Competitive bidding on BAS control wiring is encouraged and does not need to be performed by the BAS vendor.

### **Control Panel Layout**

1. Conventions:
  - a. All line voltage wiring and connections must be protected behind covers and/or in raceways. Exposed line voltage circuitry is prohibited.
  - b. Control wiring shall be neatly routed and terminated without excessive cable length. Wherever possible, control wiring should be concealed by wire duct.
2. Line voltage power:
  - a. All control panels shall be served by dedicated emergency power circuits from the same source and service level provided to the equipment controlled. Low voltage control power for fume hoods must also be served by dedicated emergency power circuits. The control panel shall be labeled with the electrical panel name and circuit source.

- b. The BAS installer shall furnish and install any power supply surge protection, filters, etc., as necessary for proper operation and protection of all controllers. All control equipment must be tolerant of voltage variations 10% above or below scheduled nominal with no impact on hardware, software, communications, or data storage.
  - c. Unless extremely critical, UPS are not allowed. In the event of highly critical equipment/spaces (e.g., BSL3), UPS must be hybrid in nature. Critical UPS basis of design will be Sola S4K2UC or equivalent. A central, online UPS may be used in place of an individual UPS for BAS equipment.
3. Labeling:
- a. Panel layouts, network riser diagrams, and power riser diagrams shall be provided in each panel upon completion of the project.
  - b. All wires and devices (field panels, transformers, relays, etc.) in the control panel shall be labeled.
  - c. The cabinet shall be clearly labeled on the outside.

### **ATTACHMENT C Continued**



## BUILDING AUTOMATION SYSTEM STANDARDS

# SEQUENCE OF OPERATIONS

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# INTRODUCTION

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Virginia Tech has commissioned CMTA to jointly develop Building Automation System (BAS) standards for future project work. The intention of these standards is to include sequence of operations used in high performing buildings, include best-practices for equipment operation, and to prescribe the minimum functionality for all systems incorporated into the BAS.

Modern BAS systems have a tremendous amount of memory and processing power which is largely unused in most projects. These standards aim to incorporate the latest controls strategies and to allow for integration with third-party systems for data analytics and reporting.

## ASHRAE Guideline 36

Although we do not recommend requiring ASHRAE Guideline 36 compliance as this would require preloaded and locked control programs (which would preclude real time energy monitoring); we do recommend the sequences described in ASHRAE Guideline 36. The following sequences are heavily based on Guideline 36 but have been modified to include equipment level energy tracking and sequences that have been proven at Virginia Tech.

## Real-time equipment level energy modeling

Energy modeling is typically accomplished by installing an energy meter at the primary incoming feed, like the utility electrical service, steam meter, or water meter. Sometimes an energy submeter is installed to monitor major system loads like building chilled water consumption; HVAC, lighting and plug loads; or steam condensate metering; however, it is cost prohibitive to install power and btu meters on every fan or coil. That said, the BAS controllers have enough processing power to use the sensors and equipment load ratings to calculate energy demand at a +/- 3% accuracy. This is good enough for a building manager to know where energy is being used in their building and to manage it appropriately.

These sequences include the mathematical algorithms required to calculate and trend energy demand at each piece of equipment.

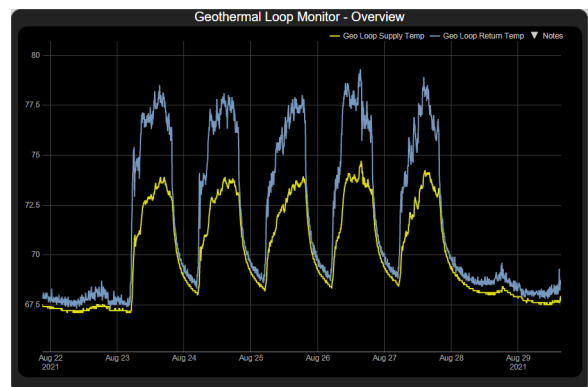
## Trending and Alarming

It is important to specify the minimum level of trending and alarming for the various values in a BAS system. BAS systems vary from being easy to add trending to requiring a manufacturer's technician to program addition trending onsite. Regardless of the manner in which trends are configure, it can be very frustrating to troubleshoot a system and find out that trends haven't been recorded or archived appropriately.

## Fault Detection and Diagnostics Readiness

Fault Detection and Diagnostics (FDD) is the process of uncovering issues with building systems before they become a problem for the building occupants. Examples might include:

- Excessive runtime of a motor which is expensive to run and might indicate a capacity problem or a locked point.
- A hunting PID which can wear out an actuator and cause system instabilities
- A leaking hot water valve which overheats a space and causes simultaneous heating and holing



- A stuck outside air damper which either does not bring in enough ventilation, or causes moisture infiltration and high energy bills

FDD can be implemented at the controller level by describing FDD sequences (edge level), or it can be overlaid on a BAS by a 3<sup>rd</sup> party software solution (cloud based). Although edge level FDD can be a cost-effective method for fault detection, it typically isn't as robust or as flexible as a cloud-based solution. By standardizing on point naming conventions, implementation costs can be reduced for integrating new systems.

## 3rd Party Building Analytics Readiness

Every year, companies invent new software solutions to integrate and share data with BAS systems. By using standard sequences and point naming conventions, the BAS system can easily be incorporated into external reporting, analytics and operations management software to keep costs low.

## Energy Rollups and Dashboarding

Dashboards are an easy way for BAS users to glean a lot of information about their systems from a single graphic. Most BAS systems have a rich set of graphics that can show detailed information about each piece of equipment as a standard offering. In addition, they can offer many dashboard options as an add-on to the basic system. That said, unless they are clearly specified, dashboards are not typically provided as part of the basic BAS package.

CMTA recommends including summary dashboards as a standard requirement.



# Sequence of Operations

## 1 STANDARD SEQUENCE OF OPERATIONS

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### GENERAL NOTES AND GUIDANCE

#### Sequence Options

The sequences listed here are intended to be a basis of design and have many sections regularly found in equipment at Virginia Tech. They are not intended to be used verbatim and will need to be configured for each project as needed.

#### Setpoints

All setpoints listed are recommended values. All setpoints shall be field adjusted during the commissioning period to meet the requirements of actual field conditions. The commissioning authority and owner shall have final approval on all setpoints.

#### Deadbands

Setpoints shall be programmed with an adjustable deadband appropriate to the controlled system

#### Hysteresis

Logical trip points shall be programmed with an adjustable hysteresis appropriate to the controlled system

#### PID Gains

Reasonable PID gains shall be set prior to equipment startup. Final PID gains shall be set by the Building Automation System (BAS) provider during functional testing and commissioning. The commissioning authority and owner shall have final approval on all PID gains.

#### Trends

Trends shall be enabled on all hard-wired points, setpoints, and calculated variables to record for a minimum of 48 hours. Points specified for historical archival shall be maintained for a minimum of 365 days. The engineer of record, commissioning authority, or other authority may request, with the owner's approval, historical trend archives longer than the minimum period. If a temporary server, or other field device is used, all historical trends shall be migrated to the final archive database.

### STEAM TO HOT WATER CONVERTER

#### Heat Exchanger System Run Conditions:

The heat exchanger system shall be enabled to run whenever:

A definable number of hot water coils need heating.

AND outside air temperature is less than 65°F (adj.).

To prevent short cycling, the heat exchanger shall run for and be off for minimum adjustable times (both user definable).

The heat exchanger system shall also run for freeze protection whenever outside air temperature is less than 38°F (adj.).

**Note to Designer: Select one of the following lead/lag or lead/standby sequences and its associated pressure control as appropriate**

#### **Hot Water Pump Lead/Standby Operation:**

The two hot water pumps shall operate in a lead/standby fashion.

The lead pump shall run first.

On failure of the lead pump, the standby pump shall run and the lead pump shall turn off.

The designated lead pump shall rotate upon one of the following conditions (user selectable):

manually through a software switch  
if pump runtime (adj.) is exceeded  
daily  
weekly  
monthly

Alarms shall be provided as follows:

##### **Hot Water Pump 1**

- Failure: Commanded on, but the status is off.
- Running in Hand: Commanded off, but the status is on.
- Runtime Exceeded: Status runtime exceeds a user definable limit.
- VFD Fault.

##### **Hot Water Pump 2**

- Failure: Commanded on, but the status is off.
- Running in Hand: Commanded off, but the status is on.
- Runtime Exceeded: Status runtime exceeds a user definable limit.
- VFD Fault.

#### **Hot Water Differential Pressure Control:**

The controller shall measure hot water differential pressure and modulate the hot water pump VFD and Minimum Flow Bypass Valve in sequence to maintain its hot water differential pressure setpoint.

The following setpoints are recommended values. All setpoints shall be field adjusted during the commissioning period to meet the requirements of actual field conditions. Incoming requests shall be weighted in proportion to the size of each coil. For example, a coil rated for 10 gpm shall send 10 requests when the valve is fully open.

The controller shall modulate hot water pump speeds to maintain a hot water differential pressure of 12 psi (adj.). The VFD's minimum speed shall not drop below 25% (adj.).

On dropping hot water differential pressure, the VFDs shall stage on and run to maintain setpoint.

On rising hot water differential pressure, if the lead VFD drops to its minimum speed 25% (adj.), the Minimum Flow Bypass Valve shall modulate to maintain setpoint plus 1 psi (adj.).

An example calculation is as follows, all actual values to be selected based on the existing system requirements:

Every 5 minutes (adj.) the controller will poll the zone valves and determine the # of requests (valves above 90% open). The controller will trim the setpoint by 20% (adj.) of the setpoint span. The controller will respond by adding the trim value divided by 10% (adj.) of the valves, multiplied by the total number of open valves (approximately 10% of your system valves to balance out the trim & respond equation).

$$Setpoint_{New} = Setpoint_{Old} - Trim + Respond(Requests)$$



Example Values:

- $\text{Setpoint}_{\text{Min}} = 8\text{psi}$
- $\text{Setpoint}_{\text{Max}} = 18\text{psi}$
- $\text{TotalZones} = 50 \text{ valves}$
- $\text{Setpoint}_{\text{span}} = 18 \text{ psi} - 8\text{psi} = 10\text{psi}$
- $\text{Trim} = \text{Setpoint}_{\text{span}} * 20\% = 2\text{psi}$
- $\text{Respond} = \text{Trim} / (50 \text{ Valves} * 10\%) = 0.4 \text{ psi/request}$

Alarms shall be provided as follows:

High Hot Water Differential Pressure: If 25% (adj.) greater than setpoint.

Low Hot Water Differential Pressure: If 25% (adj.) less than setpoint.

#### **Variable Volume Pump Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = \left( \frac{\text{VFD}\%_1 + \text{VFD}\%_2}{200\%} \right)^3 * \frac{\text{Volts} * \text{Amps} * \sqrt{\text{Phase}} * \text{PF}}{1000}$$
$$kWh = \sum_{\text{Run}} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage

Amps = The sum of all pump loads

VFD% = The output speed of VFD<sub>1</sub>

Phase = 1 or 3 phase

PF = Power Factor, assumed or measured

#### **Hot Water Pump Lead/Lag Operation:**

The two hot water pumps shall operate in a lead/lag fashion.

The lead pump shall run first.

On failure of the lead pump, the lag pump shall run and the lead pump shall turn off.

On decreasing hot water differential pressure, the lag pump shall stage on and run in unison with the lead pump to maintain hot water differential pressure setpoint.

The designated lead pump shall rotate upon one of the following conditions (user selectable):

manually through a software switch

if pump runtime (adj.) is exceeded

daily

weekly

monthly

Alarms shall be provided as follows:

Hot Water Pump 1

- Failure: Commanded on, but the status is off.

- Running in Hand: Commanded off, but the status is on.
- Runtime Exceeded: Status runtime exceeds a user definable limit.
- VFD Fault.

#### Hot Water Pump 2

- Failure: Commanded on, but the status is off.
- Running in Hand: Commanded off, but the status is on.
- Runtime Exceeded: Status runtime exceeds a user definable limit.
- VFD Fault.

#### **Hot Water Differential Pressure Control:**

The hot water differential pressure setpoint shall be programmed as the secondary optimized setpoint and will be enabled after the temperature reset has reached its minimum setpoint. The controller shall measure hot water differential pressure and modulate the secondary hot water pump VFDs and Minimum Flow Bypass Valve in sequence to maintain its hot water differential pressure setpoint.

The following setpoints are recommended values. All setpoints shall be field adjusted during the commissioning period to meet the requirements of actual field conditions. Incoming requests shall be weighted in proportion to the size of each coil. For example, a coil rated for 10 gpm shall send 10 requests when the valve is fully open.

As the facility's hot water valves open beyond a user definable threshold (90% open, typ.), the setpoint shall reset to a higher value (adj.). Once the hot water coils are satisfied (valves closing) then the setpoint shall gradually lower over time to reduce heating energy user.

An example calculation is as follows, all actual values to be selected based on the existing system requirements:

Every 5 minutes (adj.) the controller will poll the zone valves and determine the # of requests (valves above 90% open). The controller will trim the setpoint by 20% (adj.) of the setpoint span. The controller will respond by adding the trim value divided by 10% (adj.) of the valves, multiplied by the total number of open valves (approximately 10% of your system valves to balance out the trim & respond equation).

$$Setpoint_{New} = Setpoint_{Old} - Trim + Respond(Requests)$$

Example Values:

- $Setpoint_{Min} = 8\text{psi}$
- $Setpoint_{Max} = 18\text{psi}$
- $TotalZones = 50 \text{ valves}$
- $Setpoint_{Span} = 18 \text{ psi} - 8\text{psi} = 10\text{psi}$
- $Trim = Setpoint_{Span} * 20\% = 2\text{psi}$
- $Respond = Trim / (50 \text{ Valves} * 10\%) = 0.4 \text{ psi/request}$

On dropping hot water differential pressure, the VFDs shall stage on and run to maintain setpoint as follows:

- The controller shall modulate the lead VFD to maintain setpoint.
- If the lead VFD speed is greater than 50% (adj.), the lag VFD shall stage on.
- The lag VFD shall ramp up to match the lead VFD speed and then run in unison with the lead VFD to maintain setpoint.

On rising hot water differential pressure, the VFDs shall stage off as follows:

- If the VFDs speed drops back to 25% (adj.), the lag VFD shall stage off.
- The lead VFD shall continue to run to maintain setpoint.
- If the lead VFD drops to its minimum speed 25% (adj.), the Minimum Flow Bypass Valve shall modulate to maintain setpoint plus 1 psi (adj.).

Alarms shall be provided as follows:

- High Hot Water Differential Pressure: If % (adj.) greater than setpoint.
- Low Hot Water Differential Pressure: If % (adj.) less than setpoint.

**Lead/Lag Variable Volume Pump Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = \left( \frac{VFD\%_1 + VFD\%_2}{200\%} \right)^3 * \frac{Volts * Amps * \sqrt{Phase} * PF}{1000}$$
$$kWh = \sum_{Run} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage  
Amps = The sum of all pump loads  
VFD%<sub>1</sub> = The output speed of VFD<sub>1</sub>  
VFD%<sub>2</sub> = The output speed of VFD<sub>2</sub>  
Phase = 1 or 3 phase  
PF = Power Factor, assumed or measured

**Hot Water Supply Temperature Setpoint Reset:**

The hot water supply temperature setpoint shall reset using a trim and respond algorithm based on heating requirements.

As the facility's hot water valves open beyond a user definable threshold (90% open, typ.), the setpoint shall reset to a higher value (adj.). Once the hot water coils are satisfied (valves closing) then the setpoint shall gradually lower over time to reduce heating energy user. Incoming requests shall be weighted in proportion to the size of each coil. For example, a coil rated for 10 gpm shall send 10 requests when the valve is fully open.

An example calculation is as follows, all actual values to be selected based on the existing system requirements:

Every 5 minutes (adj.) the controller will poll the zone valves and determine the # of requests (valves above 95% open). The controller will trim the setpoint by 20% (adj.) of the setpoint span. The controller will respond by adding the trim value divided by 10% (adj.) of the valves, multiplied by the total number of open valves (approximately 10% of your system valves to balance out the trim & respond equation).

$$Setpoint_{New} = Setpoint_{Old} - Trim + Respond(Requests)$$

Example Values:

- Setpoint<sub>Min</sub> = 150 °F
- Setpoint<sub>Max</sub> = 180°F
- TotalZones = 500 gpm
- Setpoint<sub>Span</sub> = 180°F – 150 °F = 30°F
- Trim = Setpoint<sub>Span</sub> \* 20% = 6°F
- Respond = Trim/(500 gpm \* 10%) = 0.12 °F/request

Alarms shall be provided as follows:

High Hot Water Supply Temp: If greater than setpoint by 10°F (adj.).

Low Hot Water Supply Temp: If less than setpoint by 10°F (adj.).

**Heat Exchanger Steam Valves - Hot Water Control:**

The controller shall measure the hot water supply temperature and modulate the 1/3 and 2/3 steam valves in sequence to maintain its setpoint as follows:

Upon an initial call for heat, modulate the lead 1/3 steam valve to maintain its setpoint

If the lead 1/3 steam valve is 100% open for 5 minutes (adj.) modulate the lag 1/3 steam valve to maintain its setpoint

If the lead 1/3 steam valve is 100% open for 5 minutes (adj.) open the lead and lag 2/3 steam valves to 50% and close the lead and lag 1/3 steam valves. Modulate the 2/3 steam valves to maintain setpoint.

If the 2/3 steam valves are 100% open for 5 minutes (adj.) enable the 1/3 steam valves and modulate to maintain setpoint.

The steam valves shall be enabled whenever:

The heat exchanger is called to run.

AND hot water supply temperature is below setpoint.

The steam valves shall close whenever the hot water supply temperature rises from 190°F to 200°F (adj.).

**Demand Monitoring**

The controller shall monitor the steam meter for energy consumption on a continual basis. These values shall be made available to the system at all times.

Alarm shall be generated as follows:

Meter Failure: Sensor reading indicates a loss of pulse output from the steam meter.

**Peak Demand History:**

The controller shall monitor and record the peak (high and low) demand readings from the steam meter. Peak readings shall be recorded on a daily, month-to-date, and year-to-date basis.

**Usage History:**

The controller shall monitor and record BTU meter readings so as to provide an energy consumption history. Usage readings shall be recorded on a daily, month-to-date, and year-to-date basis.

**Demand Limiting:**

To lower power demand, the hot water system shall automatically relax when a command is received from the power monitoring system as follows:

- Demand Level 1: A command will be sent to the pump VFD's to limit their operation to 95% of capacity.
- Demand Level 2: A command will be sent to the pump VFD's to limit their operation to 90% of capacity.
- Demand Level 3: A command will be sent to the pump VFD's to limit their operation to 80% of capacity.

The pumps shall automatically return to their previous settings when the facility power demand drops below the thresholds.

## CHILLED WATER LOOP PUMPS (VARIABLE VOLUME)

### Run Conditions:

The chilled water pumps shall be enabled whenever:

- A definable number of chilled water coils need cooling.
- AND the outside air temperature is greater than 54°F (adj.).

To prevent short cycling, the chilled water pump system shall run for and be off for minimum adjustable times (both user definable).

### Chilled Water Pump Lead/Standby Operation:

The two chilled water pumps shall operate in a lead/standby fashion.

- The lead pump shall run first.
- On failure of the lead pump, the standby pump shall run and the lead pump shall turn off.

The designated lead pump shall rotate upon one of the following conditions (user selectable):

- manually through a software switch
- if pump runtime (adj.) is exceeded
- daily
- weekly
- monthly

Alarms shall be provided as follows:

- Chilled Water Pump 1
  - Failure: Commanded on, but the status is off.
  - Running in Hand: Commanded off, but the status is on.
  - Runtime Exceeded: Status runtime exceeds a user definable limit.
- Chilled Water Pump 2
  - Failure: Commanded on, but the status is off.
  - Running in Hand: Commanded off, but the status is on.
  - Runtime Exceeded: Status runtime exceeds a user definable limit.

### Chilled Water Differential Pressure Control:

The controller shall measure chilled water differential pressure and modulate the chilled water pump VFDs and Minimum Flow Bypass Valve (if present) in sequence to maintain its chilled water differential pressure setpoint. The following setpoints are recommended values. All setpoints shall be field adjusted during the commissioning period to meet the requirements of actual field conditions.

As the facility's chilled water valves open beyond a user definable threshold (90% open, typ.), the setpoint shall reset to a higher value (adj.). Once the chilled water coils are satisfied (valves closing) then the setpoint shall gradually lower over time to reduce pump energy user. Incoming requests shall be weighted in proportion to the size of each coil. For example, a coil rated for 10 gpm shall send 10 requests when the valve is fully open.

If the differential pressure setpoint is at its minimum value and the pumps are running at their minimum speed for 5 minutes (adj.) and the campus loop differential pressure (if present) is greater than the building loop differential pressure setpoint, the secondary pump will turn off and the secondary pumps bypass valve shall open and the two position decoupler valve shall fully close to allow campus water pressure to supply chilled water to the building.

An example calculation is as follows, all actual values to be selected based on the existing system requirements:

Every 5 minutes (adj.) the controller will poll the zone valves and determine the # of requests (valves above 90% open). The controller will trim the setpoint by 20% (adj.) of the setpoint span. The controller will respond by adding the trim value divided by 10% (adj.) of the valves, multiplied by the total number of open valves (approximately 10% of your system valves to balance out the trim & respond equation).

$$Setpoint_{New} = Setpoint_{Old} - Trim + Respond(Requests)$$

Example Values:

- $Setpoint_{Min} = 8\text{psi}$
- $Setpoint_{Max} = 18\text{psi}$
- $TotalZones = 50 \text{ valves}$
- $Setpoint_{Span} = 18 \text{ psi} - 8\text{psi} = 10\text{psi}$
- $Trim = Setpoint_{Span} * 20\% = 2\text{psi}$
- $Respond = Trim / (50 \text{ Valves} * 10\%) = 0.4 \text{ psi/request}$

On dropping chilled water differential pressure, the VFDs shall stage on and run to maintain setpoint as follows:

The controller shall modulate the lead VFD to maintain setpoint.

If the lead VFD speed is greater than a setpoint of 50% (adj.), the lag VFD shall stage on.

The lag VFD shall ramp up to match the lead VFD speed and then run in unison with the lead VFD to maintain setpoint.

On rising chilled water differential pressure, the VFDs shall stage off as follows:

If the VFDs speeds then drops back to 25% (adj.) below setpoint, the lag VFD shall stage off.

The lead VFD shall continue to run to maintain setpoint.

If the lead VFD drops to its minimum speed 25% (adj.), the Minimum Flow Bypass Valve shall modulate to maintain setpoint plus 1 psi (adj.).

Alarms shall be provided as follows:

High Chilled Water Differential Pressure: If the chilled water differential pressure is 25% (adj.) greater than setpoint.

Low Chilled Water Differential Pressure: If the chilled water differential pressure is 25% (adj.) less than setpoint.

**Lead/Lag Variable Volume Pump Runtime Energy reporting (where specified)**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = \left( \frac{VFD\%_1 + VFD\%_2}{200\%} \right)^3 * \frac{Volts * Amps * \sqrt{Phase} * PF}{1000}$$

$$kWh = \sum_{Run} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage

Amps = The sum of all pump loads

VFD%<sub>1</sub> = The output speed of VFD<sub>1</sub>

VFD%<sub>2</sub> = The output speed of VFD<sub>2</sub>

Phase = 1 or 3 phase

PF = Power Factor, assumed or measured

#### **Chilled Water Supply Temperature Setpoint Reset:**

If the pumps are running at their minimum speed the chilled water supply temperature setpoint shall reset using a trim and respond algorithm based on cooling requirements.

As the facility's chilled water valves open beyond a user definable threshold (90% open, typ.), the setpoint shall reset to a lower value (adj.). Once the chilled water coils are satisfied (valves closing) then the setpoint shall gradually raise over time to reduce cooling energy use. Incoming requests shall be weighted in proportion to the size of each coil. For example, a coil rated for 10 gpm shall send 10 requests when the valve is fully open.

An example calculation is as follows, all actual values to be selected based on the existing system requirements:

Every 5 minutes (adj.) the controller will poll the zone valves and determine the # of requests (valves above 95% open). The controller will trim the setpoint by 20% (adj.) of the setpoint span. The controller will respond by adding the trim value divided by 10% (adj.) of the valves, multiplied by the total number of open valves (approximately 10% of your system valves to balance out the trim & respond equation).

$$Setpoint_{New} = Setpoint_{Old} - Trim + Respond(Requests)$$

Example Values:

- $Setpoint_{Min} = 45^{\circ}F$
- $Setpoint_{Max} = 55^{\circ}F$
- $TotalZones = 500 \text{ gpm}$
- $Setpoint_{Span} = 55^{\circ}F - 45^{\circ}F = 10^{\circ}F$
- $Trim = Setpoint_{Span} * 20\% = 2^{\circ}F$
- $Respond = Trim / (500 \text{ gpm} * 10\%) = 0.04^{\circ}F/request$

Alarms shall be provided as follows:

High Chilled Water Supply Temp: If greater than setpoint by  $10^{\circ}F$  (adj.).

Low Chilled Water Supply Temp: If less than setpoint by  $10^{\circ}F$  (adj.).

#### **Chilled Water Tertiary Bridge Valve**

The controller shall measure the chilled water supply temperature and modulate the tertiary loop bypass valve to maintain its supply setpoint. When chilled water supply temperature setpoint has been achieved within its deadband, the bypass valve shall modulate to maintain chilled water differential temperature (chilled water return temperature minus chilled water supply temperature setpoint) at its setpoint, initially set at  $16^{\circ}F$  (adj.). If at any time, the chilled water temperature exceeds its setpoint deadband, supply temperature setpoint will become the primary variable for control and will equal the Campus Loop Entering Temperature.

Alarms shall be provided as follows:

- High Chilled Water Supply Temp: If greater than setpoint by  $5^{\circ}F$  (adj.).
- Low Chilled Water Supply Temp: If less than setpoint by  $5^{\circ}F$  (adj.).
- Low Building dT: If the valve is greater than 25% open and the differential temperature is less than setpoint by  $2^{\circ}F$  (adj.).
- High Campus Chilled Water Supply: If the Campus Chilled Water Supply Temperature exceeds Building Chilled Water Supply Temperature setpoint plus its deadband.

#### **Central Loop Differential Pressure:**

The controller shall monitor the central loop differential pressure.

**Demand Monitoring**

The controller shall monitor the BTU meter for energy consumption on a continual basis. These values shall be made available to the system at all times.

Alarm shall be generated as follows:

Meter Failure: Sensor reading indicates a loss of pulse output from the BTU meter.

***Peak Demand History:***

The controller shall monitor and record the peak (high and low) demand readings from the BTU meter. Peak readings shall be recorded on a daily, month-to-date, and year-to-date basis.

***Usage History:***

The controller shall monitor and record BTU meter readings so as to provide an energy consumption history. Usage readings shall be recorded on a daily, month-to-date, and year-to-date basis.

**Demand Limiting:**

To lower power demand, the hot water system shall automatically relax when a command is received from the power monitoring system as follows:

- Demand Level 1: A command will be sent to the pump VFD's to limit their operation to 95% of capacity.
- Demand Level 2: A command will be sent to the pump VFD's to limit their operation to 90% of capacity.
- Demand Level 3: A command will be sent to the pump VFD's to limit their operation to 80% of capacity.

The pumps shall automatically return to their previous settings when the facility power demand drops below the thresholds.



## **SINGLE ZONE AIR HANDLING UNIT**

### **Run Conditions - Scheduled:**

The unit shall run according to a user definable time schedule in the following modes:

- Occupied Mode: Scheduled times when the facility is deemed to be fully occupied (>25% capacity), the unit shall maintain
  - A 74°F (adj.) cooling setpoint with a 2°F hysteresis
  - A 70°F (adj.) heating setpoint with a 2°F hysteresis
  - Occupied ventilation rates
- Standby Mode: Scheduled occupied times when the facility is deemed to be lightly occupied by an occupancy sensor (if present) or time of day schedule. During Standby mode the unit shall maintain:
  - A +2°F (adj.) offset from occupied cooling setpoint
  - A -2°F (adj.) offset from occupied heating setpoint.
  - Unoccupied ventilation rates
- Unoccupied Mode (night setback): The unit shall maintain
  - A +6°F (adj.) offset from occupied cooling setpoint
  - A -6°F (adj.) offset from occupied heating setpoint.
  - Unoccupied ventilation rates

If at any time, the occupancy sensor (if present) detects people in the space, the zone shall be indexed to Occupied Mode until the detected occupancy plus any delays again detects no occupancy.

If occupancy sensors are not utilized, include an option to allow a standby mode as a scheduled instance.

Alarms shall be provided as follows:

- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

### ***Demand Limiting - Zone Setpoint Optimization:***

To lower power consumption, the zone setpoints shall automatically relax when the facility power consumption exceeds definable thresholds. The amount of relaxation shall be individually configurable for each zone. The zone setpoints shall automatically return to their previous settings when the facility power consumption drops below the thresholds.

### ***Zone Setpoint Adjust:***

The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor within a BAS operator adjustable range.

### ***Zone Optimal Start:***

The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period. During the Optimal Start period, ventilation routines will maintain their unoccupied setpoints.

### ***Zone Unoccupied Override:***

A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

**Freeze Protection:**

The unit shall shut down and generate an alarm upon receiving a freeze status.

**Smoke Detection:**

The unit shall shut down and generate an alarm upon receiving a smoke detector status.

**Supply Fan – Constant Volume:**

The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime.

Alarms shall be provided as follows:

Supply Fan Failure: Commanded on, but the status is off.

Supply Fan in Hand: Commanded off, but the status is on.

Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

**Fan Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = \frac{Volts * Amps * \sqrt{Phase} * PF}{1000}$$

$$kWh = \sum_{Run} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage

Amps = The sum of all fan loads

Phase = 1 or 3 phase

PF = Power Factor, assumed or measured

**Supply Fan – Variable Volume:**

The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime.

On an initial call for operation the fan will be energized and run at its minimum speed. The controller shall measure the zone temperature and modulate the heating and cooling coil valves to maintain its setpoints. When either valve has been commanded fully open and there is an additional call for heating or cooling, the controller will modulate the fan speed to maintain its setpoint.

Alarms shall be provided as follows:

Supply Fan Failure: Commanded on, but the status is off.

Supply Fan in Hand: Commanded off, but the status is on.

Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

### **Variable Volume Fan Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = VFD\%^3 * \frac{Volts * Amps * \sqrt{Phase} * PF}{1000}$$
$$kWh = \sum_{Run} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage  
Amps = The sum of all fan loads  
VFD% = The output speed of the VFD  
Phase = 1 or 3 phase  
PF = Power Factor, assumed or measured

### **Relief Fan:**

The controller shall monitor the building static pressure and enable the relief fan whenever the supply fan runs and building static pressure is above setpoint.

Alarms shall be provided as follows:

- Relief Fan Failure: Commanded on, but the status is off.
- Relief Fan in Hand: Commanded off, but the status is on.
- Relief Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).
- Relief Fan VFD Fault.

If the equipment is equipped with a return fan instead of a relief fan, refer to section 1.6.8 VAV AHU – Return Fan for the sequence of operation.

### **Building Static Pressure Control:**

The controller shall measure building static pressure and modulate the relief fan VFD speed to maintain a building static pressure setpoint of 0.05in H2O (adj.). The relief fan VFD speed shall not drop below 20% (adj.).

Alarms shall be provided as follows:

- High Building Static Pressure: If the building air static pressure is 25% (adj.) greater than setpoint.
- Low Building Static Pressure: If the building air static pressure is 25% (adj.) less than setpoint.

### **Variable Volume Fan Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = \text{VFD}\%^3 * \frac{\text{Volts} * \text{Amps} * \sqrt{\text{Phase}} * \text{PF}}{1000}$$

$$kWh = \sum_{\text{Run}} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage  
Amps = The sum of all fan loads  
VFD% = The output speed of the VFD  
Phase = 1 or 3 phase  
PF = Power Factor, assumed or measured

#### **Heat Recovery Wheel - Variable Speed:**

The controller shall modulate the heat recovery wheel for energy recovery as follows.

#### **Cooling Recovery Mode:**

The controller shall measure the zone temperature and modulate the heat wheel speed to maintain a setpoint 2°F (adj.) less than the zone cooling setpoint. The heat wheel shall run for cool recovery whenever:

Return air temperature is 5°F (adj.) or more below the outside air temperature.  
AND the zone temperature is above cooling setpoint.  
AND the economizer (if present) is off.  
AND the supply fan is on.

#### **Heating Recovery Mode:**

The controller shall measure the zone temperature and modulate the heat wheel speed to maintain a setpoint 2°F (adj.) greater than the zone heating setpoint. The heat wheel shall run for heat recovery whenever:

Return air temperature is 5°F (adj.) or more above the outside air temperature.  
AND the zone temperature is below heating setpoint.  
AND the economizer mode (if present) is disabled.  
AND the supply fan is on.

#### **Periodic Self-Cleaning:**

The heat wheel shall run at 5% speed (adj.) for 10sec (adj.) every 4hr (adj.) the unit runs.

#### **Frost Protection:**

The heat wheel shall run at 5% speed (adj.) whenever:

Outside air temperature drops below 15°F (adj.)  
OR the exhaust air temperature drops below 20°F (adj.).

The heat wheel bypass dampers will open whenever the heat wheel is disabled.

Alarms shall be provided as follows:

Heat Wheel Rotation Failure: Commanded on, but the status is off.  
Heat Wheel in Hand: Commanded off, but the status is on.  
Heat Wheel Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).  
Heat Wheel VFD Fault

#### **Heat Wheel Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = VFD\%^3 * \frac{Volts * Amps * \sqrt{Phase} * PF}{1000}$$

$$kWh = \sum_{Run} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage  
Amps = The sum of all motor loads  
VFD% = The output speed of the VFD  
Phase = 1 or 3 phase  
PF = Power Factor, assumed or measured

### Heating and Cooling - Compressor Stages:

The controller shall measure the zone temperature and cycle the compressor(s) to maintain its setpoint. To prevent short cycling, the stage shall have a user definable (adj.) minimum runtime. Each compressor shall run subject to its own internal safeties and controls.

The heating shall be enabled whenever:

Outside air temperature is less than 65°F (adj.).  
AND the fan is on.  
AND the reversing valve is in heat mode.

The cooling shall be enabled whenever:

Outside air temperature is greater than 60°F (adj.).  
AND the fan is on.  
AND the reversing valve is in cool mode.

On mode change, the compressor shall be disabled and remain off until after the reversing valve has changed position.

Alarms shall be provided as follows:

Compressor Runtime Exceeded: The compressor runtime exceeds a user definable limit (adj.).

### Compressor energy reporting

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Actual Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = \frac{Volts * Amps * \sqrt{Phase} * PF}{1000}$$

$$kWh = \sum_{Run} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage  
Amps = The sum of each compressor  
Phase = 1 or 3 phase  
PF = Power Factor, assumed or measured

#### **Supplemental Electric Heating Stages:**

The controller shall measure the zone temperature and stage the heating to maintain its heating setpoint should the compressors not meet the heating demand. To prevent short cycling, there shall be a user definable (adj.) delay between stages, and each stage shall have a user definable (adj.) minimum runtime.

The heating shall be enabled whenever:  
The heat pump is in heating mode.  
AND the zone temperature is below heating setpoint.  
AND the fan is on.

#### **Electric heat energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Actual Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kWStages = \sum_{Stages} kW$$
$$kWh = \sum_{Run} \left( kWStages * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

kW = Rated kW of each stage

#### **Preheating Coil Valve:**

The controller shall measure the mixed air temperature and preheat coil leaving temperature and modulate the preheating coil valve to maintain the lower of the two sensors at its setpoint, 5°F (adj.) less than the supply air temperature setpoint. If the valve provided is a globe valve, upon an initial call for control, hold the valve closed until the PID calls for at least 15% control signal in order to extent valve life. In addition, the preheat coil valve shall modulate to maintain a minimum setpoint of 45°F (ad.).

The preheating shall be enabled whenever:

- Outside air temperature is less than 60°F (adj.).
- AND the supply fan status is on.

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the coil is rated for 10 gpm, the controller shall send 10 requests when it is fully open. The operator shall have the ability to suppress requests for any valve that is deemed to be out of service.

The preheating coil valve shall open for freeze protection whenever the freezestat is on.

### **Coil energy reporting (water-side calculation)**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- kBtu/hr – Instantaneous energy demand
- kBtu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kBtu/hr = \frac{Valve\% * GPM * (WST - WRT) * 500}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

$$kBtu_{Savings} = kBtu_{Base} - kBtu_{Act}$$

Where:

Valve% = Valve Actuator Command Signal (or feedback)  
GPM = The rated flow of the coil  
WST = Water supply temperature (from central plant)  
WRT = Water return temperature (from sensor)

### **Cooling Coil Valve:**

The controller shall measure the zone temperature and modulate the cooling coil valve to maintain its cooling setpoint. If the valve provided is a globe valve, upon an initial call for control, hold the valve closed until the PID calls for at least 15% (adj.) control signal in order to extent valve life. The cooling shall be enabled whenever:

- Outside air temperature is greater than 60°F (adj.).
- AND the economizer (if present) is disabled or fully open.
- AND the supply fan status is on.
- AND the heating (if present) is not active.

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the coil is rated for 10 gpm, the controller shall send 10 requests when it is fully open. The operator shall have the ability to suppress requests for any valve that is deemed to be out of service.

The cooling coil valve shall open to 50% (adj.) whenever the freezestat (if present) is on.

The controller will monitor the return water temperature (sensed downstream of the cooling coil), and the supply water temperature sensed at the central plant. Upon a call for cooling greater than 25% of the valve capacity, the controller will hold the position of the valve until the differential temperate exceeds 8°F (adj.). The controller will resume normal control when the differential temperate is above setpoint.

Alarms shall be provided as follows:

- High Supply Air Temp: If the supply air temperature is 5°F (adj.) greater than setpoint.
- Low Supply Air Temperature Alarm: The controller shall alarm if the supply air temperature is less than 45°F (adj.).
- Low Coil dT: If the valve is greater than 25% open and the differential temperature is less than setpoint by 2°F (adj.).

**Coil energy reporting (water-side calculation)**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Actual Runtime – Run – Actual equipment runtime
- Equip Btu – Instantaneous energy demand
- Equip Btu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kBtu/hr = \frac{Valve\% * GPM * (WST - WRT) * 500}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Valve% = Valve Actuator Command Signal (or feedback)

GPM = The rated flow of the coil

WST = Water supply temperature (from central plant)

WRT = Water return temperature (from sensor)

**Heating Coil Valve:**

The controller shall measure the zone temperature and modulate the heating coil valve to maintain its heating setpoint. If the valve provided is a globe valve, upon an initial call for control, hold the valve closed until the PID calls for at least 15% control signal in order to extend valve life. The heating shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- OR dehumidification is active
- AND the zone temperature is below heating setpoint.
- AND the supply fan status is on.
- AND the cooling is not active.

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the coil is rated for 10 gpm, the controller shall send 10 requests when it is fully open. The operator shall have the ability to suppress requests for any valve that is deemed to be out of service.

The heating coil valve shall open whenever the freezestat (if present) is on.

**Coil energy reporting (water-side calculation)**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days. and shall be historically archived for a minimum of 365 days.

- Actual Runtime – Run – Actual equipment runtime
- Equip Btu – Instantaneous energy demand
- Equip Btu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kBtu/hr = \frac{Valve\% * GPM * (WST - WRT) * 500}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$



Where:

Valve% = Valve Actuator Command Signal (or feedback)

GPM = The rated flow of the coil

WST = Water supply temperature (from central plant)

WRT = Water return temperature (from sensor)

#### **Economizer:**

The controller shall measure the zone temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F less than the zone cooling setpoint. The economizer shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the outside air enthalpy is less than 22% (adj.).
- AND the outside air temperature is less than the return air temperature.
- AND the outside air enthalpy is less than the return air enthalpy.
- AND the supply fan status is on.

The economizer shall close whenever:

- Mixed air temperature drops from 45°F to 40°F (adj.).
- OR on loss of supply fan status.
- OR freezestat (if present) is on.

The outside and exhaust air dampers shall close and the return air damper shall open when the unit is off. If Optimal Start Up is available, the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully closed.

#### **Dehumidification:**

The controller shall measure the return or space humidity (if present) and override the cooling sequence to maintain return air humidity at or below 60% rh (adj.).

During dehumidification, the heating shall modulate to maintain a setpoint 1°F (adj.) less than the zone cooling setpoint.

Dehumidification shall be enabled whenever:

the supply fan status is on.  
AND preheating is disabled.  
AND humidity is greater than the humidity setpoint.

#### **Humidifier Control:**

The controller shall measure the return or space humidity (if present) and modulate the humidifier to maintain a setpoint of 30% rh (adj.). The humidifier shall be enabled whenever the supply fan status is on.

The humidifier shall turn off whenever:

Supply air humidity rises from 90% rh to 95% rh (adj.).  
OR on loss of supply fan status.  
OR if cooling is active.

Alarms shall be provided as follows:

High Supply Air Humidity: If the supply air humidity is greater than 90% rh (adj.).  
Low Supply Air Humidity: If the supply air humidity is less than 30% rh (adj.).

**Minimum Outside Air Ventilation - Carbon Dioxide (CO2) Control:**

When in the occupied mode, the controller shall measure the return air CO2 or space CO2 (if present) levels and modulate the outside air dampers on rising CO2 concentrations, overriding normal damper operation to maintain a CO2 setpoint of 1000 ppm (adj.). The controller shall measure the outside airflow and modulate the dampers between minimum airflow ventilation rates and the maximum airflow ventilation rate.

**Minimum Outside Air Ventilation – Airflow Monitoring:**

When in the occupied mode, the controller shall measure the outside airflow and modulate the outside air dampers to maintain the proper minimum outside air ventilation, overriding normal damper control. On dropping outside airflow, the controller shall modulate the outside air dampers open to maintain the outside airflow setpoint (adj.).

**Filter Status:**

The controller shall monitor the filter status.

Alarms shall be provided as follows:

- Filter Change Required: Filter differential pressure exceeds a user definable limit (adj.).

**Mixed Air Temperature:**

The controller shall monitor the mixed air temperature and use as required for economizer control (if present) or preheating control (if present).

Alarms shall be provided as follows:

- Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

**Return Air Carbon Dioxide (CO2) Concentration Monitoring:**

The controller shall measure the return air CO2 levels.

Alarms shall be provided as follows:

- High Return Air Carbon Dioxide Concentration: If the return air CO2 concentration is greater than 1000ppm (adj.) when in the occupied mode.

**Return Air Humidity:**

The controller shall monitor the return air humidity and use as required for economizer control (if present) or humidity control (if present).

Alarms shall be provided as follows:

- High Return Air Humidity: If the return air humidity is greater than 70% (adj.).
- Low Return Air Humidity: If the return air humidity is less than 35% (adj.).

**Return Air Temperature:**

The controller shall monitor the return air temperature and use as required for economizer control (if present).

Alarms shall be provided as follows:

- High Return Air Temp: If the return air temperature is greater than 90°F (adj.).
- Low Return Air Temp: If the return air temperature is less than 45°F (adj.).

**Supply Air Temperature:**

The controller shall monitor the supply air temperature.

Alarms shall be provided as follows:

- High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).

- Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

## FAN COIL UNIT, UNIT VENTILATOR, BLOWER COILS

### Run Conditions - Scheduled:

The unit shall run according to a user definable time schedule in the following modes:

- Occupied Mode: Scheduled times when the facility is deemed to be fully occupied (>25% capacity), the unit shall maintain
  - A 74°F (adj.) cooling setpoint with a 2°F hysteresis
  - A 70°F (adj.) heating setpoint with a 2°F hysteresis
  - Occupied ventilation rates
- Standby Mode: Scheduled occupied times when the facility is deemed to be lightly occupied by an occupancy sensor (if present) or time of day schedule. During Standby mode the unit shall maintain
  - A +2°F (adj.) offset from occupied cooling setpoint
  - A -2°F (adj.) offset from occupied heating setpoint.
  - Unoccupied ventilation rates
- Unoccupied Mode (night setback): The unit shall maintain
  - A +6°F (adj.) offset from occupied cooling setpoint
  - A -6°F (adj.) offset from occupied heating setpoint.
  - Unoccupied ventilation rates

If at any time, the occupancy sensor (if present) detects people in the space, the zone shall be indexed to Occupied Mode until the detected occupancy plus any delays again detects no occupancy.

Alarms shall be provided as follows:

- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

### ***Demand Limiting - Zone Setpoint Optimization:***

To lower power consumption, the zone setpoints shall automatically relax when the facility power consumption exceeds definable thresholds. The amount of relaxation shall be individually configurable for each zone. The zone setpoints shall automatically return to their previous settings when the facility power consumption drops below the thresholds.

### ***Zone Setpoint Adjust:***

The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

### ***Zone Optimal Start:***

The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

### ***Zone Unoccupied Override:***

A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

### **Supply Fan – Variable Volume:**

On an initial call for operation the fan will be energized and run at its minimum speed. The controller shall measure the zone temperature and modulate the heating and cooling coil valves to maintain its setpoints. When either valve has been commanded fully open and there is an additional call for heating or cooling, the controller will modulate the fan speed to maintain its setpoint.

Alarms shall be provided as follows:

Supply Fan Failure: Commanded on, but the status is off.

Supply Fan in Hand: Commanded off, but the status is on.

Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

### **Fan Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = ECM\%^3 \frac{Volts * Amps * \sqrt{Phase} * PF}{1000}$$
$$kWh = \sum_{Run} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

ECM% = Fan Speed Command Signal (or feedback)

Volts = Equipment supply voltage

Amps = The sum of all fan loads

Phase = 1 or 3 phase

PF = Power Factor, assumed or measured

### **Cooling Coil Valve:**

The controller shall measure the zone temperature and modulate the cooling coil valve to maintain its cooling setpoint.

The cooling shall be enabled whenever:

- AND the zone temperature is above cooling setpoint.
- AND the economizer (if present) is disabled or fully open.
- AND the fan is on.
- AND the heating (if present) is not active.

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the coil is rated for 10 gpm, the controller shall send 10 requests when it is fully open. The operator shall have the ability to suppress requests for any valve that is deemed to be out of service. Cooling Coil energy reporting (air-side calculation)

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- kBtu/hr – Instantaneous energy demand
- kBtu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows if zone temp is greater than discharge air temp:

$$kBtu/hr = \frac{ECM\% * CFM * (DAT - ZONT) * 1.08}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

ECM% = Fan Speed Command Signal (or feedback)  
 CFM = The rated flow of the fan times the VFD fan speed  
 ZONT = Zone air temperature  
 DAT = Discharge Air Temperature

#### Heating Coil Valve:

The controller shall measure the zone temperature and modulate the heating coil valve to maintain its heating setpoint.

The heating shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the zone temperature is below heating setpoint.
- AND the fan is on.
- AND the cooling (if present) is not active.

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the coil is rated for 10 gpm, the controller shall send 10 requests when it is fully open. The operator shall have the ability to suppress requests for any valve that is deemed to be out of service.

The heating coil valve shall open whenever the freezestat (if present) is on.

#### Heating Coil energy reporting (air-side calculation)

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- kBtu/hr – Instantaneous energy demand
- kBtu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows if zone temp is less than discharge air temp:

$$kBtu/hr = \frac{EC\% * CFM * (ZONT - DAT) * 1.08}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

EC% = Fan Speed Command Signal (or feedback)  
 CFM = The rated flow of the fan times the VFD fan speed  
 ZONT = Zone air temperature  
 DAT = Discharge Air Temperature

#### Economizer (ASHRAE Cycle II):

The controller shall measure the zone temperature and modulate the mixed air dampers in sequence to maintain the zone cooling setpoint. The outside air dampers shall maintain a minimum adjustable position of 20% (adj.) open during heating and ventilation whenever occupied.

The economizer shall be enabled whenever:

- Outside air temperature is at least 3°F (adj.) less than the Zone Temperature.
- AND the outside air temperature is less than 75°F (adj.)

The economizer shall close whenever the freezestat (if present) is on.

The outside air dampers shall close and the return air damper shall open when the unit is off. If Optimal Start Up is available the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully closed.

The controller shall monitor the discharge air temperature. Should discharge temperature drop below a user definable temperature (adj.), the controller shall enable the heating, close the outside damper and open the return damper.

**Discharge Air Temperature:**

The controller shall monitor the discharge air temperature.

Alarms shall be provided as follows:

- High Discharge Air Temp: If the discharge air temperature is greater than 120°F (adj.).
- Low Discharge Air Temp: If the discharge air temperature is less than 40°F (adj.).

## **VARIABLE AIR VOLUME – AHU**

### **Run Conditions – Requested:**

The unit shall run whenever:

- Any zone is occupied.
- OR a definable number of unoccupied zones need heating or cooling.

If unoccupied zones become satisfied, the unit shall be disabled.

### **Freeze Protection:**

The unit shall shut down and generate an alarm upon receiving a freeze status.

### **High Static Shutdown:**

The unit shall shut down and generate an alarm upon receiving a high static shutdown signal.

### **Return Air Smoke Detection:**

The unit shall shut down and generate an alarm upon receiving a return air smoke detector status.

### **AHU Optimal Start:**

The unit shall start prior to scheduled occupancy based on the time necessary for the zones to reach their occupied setpoints. The start time shall automatically adjust based on changes in outside air temperature and zone temperatures.

### **Demand Limiting – Setpoint Adjust:**

To lower power consumption, the supply air temperature setpoint shall automatically relax (raised for cooling; lowered for heating) when the facility power consumption exceeds definable thresholds. The amount of relaxation shall be accomplished by one of the following methods:

- The supply air temperature setpoint shall relax by 2°F (adj.) for each demand threshold exceeded.
- The setpoints in the zones supplied by this unit shall be relaxed as specified in the Sequence of Operations for the zones. This shall in turn relax the unit's supply air temperature setpoint by a user definable amount.

All setpoints shall automatically return to their previous settings when the facility power consumption drops below the thresholds.

### **Supply Fan:**

The supply fan shall run anytime the unit is commanded to run based on run conditions, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime.

Alarms shall be provided as follows:

- Supply Fan Failure: Commanded on, but the status is off.
- Supply Fan in Hand: Commanded off, but the status is on.
- Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

### **Supply Air Duct Static Pressure Control:**

The controller shall measure duct static pressure and modulate the supply fan VFD speed to maintain a duct static pressure setpoint. The speed shall not drop below 30% (adj.). The static pressure setpoint shall be reset based on zone cooling requirements.

- The initial duct static pressure setpoint shall be 1.0 in H<sub>2</sub>O (adj.).
- As airflow demand increases, the setpoint shall incrementally reset up to a maximum of 2.0 in H<sub>2</sub>O (adj.).



- As airflow demand decreases, the setpoint shall incrementally reset down to a minimum of 0.35 in H2O (adj.).

An example calculation is as follows, all actual values to be selected based on the existing system requirements:

Every 2 minutes (adj.) the controller will poll the zone dampers and determine the # of requests (dampers above 90% open). The controller will trim the setpoint by 20% (adj.) of the setpoint span. The controller will respond by adding the trim value divided by 10% (adj.) of the dampers, multiplied by the total number of open dampers (approximately 10% of your system dampers to balance out the trim & respond equation).

$$Setpoint_{New} = Setpoint_{Old} - Trim + Respond(Requests)$$

Example Values:

- Setpoint<sub>Min</sub> = 0.35 in H2O
- Setpoint<sub>Max</sub> = 2.0 in H2O
- TotalZones = 50 zone dampers
- Setpoint<sub>Span</sub> = 2.0 in H2O – 0.35 in H2O = 1.65 in H2O
- Trim = Setpoint<sub>Span</sub> \* 20% = 0.33 in H2O
- Respond = Trim/(50 dampers \* 10%) = 0.066 psi/request

Alarms shall be provided as follows:

- High Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) greater than setpoint.
- Low Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) less than setpoint.
- Supply Fan VFD Fault.

#### **Variable Volume Fan Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = VFD\%^3 * \frac{Volts * Amps * \sqrt{Phase} * PF}{1000}$$

$$kWh = \sum_{Run} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage  
Amps = The sum of all fan loads  
VFD% = The output speed of the VFD  
Phase = 1 or 3 phase  
PF = Power Factor, assumed or measured

**Note to the Designer: Modify Return Fan section to be Relief Fan or Exhaust Fan as necessary.**

#### **Return Fan:**

The return fan shall run whenever the supply fan runs.

Alarms shall be provided as follows:

- Return Fan Failure: Commanded on, but the status is off.
- Return Fan in Hand: Commanded off, but the status is on.
- Return Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).
- Return Fan VFD Fault.

**Return Plenum Static Pressure Control:**

The controller shall measure return plenum static pressure and modulate the return fan VFD to maintain a plenum pressure setpoint of 0.2in H2O (adj.).

Alarms shall be provided as follows:

- High Building Static Pressure: If the building air static pressure is 25% (adj.) greater than setpoint.
- Low Building Static Pressure: If the building air static pressure is 25% (adj.) less than setpoint.

**Building Static Pressure Control:**

The controller shall measure building static pressure and modulate the relief damper to maintain a building static pressure setpoint of 0.05in H2O (adj.).

Alarms shall be provided as follows:

- High Building Static Pressure: If the building air static pressure is 25% (adj.) greater than setpoint.
- Low Building Static Pressure: If the building air static pressure is 25% (adj.) less than setpoint.

**Variable Volume Fan Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = VFD\%^3 * \frac{Volts * Amps * \sqrt{Phase} * PF}{1000}$$

$$kWh = \sum_{Run} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage  
 Amps = The sum of all fan loads  
 VFD% = The output speed of the VFD  
 Phase = 1 or 3 phase  
 PF = Power Factor, assumed or measured

**Heat Recovery Wheel – Constant Speed:**

The controller shall run the heat recovery wheel for energy recovery as follows.

**Cooling Recovery Mode:**

The controller shall measure the heat wheel discharge air temperature and modulate the heat wheel to maintain a setpoint 2°F (adj.) less than the unit supply air temperature setpoint. The heat wheel shall run for cool recovery whenever:

- The unit return air temperature is 5°F (adj.) or more below the outside air temperature.
- AND the unit is in a cooling mode.

- AND the economizer mode (if present) is disabled.
- AND the supply fan is on.

**Heating Recovery Mode:**

The controller shall measure the heat wheel discharge air temperature and modulate the heat wheel to maintain a setpoint 2°F (adj.) greater than the unit supply air temperature setpoint. The heat wheel shall run for heat recovery whenever:

- The unit return air temperature is 5°F (adj.) or more above the outside air temperature.
- AND the unit is in a heating mode.
- AND the economizer mode (if present) is disabled.
- AND the supply fan is on.

**Periodic Self-Cleaning:**

The heat wheel shall run for 10sec (adj.) every 4hr (adj.) the unit runs.

**Frost Protection:**

The heat wheel shall run for 10sec (adj.) every 600sec (adj.) whenever:

- Outside air temperature drops below 15°F (adj.)
- OR the exhaust air temperature drops below 20°F (adj.).

The heat wheel bypass dampers will open whenever the heat wheel is disabled.

Alarms shall be provided as follows:

- Heat Wheel Rotation Failure: Commanded on, but the status is off.
- Heat Wheel in Hand: Commanded off, but the status is on.
- Heat Wheel Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

**Heat Wheel Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = VFD\%^3 * \frac{Volts * Amps * \sqrt{Phase} * PF}{1000}$$

$$kWh = \sum_{Run} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage  
Amps = The sum of all motor loads  
VFD% = The output speed of the VFD  
Phase = 1 or 3 phase  
PF = Power Factor, assumed or measured

**Heat Recovery Coil – Runaround Loop:**

The controller shall run the heat recovery loop for energy recovery as follows.

**Cooling Recovery Mode:**

The controller shall measure the heat recovery coil air temperature and modulate the loop pump VFD to maintain a setpoint 2°F (adj.) less than the unit supply air temperature setpoint. The heat recovery loop shall run for cool recovery whenever:

- The unit return air temperature is 5°F (adj.) or more below the outside air temperature.
- AND the unit is in a cooling mode.
- AND the economizer (if present) is off.
- AND the supply fan is on.

**Heating Recovery Mode:**

The controller shall measure the heat recovery coil discharge air temperature and run the loop pump VFD to maintain a setpoint 2°F (adj.) greater than the unit supply air temperature setpoint. The heat wheel shall run for heat recovery whenever:

- The unit return air temperature is 5°F (adj.) or more above the outside air temperature.
- AND the unit is in a heating mode.
- AND the economizer (if present) is off.
- AND the supply fan is on.

**Preheating Coil Valve:**

The controller shall measure the mixed air temperature and preheat coil leaving temperature and modulate the preheating coil valve to maintain the lower of the two sensors at its setpoint, 5°F (adj.) less than the supply air temperature setpoint. If the valve provided is a globe valve, upon an initial call for control, hold the valve closed until the PID calls for at least 15% control signal in order to extent valve life. In addition, the preheat coil valve shall modulate to maintain a minimum setpoint of 45°F (adj.).

The preheating shall be enabled whenever:

- Outside air temperature is less than 60°F (adj.).
- AND the economizer mode (if present) is disabled.
- AND the supply fan status is on.
- AND the heat recovery (if present) is at its full output in the heating mode

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the coil is rated for 10 gpm, the controller shall send 10 requests when it is fully open. The operator shall have the ability to suppress requests for any valve that is deemed to be out of service.

The preheating coil valve shall open for freeze protection whenever the freezestat is on.

**Coil energy reporting (water-side calculation)**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- kBtu/hr – Instantaneous energy demand
- kBtu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kBtu/hr = \frac{Valve\% * GPM * (WST - WRT) * 500}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

$$kBtu_{Savings} = kBtu_{Base} - kBtu_{Act}$$

Where:

Valve% = Valve Actuator Command Signal (or feedback)

GPM = The rated flow of the coil

WST = Water supply temperature (from central plant)

WRT = Water return temperature (from sensor)

### Supply Air Temperature Setpoint – Optimized:

The controller shall monitor the supply air temperature and shall maintain a supply air temperature setpoint reset based on zone cooling requirements.

If the fan is running at its minimum speed, the supply air temperature setpoint shall be reset based on zone cooling requirements as follows:

- The initial supply air temperature setpoint shall be 55°F (adj.).
- As cooling demand increases, the setpoint shall incrementally reset down to a minimum of 53°F (adj.).
- As cooling demand decreases, the setpoint shall incrementally reset up to a maximum of 72°F (adj.).

Incoming requests shall be weighted in proportion to the size of each coil. For example, a coil rated for 10 gpm shall send 10 requests when the valve is fully open.

An example calculation is as follows, all actual values to be selected based on the existing system requirements:

Every 5 minutes (adj.) the controller will poll the zone dampers and determine the # of requests (dampers above 95% open). The controller will trim the setpoint by 20% (adj.) of the setpoint span. The controller will respond by adding the trim value divided by 10% (adj.) of the dampers, multiplied by the total number of open dampers (approximately 10% of your system dampers to balance out the trim & respond equation).

$$Setpoint_{New} = Setpoint_{Old} - Trim + Respond(Requests)$$

Example Values:

- $Setpoint_{Min} = 55^{\circ}F$
- $Setpoint_{Max} = 65^{\circ}F$
- $TotalZones = 500 \text{ gpm}$
- $Setpoint_{Span} = 65^{\circ}F - 55^{\circ}F = 10^{\circ}F$
- $Trim = Setpoint_{Span} * 20\% = 2^{\circ}F$
- $Respond = Trim / (500 \text{ gpm} * 10\%) = 0.04^{\circ}F/request$

### Cooling Coil Valve:

The controller shall measure the supply air temperature and modulate the cooling coil valve to maintain its cooling setpoint. If the valve provided is a globe valve, upon an initial call for control, hold the valve closed until the PID calls for at least 15% control signal in order to extent valve life. The cooling shall be enabled whenever:

- Outside air temperature is greater than 60°F (adj.).
- AND the economizer (if present) is disabled or fully open.
- AND the supply fan status is on.
- AND the heating (if present) is not active.
- AND heat recovery (if present) is not active in the heating mode

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the coil is rated for 10 gpm, the controller shall send 10 requests when it is fully open. The operator shall have the ability to suppress requests for any valve that is deemed to be out of service.

The cooling coil valve shall open to 50% (adj.) whenever the freezestat (if present) is on.

The controller will monitor the return water temperature (sensed downstream of the cooling coil), and the supply water temperature sensed at the central plant. Upon a call for cooling greater than 25% of the valve capacity, the controller will hold the position of the valve until the differential temperature exceeds 8°F (adj.). The controller will resume normal control when the differential temperature is above setpoint.

Alarms shall be provided as follows:

- High Supply Air Temp: If the supply air temperature is 5°F (adj.) greater than setpoint.
- Low Supply Air Temperature Alarm: The controller shall alarm if the supply air temperature is less than 45°F (adj.).
- Low Coil dT: If the valve is greater than 25% open and the differential temperature is less than setpoint by 2°F (adj.).

#### ***Coil energy reporting (water-side calculation)***

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Actual Runtime – Run – Actual equipment runtime
- Equip Btu – Instantaneous energy demand
- Equip Btu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kBtu/hr = \frac{Valve\% * GPM * (WST - WRT) * 500}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Valve% = Valve Actuator Command Signal (or feedback)

GPM = The rated flow of the coil

WST = Water supply temperature (from central plant)

WRT = Water return temperature (from sensor)

#### **Economizer:**

The controller shall measure the mixed air temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F (adj.) less than the supply air temperature setpoint.

The economizer shall be enabled whenever:

- Outside air temperature is less than 68°F (adj.).
- AND the outside air enthalpy is less than 22Btu/lb (adj.)
- AND the outside air temperature is less than the return air temperature.
- AND the outside air enthalpy is less than the return air enthalpy.
- AND the supply fan status is on.

The economizer shall close whenever:

- Mixed air temperature drops from 40°F to 35°F (adj.)
- OR the freezestat (if present) is on.
- OR on loss of supply fan status.

The outside and exhaust air dampers shall close, and the return air damper shall open when the unit is off. If Optimal Start Up is available, the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully closed.

#### **Minimum Outside Air Ventilation – Airflow Monitoring:**

When in the occupied mode, the controller shall measure the outside airflow and modulate the outside air dampers to maintain the proper minimum outside air ventilation, overriding normal damper control. On dropping outside airflow, the controller shall modulate the outside air dampers open to maintain the outside airflow setpoint (adj.).

#### **Dehumidification:**

The controller shall measure the return air humidity and override the cooling setpoint to 53°F (adj.) to maintain return air humidity at or below 60% rh (adj.). Dehumidification shall be enabled whenever the supply fan status is on.

#### **Humidifier Control:**

The controller shall measure the return air humidity and modulate the humidifier to maintain a setpoint of 50% rh (adj.). The humidifier shall be enabled whenever the supply fan status is on.

The humidifier shall turn off whenever:

- Supply air humidity rises from 90% rh to 95% rh (adj.).
- OR on loss of supply fan status.

Alarms shall be provided as follows:

- High Supply Air Humidity: If the supply air humidity is greater than 90% rh (adj.).
- Low Supply Air Humidity: If the supply air humidity is less than 30% rh (adj.).

#### **Prefilter Differential Pressure Monitor:**

The controller shall monitor the differential pressure across the prefilter.

Alarms shall be provided as follows:

- Prefilter Change Required: Prefilter differential pressure exceeds a user definable limit (adj.).

#### **Mixed Air Temperature:**

The controller shall monitor the mixed air temperature and use as required for economizer control (if present) or preheating control (if present).

Alarms shall be provided as follows:

- High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).
- Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

#### **Return Air Carbon Dioxide (CO2) Concentration Monitoring:**

The controller shall measure the return air CO2 levels.

Alarms shall be provided as follows:

- High Return Air Carbon Dioxide Concentration: If the return air CO2 concentration is greater than 1000ppm (adj.) when in the unit is running.

**Return Air Humidity:**

The controller shall monitor the return air humidity and use as required for economizer control (if present) or humidity control (if present).

Alarms shall be provided as follows:

- High Return Air Humidity: If the return air humidity is greater than 70% (adj.).
- Low Return Air Humidity: If the return air humidity is less than 35% (adj.).

**Return Air Temperature:**

The controller shall monitor the return air temperature and use as required for setpoint control or economizer control (if present).

Alarms shall be provided as follows:

- High Return Air Temp: If the return air temperature is greater than 90°F (adj.).
- Low Return Air Temp: If the return air temperature is less than 45°F (adj.).

**Supply Air Temperature:**

The controller shall monitor the supply air temperature.

Alarms shall be provided as follows:

- High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
- Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

**Demand Limiting:**

To lower power demand, the AHU shall automatically relax when a command is received from the power monitoring system as follows:

- Demand Level 1: A command will be sent to the fan VFD's to limit their operation to 95% of capacity.
- Demand Level 2: A command will be sent to the fan VFD's to limit their operation to 90% of capacity.
- Demand Level 3: A command will be sent to the fan VFD's to limit their operation to 80% of capacity.

The fans shall automatically return to their previous settings when the facility power demand drops below the thresholds.

## **100% OUTSIDE AIR UNIT – SUPPLY AIR TEMP**

**Run Conditions – Scheduled:**

The unit shall run based upon an operator adjustable schedule.

**Freeze Protection:**

The unit shall shut down and generate an alarm upon receiving a freezestat status.

**Smoke Detection:**

The unit shall shut down and generate an alarm upon receiving a smoke detector status.

**Outside Air Damper:**

The outside air damper shall open anytime the unit runs and shall close anytime the unit stops. The supply fan shall start only after the damper status has proven the damper is open. The outside air damper shall close 4sec (adj.) after the supply fan stops.

Alarms shall be provided as follows:



- Outside Air Damper Failure: Commanded open, but the status is closed.
- Outside Air Damper in Hand: Commanded closed, but the status is open.

#### **Supply Fan:**

The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime.

Alarms shall be provided as follows:

- Supply Fan Failure: Commanded on, but the status is off.
- Supply Fan in Hand: Commanded off, but the status is on.
- Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

#### **Supply Air Duct Static Pressure Control:**

The controller shall measure duct static pressure and modulate the supply fan VFD speed to maintain a duct static pressure setpoint. The speed shall not drop below 30% (adj.). The static pressure setpoint shall be reset based on zone cooling requirements.

- The initial duct static pressure setpoint shall be 1.0 in H2O (adj.).
- As airflow demand increases, the setpoint shall incrementally reset up to a maximum of 2.0 in H2O (adj.).
- As airflow demand decreases, the setpoint shall incrementally reset down to a minimum of 0.35 in H2O (adj.).

An example calculation is as follows, all actual values to be selected based on the existing system requirements:

Every 2 minutes (adj.) the controller will poll the zone dampers and determine the # of requests (dampers above 90% open). The controller will trim the setpoint by 20% (adj.) of the setpoint span. The controller will respond by adding the trim value divided by 10% (adj.) of the dampers, multiplied by the total number of open dampers (approximately 10% of your system dampers to balance out the trim & respond equation).

$$Setpoint_{New} = Setpoint_{Old} - Trim + Respond(Requests)$$

Example Values:

- $Setpoint_{Min} = 0.35$  in H2O
- $Setpoint_{Max} = 2.0$  in H2O
- TotalZones = 50 zone dampers
- $Setpoint_{Span} = 2.0$  in H2O – 0.35 in H2O = 1.65 in H2O
- $Trim = Setpoint_{Span} * 20\% = 0.33$  in H2O
- $Respond = Trim / (50 \text{ dampers} * 10\%) = 0.066$  psi/request

Alarms shall be provided as follows:

- High Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) greater than setpoint.
- Low Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) less than setpoint.
- Supply Fan VFD Fault.

#### **Variable Volume Fan Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = \text{VFD}\%^3 * \frac{\text{Volts} * \text{Amps} * \sqrt{\text{Phase}} * \text{PF}}{1000}$$

$$kWh = \sum_{\text{Run}} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage  
Amps = The sum of all fan loads  
VFD% = The output speed of the VFD  
Phase = 1 or 3 phase  
PF = Power Factor, assumed or measured

#### **Exhaust Fan:**

The exhaust fan shall run whenever the supply fan runs.

Alarms shall be provided as follows:

- Exhaust Fan Failure: Commanded on, but the status is off.
- Exhaust Fan in Hand: Commanded off, but the status is on.
- Exhaust Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).
- Exhaust Fan VFD Fault.

#### **Building Static Pressure Control:**

The controller shall measure building static pressure and modulate the exhaust fan VFD speed to maintain a building static pressure setpoint of 0.05in H2O (adj.). The exhaust fan VFD speed shall not drop below 20% (adj.).

Alarms shall be provided as follows:

- High Building Static Pressure: If the building air static pressure is 25% (adj.) greater than setpoint.
- Low Building Static Pressure: If the building air static pressure is 25% (adj.) less than setpoint.

#### **Variable Volume Fan Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = \text{VFD}\%^3 * \frac{\text{Volts} * \text{Amps} * \sqrt{\text{Phase}} * \text{PF}}{1000}$$

$$kWh = \sum_{\text{Run}} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage  
Amps = The sum of all fan loads  
VFD% = The output speed of the VFD  
Phase = 1 or 3 phase  
PF = Power Factor, assumed or measured

**Heat Recovery Wheel – Constant Speed:**

The controller shall run the heat recovery wheel for energy recovery as follows.

**Cooling Recovery Mode:**

The controller shall measure the heat wheel discharge air temperature and run the heat wheel to maintain a setpoint 2°F (adj.) less than the unit supply air temperature setpoint. The heat wheel shall run for cool recovery whenever:

- The unit return air temperature is 5°F (adj.) or more below the outside air temperature.
- AND the unit is in a cooling mode.
- AND the economizer (if present) is off.
- AND the supply fan is on.

**Heating Recovery Mode:**

The controller shall measure the heat wheel discharge air temperature and run the heat wheel to maintain a setpoint 2°F (adj.) greater than the unit supply air temperature setpoint. The heat wheel shall run for heat recovery whenever:

- The unit return air temperature is 5°F (adj.) or more above the outside air temperature.
- AND the unit is in a heating mode.
- AND the economizer (if present) is off.
- AND the supply fan is on.

**Periodic Self-Cleaning:**

The heat wheel shall run for 10sec (adj.) every 4hr (adj.) the unit runs.

**Frost Protection:**

The heat wheel shall run for 10sec (adj.) every 600sec (adj.) whenever:

- Outside air temperature drops below 15°F (adj.)
- OR the exhaust air temperature drops below 20°F (adj.).

The heat wheel bypass dampers will open whenever the heat wheel is disabled.

Alarms shall be provided as follows:

- Heat Wheel Rotation Failure: Commanded on, but the status is off.
- Heat Wheel in Hand: Commanded off, but the status is on.
- Heat Wheel Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

**Heat Wheel Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = VFD\%^3 * \frac{Volts * Amps * \sqrt{Phase} * PF}{1000}$$

$$kWh = \sum_{Run} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage  
 Amps = The sum of all motor loads  
 VFD% = The output speed of the VFD  
 Phase = 1 or 3 phase  
 PF = Power Factor, assumed or measured

**Note to the Designer: Select one of the following supply temperature control strategies as appropriate and remove the other.**

**Supply Air Temperature Setpoint – Optimized for Space Conditions:**

The controller shall monitor the supply air temperature and shall maintain a supply air temperature setpoint reset based on zone cooling requirements.

The supply air temperature setpoint shall be reset based on zone cooling requirements as follows:

- The initial supply air temperature setpoint shall be 55°F (adj.).
- As cooling demand increases, the setpoint shall incrementally reset down to a minimum of 53°F (adj.).
- As cooling demand decreases, the setpoint shall incrementally reset up to a maximum of 72°F (adj.).

**Supply Air Temperature Setpoint – Ventilation Air:**

The controller shall monitor the supply air temperature and shall maintain a fixed supply air temperature setpoint of 70°F (adj.).

**Preheating Coil Face and Bypass Dampers:**

The controller shall measure the mixed air temperature and preheat coil leaving temperature and modulate the preheating coil valve and dampers to maintain the lower of the two sensors at its setpoint, 5°F (adj.) less than the supply air temperature setpoint. In addition, the preheat coil dampers shall modulate to maintain a minimum setpoint of 45°F (adj.). The coil valve and face and bypass dampers shall be sequenced as follows:

- When the unit is off, the face and bypass dampers will be in the full face position and the preheat coil valve shall modulate to maintain setpoint in the airstream with no flow.
- When the unit is running, and the outside air temperature is below 38°F (adj.), the coil valve shall be fully open to the coil and the face and bypass dampers shall modulate to maintain setpoint.
- When the unit is running, and the outside air temperature is above 40°F (adj.), the face and bypass dampers shall be in the full face position and the coil valve shall modulate to maintain setpoint.
- When the unit is running and there is no call for preheating, the coil valve shall be closed and the face and bypass dampers in the full bypass position.

**Coil energy reporting (air-side calculation)**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- kBtu/hr – Instantaneous energy demand
- kBtu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kBtu/hr = \frac{VFD\% * CFM * (MAT - PH DAT) * 1.08}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 min}{60 min/hr} \right) \right)$$

$$kBtu_{Savings} = kBtu_{Base} - kBtu_{Act}$$

Where:

VFD% = Fan Speed Command Signal (or feedback)  
 CFM = The rated flow of the fan  
 MAT = Mixed air temperature  
 PH DAT = Preheat Coil Discharge Air Temperature

#### **Cooling Coil Valve:**

The controller shall measure the supply air temperature and modulate the cooling coil valve to maintain its cooling setpoint. If the valve provided is a globe valve, upon an initial call for control, hold the valve closed until the PID calls for at least 15% control signal in order to extent valve life. The cooling shall be enabled whenever:

- Outside air temperature is greater than 60°F (adj.).
- AND the economizer (if present) is disabled or fully open.
- AND the supply fan status is on.
- AND the heating (if present) is not active.

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the coil is rated for 10 gpm, the controller shall send 10 requests when it is fully open. The operator shall have the ability to suppress requests for any valve that is deemed to be out of service.

The cooling coil valve shall open to 50% (adj.) whenever the freezestat (if present) is on.

The controller will monitor the return water temperature (sensed downstream of the cooling coil), and the supply water temperature sensed at the central plant. Upon a call for cooling greater than 25% of the valve capacity, the controller will hold the position of the valve until the differential temperate exceeds 8°F (adj). The controller will resume normal control when the differential temperate is above setpoint.

Alarms shall be provided as follows:

- High Supply Air Temp: If the supply air temperature is 5°F (adj.) greater than setpoint.
- Low Supply Air Temperature Alarm: The controller shall alarm if the supply air temperature is less than 45°F (adj.).
- Low Coil dT: If the valve is greater than 25% open and the differential temperature is less than setpoint by 2°F (adj.).

#### **Coil energy reporting (water-side calculation)**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Actual Runtime – Run – Actual equipment runtime
- Equip Btu – Instantaneous energy demand
- Equip Btu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kBtu/hr = \frac{Valve\% * GPM * (WST - WRT) * 500}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Valve% = Valve Actuator Command Signal (or feedback)  
 GPM = The rated flow of the coil  
 WST = Water supply temperature (from central plant)  
 WRT = Water return temperature (from sensor)

#### Heating Coil Valve:

The controller shall measure the supply air temperature and modulate the heating coil valve to maintain its heating setpoint. If the valve provided is a globe valve, upon an initial call for control, hold the valve closed until the PID calls for at least 15% control signal in order to extend valve life. The heating shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the supply air temperature is below heating setpoint.
- AND the fan status is on.
- AND any heat recovery is at full output.

If the heating fluid is not steam, the controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the coil is rated for 10 gpm, the controller shall send 10 requests when it is fully open. The operator shall have the ability to suppress requests for any valve that is deemed to be out of service.

The heating coil valve shall open to 100% (adj.) whenever the freezestat is on.

#### Coil energy reporting (water-side calculation)

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- kBtu/hr – Instantaneous energy demand
- kBtu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kBtu/hr = \frac{Valve\% * GPM * (WST - WRT) * 500}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

$$kBtu_{Savings} = kBtu_{Base} - kBtu_{Act}$$

Where:

Valve% = Valve Actuator Command Signal (or feedback)  
 GPM = The rated flow of the coil  
 WST = Water supply temperature (from central plant)  
 WRT = Water return temperature (from sensor)

#### Filter Status:

The controller shall monitor the filter status.

Alarms shall be provided as follows:

- Filter Change Required: filter differential pressure exceeds a user definable limit (adj.).

#### Supply Air Temperature:

The controller shall monitor the supply air temperature.

Alarms shall be provided as follows:

- High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
- Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

**Demand Limiting:**

To lower power demand, the AHU shall automatically relax when a command is received from the power monitoring system as follows:

- Demand Level 1: A command will be sent to the fan VFD's to limit their operation to 95% of capacity.
- Demand Level 2: A command will be sent to the fan VFD's to limit their operation to 90% of capacity.
- Demand Level 3: A command will be sent to the fan VFD's to limit their operation to 80% of capacity.

The fans shall automatically return to their previous settings when the facility power demand drops below the thresholds.

## VARIABLE AIR VOLUME - TERMINAL UNIT

Run Conditions - Scheduled:

The unit shall run according to a user definable time schedule in the following modes:

- Occupied Mode: Scheduled times when the facility is deemed to be fully occupied (>25% capacity), the unit shall maintain
  - A 74°F (adj.) cooling setpoint with a 2°F hysteresis
  - A 70°F (adj.) heating setpoint with a 2°F hysteresis
  - Occupied ventilation rates
- Standby Mode: Scheduled occupied times when the facility is deemed to be lightly occupied by an occupancy sensor (if present) or time of day schedule. During Standby mode the unit shall maintain
  - A +2°F (adj.) offset from occupied cooling setpoint
  - A -2°F (adj.) offset from occupied heating setpoint.
  - Unoccupied ventilation rates
- Unoccupied Mode (night setback): The unit shall maintain
  - A +6°F (adj.) offset from occupied cooling setpoint
  - A -6°F (adj.) offset from occupied heating setpoint.
  - Unoccupied ventilation rates

If at any time, the occupancy sensor (if present) detects people in the space, the zone shall be indexed to Occupied Mode until the detected occupancy plus any delays again detects no occupancy.

Alarms shall be provided as follows:

- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

### ***Demand Limiting - Zone Setpoint Optimization:***

To lower power consumption, the zone setpoints shall automatically relax when the facility power consumption exceeds definable thresholds. The amount of relaxation shall be individually configurable for each zone. The zone setpoints shall automatically return to their previous settings when the facility power consumption drops below the thresholds.

### ***Zone Setpoint Adjust:***

The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

### ***Zone Optimal Start:***

The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

### ***Zone Unoccupied Override:***

A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

### **Constant Volume Terminal Unit - Flow Control:**

The unit shall maintain constant airflow through one of the following:

Standby:



The zone damper shall modulate to a constant unoccupied airflow (adj.) distributed into the zone.

When zone temperature is less than its heating setpoint, the controller shall enable heating to maintain the zone temperature at its unoccupied heating setpoint.

Occupied:

The zone damper shall modulate to maintain a constant occupied airflow (adj.) distributed into the zone.

When zone temperature is less than its heating setpoint, the controller shall enable heating to maintain the zone temperature at its heating setpoint.

Unoccupied:

The zone damper shall modulate to a constant unoccupied airflow (adj.) distributed into the zone.

When zone temperature is less than its heating setpoint, the controller shall enable heating to maintain the zone temperature at its unoccupied heating setpoint.

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the damper is rated for 100 cfm, the controller shall send 100 requests when it is fully open. The operator shall have the ability to suppress requests for any damper that is deemed to be out of service.

### **Cooling energy reporting (air-side calculation)**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- kBtu/hr – Instantaneous energy demand
- kBtu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kBtu/hr = \frac{EC\% * CFM * (ZONE - SAT) * 1.08}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

EC% = Fan Speed Command Signal (or feedback)

CFM = The rated flow of the fan times the VFD fan speed

ZONE = Zone temperature

SAT = Supply Air Temperature

### **Variable Volume Terminal Unit - Flow Control:**

The unit shall maintain zone setpoints by controlling the airflow through one of the following:

Standby:

- When zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum unoccupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.
- When the zone temperature is less than the cooling setpoint, the zone damper shall control to its minimum unoccupied airflow (adj.).

Occupied:

- When zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum occupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.
- When the zone temperature is less than the cooling setpoint, the zone damper shall maintain the minimum required zone ventilation (adj.).

Unoccupied:

- When the zone is unoccupied the zone damper shall control to its minimum unoccupied airflow (adj.).
- When the zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum unoccupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the damper is rated for 100 cfm, the controller shall send 100 requests when it is fully open. The operator shall have the ability to suppress requests for any damper that is deemed to be out of service.

### **Cooling energy reporting (air-side calculation)**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- kBtu/hr – Instantaneous energy demand
- kBtu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kBtu/hr = \frac{EC\% * CFM * (ZONE - SAT) * 1.08}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

EC% = Fan Speed Command Signal (or feedback)  
 CFM = The rated flow of the fan times the VFD fan speed  
 ZONE = Zone temperature  
 SAT = Supply Air Temperature

### **Fan Control - Parallel:**

The fan shall run whenever the zone controller calls for heat. The fan shall run for a minimum user definable time (adj.). If the AHU is not running, the zone damper will close completely to prevent the unit fan from blowing air back into the supply duct. In the unoccupied mode, the damper will remain closed and fan will cycle on when the space temperature drops below the effective heating setpoint.

### **Fan Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = ECM\%^3 \frac{Volts * Amps * \sqrt{Phase} * PF}{1000}$$

$$kWh = \sum_{Run} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

ECM% = Fan Speed Command Signal (or feedback)

Volts = Equipment supply voltage

Amps = The sum of all fan loads

Phase = 1 or 3 phase

PF = Power Factor, assumed or measured

#### **Fan Control - Series:**

The fan shall run anytime the unit is commanded to run. The fan shall run for a minimum user definable time (adj.). The zone damper will close completely before the fan starts to prevent air from the AHU from causing the fan to spin backward. The zone damper will return to automatic control after the fan starts. In the unoccupied mode, the damper will remain closed and fan will cycle on when the space temperature drops below the effective heating setpoint.

#### **Fan Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = ECM\%^3 \frac{Volts * Amps * \sqrt{Phase} * PF}{1000}$$

$$kWh = \sum_{Run} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

ECM% = Fan Speed Command Signal (or feedback)

Volts = Equipment supply voltage

Amps = The sum of all fan loads

Phase = 1 or 3 phase

PF = Power Factor, assumed or measured

#### **Reheating Coil Valve:**

The controller shall measure the zone temperature and modulate the reheating coil valve open on dropping temperature to maintain its heating setpoint

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the coil is rated for 10 gpm, the controller shall send 10 requests when it is fully open. The operator shall have the ability to suppress requests for any valve that is deemed to be out of service.

#### **Reheating - High Discharge Air Temperature Limit:**

The controller shall measure the discharge air temperature and limit reheating if the discharge air temperature is more than 15°F (adj.) above the zone temperature.

### ***Coil energy reporting (air-side calculation)***

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- kBtu/hr – Instantaneous energy demand
- kBtu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kBtu/hr = \frac{CFM * (SAT - DAT) * 1.08}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

CFM = The measured flow of terminal box

SAT = Supply air temperature from AHU

DAT = Discharge Air Temperature

Discharge Air Temperature:

The controller shall monitor the discharge air temperature.

Alarms shall be provided as follows:

- High Discharge Air Temp: If the discharge air temperature is greater than 120°F (adj.).
- Low Discharge Air Temp: If the discharge air temperature is less than 40°F (adj.).

## **LABORATORY ROOM PRESSURIZATION SYSTEMS**

Run Conditions - Scheduled:

The unit shall run according to a user definable time schedule in the following modes:

- Occupied Mode: Scheduled times when the facility is deemed to be fully occupied (>25% capacity), the unit shall maintain
  - A 74°F (adj.) cooling setpoint with a 2°F hysteresis
  - A 70°F (adj.) heating setpoint with a 2°F hysteresis
  - Occupied ventilation rates
- Standby Mode: Scheduled occupied times when the facility is deemed to be lightly occupied by an occupancy sensor (if present) or time of day schedule. During Standby mode the unit shall maintain
  - A +2°F (adj.) offset from occupied cooling setpoint
  - A -2°F (adj.) offset from occupied heating setpoint.
  - Unoccupied ventilation rates
- Unoccupied Mode (night setback): The unit shall maintain
  - A +6°F (adj.) offset from occupied cooling setpoint
  - A -6°F (adj.) offset from occupied heating setpoint.
  - Unoccupied ventilation rates

If at any time, the occupancy sensor (if present) detects people in the space, the zone shall be indexed to Occupied Mode until the detected occupancy plus any delays again detects no occupancy.

Alarms shall be provided as follows:

- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

***Demand Limiting - Zone Setpoint Optimization:***

To lower power consumption, the zone temperature setpoints shall automatically relax when the facility power consumption exceeds definable thresholds. The amount of relaxation shall be individually configurable for each zone. The zone setpoints shall automatically return to their previous settings when the facility power consumption drops below the thresholds.

***Zone Setpoint Adjust:***

The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

***Zone Optimal Start:***

The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

***Zone Unoccupied Override:***

A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

***Supply Air Damper Control:***

The unit shall maintain zone setpoints by controlling the airflow through one of the following:

Occupied:

- When zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum occupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.
- When the zone temperature is less than the cooling setpoint, the zone damper shall maintain the minimum required zone ventilation (adj.).

Standby:

- When zone temperature is greater than its standby cooling setpoint, the zone damper shall modulate between the minimum unoccupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.
- When the zone temperature is less than the standby cooling setpoint, the zone damper shall control to its minimum unoccupied airflow (adj.).

Unoccupied:

- When the zone is unoccupied the zone damper shall control to its minimum unoccupied airflow (adj.).
- When the zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum unoccupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the damper is rated for 100 cfm, the controller shall send 100 requests when it is fully open.

**Cooling energy reporting (air-side calculation)**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- kBtu/hr – Instantaneous energy demand
- kBtu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kBtu/hr = \frac{EC\% * CFM * (ZONE - SAT) * 1.08}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

EC% = Fan Speed Command Signal (or feedback)  
 CFM = The rated flow of the fan times the VFD fan speed  
 ZONE = Zone temperature  
 SAT = Supply Air Temperature

**Reheating Coil Valve:**

The controller shall measure the zone temperature and modulate the reheating coil valve open on dropping temperature to maintain its heating setpoint. Upon an initial call for control, hold the valve closed until the PID calls for at least 15% control signal in order to extent valve life.

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the coil is rated for 10 gpm, the controller shall send 10 requests when it is fully open. The operator shall have the ability to suppress requests for any valve that is deemed to be out of service.

**Reheating - High Discharge Air Temperature Limit:**

The controller shall measure the discharge air temperature and limit reheating if the discharge air temperature is more than 15°F (adj.) above the zone temperature.

**Coil energy reporting (air-side calculation)**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days. and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- kBtu/hr – Instantaneous energy demand
- kBtu – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kBtu/hr = \frac{CFM * (SAT - DAT) * 1.08}{1000}$$

$$kBtu = \sum_{Run} \left( kBtu/hr * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

CFM = The measured flow of terminal box

SAT = Supply air temperature from AHU

DAT = Discharge Air Temperature

Discharge Air Temperature:

The controller shall monitor the discharge air temperature.

Alarms shall be provided as follows:

- High Discharge Air Temp: If the discharge air temperature is greater than 120°F (adj.).
- Low Discharge Air Temp: If the discharge air temperature is less than 40°F (adj.).

#### **Fume Hood Flow Control**

The fume hood controller shall monitor the sash position of the fume hood and modulate the fume hood exhaust dampers as follows:

The controller shall calculate the total open area as indicated by sash position.

The controller shall calculate the fume hood exhaust cfm required to maintain the average face velocity at the airflow velocity setpoint for the open area of the fume hood.

The controller shall modulate the fume hood exhaust terminal box to maintain the fume hood exhaust setpoint.

#### **Laboratory Exhaust Control**

The laboratory controller shall measure the laboratory general exhaust cfm and modulate the laboratory exhaust damper as follows:

The controller shall totalize the exhaust airflow of all fume hoods in the laboratory.

The controller shall calculate the general exhaust cfm required to maintain the room pressurization offset cfm at its setpoint. The exhaust cfm setpoint is equal to the laboratory pressurization offset cfm, plus the sum of all fume hood cfm, minus the supply air cfm.

The controller shall modulate the general exhaust terminal box to maintain the laboratory exhaust cfm setpoint.

If the exhaust damper is at its minimum position and the laboratory cfm offset is not met, override the supply damper to maintain the laboratory offset cfm at its setpoint.

The controller shall send a setpoint request value proportional to its rated capacity to its parent equipment for setpoint optimization. For example, if the damper is rated for 100 cfm, the controller shall send 100 requests when it is fully open.

### **LABORATORY EXHAUST SYSTEMS (N+1 FANS)**

#### **Exhaust Fans Lead/Lag/Standby Operation:**

The exhaust fans shall operate in a lead/lag/standby fashion.

The lead fan shall run first.

Upon start up, the lead fan isolation dampers shall open. When the lead fan dampers have been proven open, the lead fan shall run at its minimum speed. Index the fan and dampers for exhaust duct static pressure control.

On failure of the lead fan, the standby fan isolation dampers shall modulate open. When the standby fan dampers have been proven open, the standby fan shall run and the lead fan shall turn off.

On decreasing duct differential pressure, the lag fans shall stage on in sequence and run in unison with the lead fan to maintain duct differential pressure setpoint.

On rising differential pressure, if the bypass damper exceeds 75% open (adj.), the fans shall stage off in sequence.

The designated lead fan shall rotate upon one of the following conditions (user selectable):

manually through a software switch  
if pump runtime (adj.) is exceeded  
daily  
weekly  
monthly

Upon a command to rotate the fans, start the standby fan at 25% and open the standby isolation damper. Allow the bypass damper to maintain exhaust duct static pressure. Ramp the standby fan up to match the lead fan and disable the lead fan while closing its isolation dampers. Designate the standby fan as the new lead fan.

Alarms shall be provided as follows:

#### Exhaust Fan 1

Failure: Commanded on, but the status is off.  
Running in Hand: Commanded off, but the status is on.  
Runtime Exceeded: Status runtime exceeds a user definable limit.  
VFD Fault.

#### Exhaust Fan 2

Failure: Commanded on, but the status is off.  
Running in Hand: Commanded off, but the status is on.  
Runtime Exceeded: Status runtime exceeds a user definable limit.  
VFD Fault.

#### **Exhaust Duct Static Pressure Control:**

The controller shall measure exhaust duct static pressure and exhaust plenum static pressure, and modulate the exhaust fan VFD speed first, and bypass dampers second to maintain an exhaust duct static pressure setpoint of 2 in H2O (adj.). If the exhaust duct static pressure sensor becomes unreliable, the exhaust plenum static pressure sensor shall become the controlled sensor. If the exhaust fan is running at its minimum speed, the bypass damper shall be indexed for operation and shall modulate to maintain exhaust duct static pressure at its setpoint.

Once the fans have reached a steady state condition, the static pressure setpoint shall be reset based on zone cooling requirements.

- The initial duct static pressure setpoint shall be 1.0 in H2O (adj.).
- As airflow demand increases, the setpoint shall incrementally reset up to a maximum of 2.0 in H2O (adj.).
- As airflow demand decreases, the setpoint shall incrementally reset down to a minimum of 0.35 in H2O (adj.).

An example calculation is as follows, all actual values to be selected based on the existing system requirements:

Every 2 minutes (adj.) the controller will poll the zone dampers and determine the # of requests (dampers above 90% open). The controller will trim the setpoint by 20% (adj.) of the setpoint span. The controller will respond by adding the trim value divided by 10% (adj.) of the dampers, multiplied by the total number of open dampers (approximately 10% of your system dampers to balance out the trim & respond equation).

$$Setpoint_{New} = Setpoint_{Old} - Trim + Respond(Requests)$$

Example Values:

- $Setpoint_{Min} = 0.35$  in H2O
- $Setpoint_{Max} = 2.0$  in H2O
- TotalZones = 50 zone dampers



- $\text{Setpoint}_{\text{span}} = 2.0 \text{ in H}_2\text{O} - 0.35 \text{ in H}_2\text{O} = 1.65 \text{ in H}_2\text{O}$
- $\text{Trim} = \text{Setpoint}_{\text{span}} * 20\% = 0.33 \text{ in H}_2\text{O}$
- $\text{Respond} = \text{Trim} / (50 \text{ dampers} * 10\%) = 0.066 \text{ psi/request}$

Alarms shall be provided as follows:

- High Exhaust Duct Static Pressure: If the exhaust duct static pressure is 25% (adj.) greater than setpoint.
- Low Exhaust Duct Static Pressure: If the exhaust duct static pressure is 25% (adj.) less than setpoint.

#### **Variable Volume Fan Runtime Energy reporting**

The controller shall determine the energy demand by trending the following points at 10-minute intervals and shall be historically archived for a minimum of 365 days.

- Runtime – Run – Actual equipment runtime
- Equip kW – Instantaneous energy demand
- Equip kWh – Energy usage over time calculated as a least squares integration (or similar)

These values are calculated as follows:

$$kW = \text{VFD}\%^3 * \frac{\text{Volts} * \text{Amps} * \sqrt{\text{Phase}} * \text{PF}}{1000}$$

$$kWh = \sum_{\text{Run}} \left( kW * \left( \frac{10 \text{ min}}{60 \text{ min/hr}} \right) \right)$$

Where:

Volts = Equipment supply voltage  
 Amps = The sum of all fan loads  
 VFD% = The output speed of the VFD  
 Phase = 1 or 3 phase  
 PF = Power Factor, assumed or measured

## **ENERGY TRACKING**

### **Energy Meters and Calculations:**

The controller shall monitor the KW, chilled water kBtu, hot water kBtu, steam, and any other energy calculations for energy consumption on a continual basis. These values shall be made available to the system at all times.

Alarm shall be generated as follows:

Meter Failure: Sensor reading indicates a loss of pulse output from the energy meter.

### **Peak Demand History:**

The controller shall monitor and record the peak (high and low) demand readings from the energy meter. Peak readings shall be recorded on a daily, month-to-date, and year-to-date basis.

### **Usage History:**

The controller shall monitor and record energy meter readings so as to provide an energy consumption history. Usage readings shall be recorded on a daily, month-to-date, and year-to-date basis.

### **Energy Normalization**

The controller shall have the ability to display all energy meters and calculations in the facility's billable units (i.e.: kW, kWh, ccf, Btu, lbs/hr, etc.). In addition, the controller shall normalize all units to kBtu for EUI (Energy Use Index) calculations.

## **Energy Totalizations**

The system shall totalize the peak demand and consumption data for each area in the facility as well as a total energy rollup. An area is defined as a space or collection of spaces with similar usage and scheduling patterns. The BAS submittal shall include proposed totalizations and an example of the energy dashboards for approval.

Examples of Facility Areas may include:

- Floors – All of the equipment serving a floor of a multi-story building

- HVAC System Zones – Zones served by an AHU and all of its child equipment

- Category Loads – A totalization of all loads that fit within HVAC, Lighting, Plug Load, etc. categories

- HVAC energy types – A totalization of all energy meters and calculations that originate from a main source.

  - Examples include Electrical kWh and kw; chilled water kBtu, hot water kBtu, etc.

## **SYSTEM DASHBOARDS**

### **Energy Dashboards**

Energy Dashboard graphics shall be provided at each totalization location. The dashboard shall display energy data in a graphical format. Tabular data shall not be acceptable. The dashboards shall display the following information at a minimum:

- Instantaneous demands for each energy monitored

- Peak historic demand and the date the peak was set for each energy monitored

- Instantaneous demand as a percent of its peak.

- Total energy normalized to kBtu and a chart comparing each energy source (stacked bar chart, pie chart, etc.)

### **Energy Intensity Floorplan Graphic**

Energy intensity graphics shall be provided at each totalization location. The dashboard shall display energy intensity data in a thermographic floorplan. Tabular data shall not be acceptable. The dashboards shall display the following information at a minimum:

- Each zone shall have a color corresponding to the energy used as a percentage of its peak load.

- Links to each totalization zone or equipment

### **Air Handling Systems Dashboard**

The intention of an Air Handling Systems Dashboard is to display on a single screen Key Performance Indicators (KPI) for all the AHUs in a building.

In addition to the standard air handling unit graphics, provide AHU system dashboard graphics which display information from all the AHUs in the building. The dashboard shall display AHU data in a graphical format. Tabular data shall not be acceptable. The dashboards shall display the following information at a minimum:

- Source Hot and Chilled Water supply temperatures

- AHU Supply Air Temperature, Airflow, Down Duct Static Pressure, Fan Speed

- VAV Box summary information per AHU: # zones in heating, cooling, satisfied

- Links to each piece of equipment

### **VAV System Dashboard**

The intention of a VAV System Dashboard is to display on a single screen Key Performance Indicators (KPI) for an entire VAV terminal box system.

In addition to the standard air handling unit graphics, provide VAV box system dashboard graphics which display information from the VAV boxes served by each AHU in real time. The dashboard shall display vav box data in a

graphical format. Tabular data shall not be acceptable. The dashboards shall display the following information at a minimum:

- AHU Supply Air Temperature, Airflow, Down Duct Static Pressure, Fan Speed

- VAV Box Zone Temperature, Zone Temperature Setpoints, Damper Position, Airflow, Airflow Setpoint, Reheat status (if applicable), Fan Status (if applicable)

- Links to each piece of equipment

### **Chilled Water System Dashboard**

The intention of a Chilled Water System Dashboard is to display on a single screen Key Performance Indicators (KPI) for an entire chilled water system.

In addition to the standard chilled water graphic, provide a chilled water system dashboard graphic to display information about the cooling coils in real time. The dashboard shall display cooling coil data in a graphical format. Tabular data shall not be acceptable. The dashboards shall display the following information at a minimum:

- Chiller Status(s), Chilled Water Supply Temperature and Setpoint

- Chilled Water Pump(s) Status, Chilled Water Differential Pressure and Setpoint

- Each Cooling Coil Valve Position, Each Cooling Coil Leaving Temperature, Each Cooling Coil Leaving Water Temperature if available

- Links to each piece of equipment

# ALARMS AND REPORTING ACTIONS

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## ALARM CATEGORIZATION

Alarms shall be configured within the following categories. The commissioning authority and owner shall have final approval on all alarm setup and activation.

- HVAC Critical – Alarms that indicate that HVAC equipment is potentially damaged or that damage is imminent. Examples include: Freezestats, Smoke Detectors, Fan Failure.
- HVAC General – Alarms that indicate an HVAC condition is out of normal operation. Examples include: Zone Temperature Alarms, Setpoint alarms, and most other alarms.
- HVAC Maintenance – Alarms that indicate HVAC equipment maintenance is required. Examples include: Dirty Filters, and Motor Runtime.
- HVAC Energy - Alarms that indicate HVAC energy is being wasted. Examples include: Motor in Hand, Leak Detection, and PID Hunting.

## ALARM ACTIVATION

When the BAS is merged into the main database, Alarms shall be activated according to their Category

- HVAC Critical – Alarms shall be enabled for reporting and shall require operator acknowledgement. A reporting action shall be assigned. A return-to-normal notification shall be received at the head end but shall not require acknowledgement. Escalations shall be configured. All alarms shall be historically archived to the alarms database.
- HVAC General – Alarms shall be initially disabled for reporting. If the alarm is enabled, a reporting action shall be assigned, and it shall require operator acknowledgement. A return-to-normal notification is not necessary. Escalations shall not be configured.
- HVAC Maintenance – Alarms shall be initially disabled for reporting. If the alarm is enabled, a reporting action is not necessary and it shall not require operator acknowledgement. A return-to-normal notification is not necessary. Escalations shall not be configured.
- HVAC Energy - Alarms shall be initially disabled for reporting. If the alarm is enabled, a reporting action shall be assigned, and it shall require operator acknowledgement. A return-to-normal notification is not necessary. Escalations shall not be configured.

All enabled alarms shall be historically archived to the alarms database.

## ALARM REPORTING ACTIONS

Reporting actions are notifications through various platforms in order to elicit a response from facilities staff and service contractors. Reporting actions shall be configured as needed and the commissioning authority and owner shall have final approval on all alarm setup and activation.

Examples of reporting actions are as follows:

- Alarm Popup: A pop-up window shall display on the front end computer screen.
- Email: An email shall be sent to a user or user group
- Text: A text message shall be sent to a user or user group
- Alphanumeric Page: A pager message shall be sent to a user or user group
- Print: The alarm shall be sent to a print service. This can either be a physical printer which prints to a spool of media, or a virtual print service which appends a file.

- 3<sup>rd</sup> Party Database Write: The alarm information shall be sent to a software platform residing in the cloud or on another server. An example might be a maintenance dispatching service or an analytics platform
- Run an External Program: An external program can be run upon activation of the alarm. A typical example is a sound being played through the computer's speakers or a light illuminating.

## **ALARM TEMPLATES**

All alarms shall be configured so that the operator can easily determine the source of the alarm. Each alarm reporting action shall contain the following information:

1. Building code
2. Equipment Code
3. Alarm Name
4. Alarm Details
5. Timestamp
6. Link to the source equipment within the BAS

## **ALARM ESCALATIONS**

Alarms reporting actions shall have the ability to escalate if the alarm has not been acknowledged. Escalations shall have a user definable delay before an additional reporting action is triggered.

An example escalation is as follows:

1. First Notification: The alarm is received at the front end. A pop-up notification is displayed on the operator's screen and a visual indication is shown within the graphic of the equipment. Upon acknowledgement, the alarm, timestamp, and operator acknowledging the alarm are archived to the alarms database.
2. Second Notification: If the alarm has remained unacknowledged for 10 minutes, a text shall be sent to the operators on duty.
3. Third Notification: If the alarm has remained unacknowledged for 20 minutes, a text shall be sent to the manager on duty.
4. Fourth Notification: If the alarm has remained unacknowledged for 30 minutes, a text shall be sent to the facilities director.
5. Etc.



Automated Logic  
Response to **218672306**  
Building Automation Systems  
Request For Proposal  
Virginia Tech

December 2, 2022

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*Section 12: **APPENDIX***

RFP 218672306 BAS – Acknowledged

Sec. 2 Company Financial Information

Sec. 2 Automated Logic Org Chart

Sec. 3 Automated Logic Preventative Maintenance Suite of Services

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Sec. 11 SWaM DGS Form

December 2, 2022

Virginia Tech  
Procurement Department  
North End Center  
300 Turner Street, Suite 2100  
Blacksburg, Virginia 24061

Automated Logic Virginia is pleased to provide this proposal in response to:

**REQUEST FOR PROPOSAL 218672306  
FOR  
BUILDING AUTOMATION SYSTEMS (BAS) PROGRAM**

Our proposal is based upon the following:

- **Request for Proposal dated November 1, 2022**

Following this letter you will find one (1) complete proposal package. It is Automated Logic's intention to provide, as concisely as possible, a response to all items requested in the Request for Proposal. Our approach was to address the information specifically called for in Section VII "Technical Proposal". In many instances, additional information was provided for the purpose of assisting the evaluation team in fully understanding the response if the response might not be clear or if a more in-depth understanding was desired.

Automated Logic provides this proposal in a good-faith effort to comply with the offered RFP. Any errors of interpretation or of a mathematical or typographical nature are unintentional. Additionally, this proposal is offered as a non-binding response. This proposal shall be binding at such time as such clarifications and changes are mutually developed and accepted; it therefore being understood that no order issued pursuant to this proposal shall be binding until duly accepted by an authorized representative of Automated Logic. Issuance of this proposal does not constitute acceptance of any offered terms and conditions.

Please direct any questions, comments or follow-up communications to:

**John D. Adams, Jr.**  
**Automated Logic**  
**4948 Dominion Boulevard | Glen Allen, VA 23060**  
**(804) 864-2086 | Fax (804) 346-9338**  
[John.Adams@carrier.com](mailto:John.Adams@carrier.com)

Thank you for the opportunity to respond to this request.

Sincerely,

A handwritten signature in black ink, appearing to be "JD Adams".

John D. Adams, Jr.  
Senior Sales Engineer, Automated Logic



## BAS Program RFP Sec. 2.a – Firm Description

Automated Logic Corporation provides complete, state of the art energy management and building automation solutions. For over 20 years, ALC has been serving clients across the Commonwealth of Virginia. During that time, we have refined our solutions and services to meet the discriminating needs of our local region and our advanced clientele.

Automated Logic Virginia is headquartered just outside of Richmond in Glen Allen, Virginia. Our construction and service departments are managed from this location; however our technical personnel and resources are distributed throughout Virginia to better serve our clients.

Although ALC serves a wide variety of customers, including the private sector, the vast majority of our clients are institutional in nature. These include institutions of higher education healthcare, state and local governments, local school systems, and detention facilities. During years spent working with a variety of building types and technologies, ALC has developed the means and methods to design and implement building automation solutions that fit the individual needs of each customer.

ALC has provided industry leading building automation solutions for a multitude of projects with a variety of unique needs. Whether it was a campus-wide performance contract for retrofitting controls in 29 buildings, or finding unique solutions that preserve the authenticity of 200 year old buildings, ALC has always risen to the challenge.

Our goal is to be the very best at what we do. In pursuit of this goal, ALC has always sought to hire only the most qualified personnel, provide only the most reliable and advanced products, and work with the best available installation subcontractors. Through these practices, ALC seeks to provide the very best total building automation and energy management solution possible.

ALC has provided hundreds of turnkey building automation solutions. Whether working as part of a construction team on new, out-of-the-ground facilities or providing retrofit solutions when the existing system just doesn't meet the needs of the building, we have a long history of getting the job done.

ALC has the design knowledge, project management experience and technical resources to ensure that your building automation solution is implemented on time, on budget and with outstanding results.

ALC has worked hard to achieve our success the right way. We believe that our own successes must go hand in hand with those of our customers. By guiding our firm with this philosophy, ALC has achieved consistent growth over the years. We hope that the University of Virginia will become a part of our continued success.

Automated Logic and Automated Logic Contracting Services are a division of the HVAC services portfolio of Carrier. Carrier employs over 58,000 people in three distinct divisions across 160 countries. Total sales in 2021 were \$20.6 Billion Dollars with the HVAC division contributing 54% of the total reported sales. Please see the financial information attached to this response for additional details.

**NOTE:** The attached organizational chart in Section 12 indicates (highlighted in orange) all personnel that will be directly responsible for the execution of Virginia Tech projects and service support. Additionally, all personnel that are available for Virginia Tech project work and support (highlighted in yellow) are also provided. These additional personnel will be utilized on an as-needed basis dependent upon projected and/or active Virginia Tech project load and service support needs.

## BAS Program RFP Sec. 2.a.2 – Resources Commitment to Virginia Tech

ALC directly employs Project Engineers, Project Managers and Field Technical Services. Our Project Engineers are responsible for the application design of hardware components and the development of the customized software for each controlled system. Although the Project Manager's primary role and training is focused on financial, contract and installation management, they are also trained on the Automated Logic system to the extent that they can assist in startup, commissioning and technical troubleshooting. Our Field Technicians are the lead technical support for the startup, checkout and commissioning of the system. ALC utilizes local, prequalified electrical subcontractors who specialize in the installation and termination of Building Automation Systems. This provides ALC and the customer scalability, superior quality installation and cost efficiency for our projects in an area that generally requires the largest investment in manpower. Following are organizational charts and resumes for personnel in the areas of Project Engineering, Project Management, Field Technician, and Service Management and Technicians that would be specifically focused on Virginia Tech projects.

Automated Logic maintains a staff of over 30 full time employees who operate out of our Richmond office. Several of these employees are located in the central and western parts of Virginia and are dedicated to supporting our customers in those areas. Additionally, there are numerous staff members in our Greensboro, NC office who are well positioned to provide support on an as-needed basis.

Automated Logic also enjoys the support of our SE regional hub for administration support, general management, and supplemental engineering services. All in, there are over 100 full time technical staff members in the immediate region who stand ready to support Virginia Tech.

It is important to note that all of the staff supporting Virginia Tech, including senior leadership and engineering, would be US based. We do not send projects overseas for design development or programming. The engineers for your projects will be local, and available.

ALC is a fast growing company, and our numbers are regularly increasing. In the past few years, we have taken on mission critical projects for a large technology company. These projects, based in a remote and underdeveloped part of Virginia total several million dollars of automation work each year. Despite taking on the first of these large opportunities with no extant resources in the area, we quickly we quickly built a team of project management and technical professionals. In our work on that site, we have never missed a deadline, and have never lacked the staff to complete our work with a high level of performance.

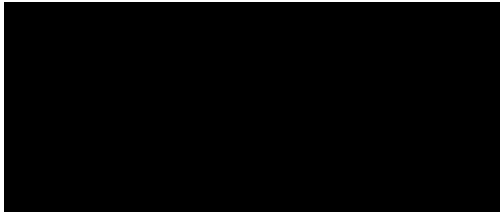
We anticipate that should we be selected to partner with Virginia Tech, we would do the same in the Blacksburg area. We feel that if we can build a team in an area with no existing technical labor pool, that we can certainly do so in southwest Virginia. After all, our area sales manager, area operations manager and regional engineering manager are all Virginia Tech alumni. We know where to go to find great engineering and technical talent.

## BAS Program RFP Sec. 2.a.3 – Price Catalog

ALC has provided a price catalog and discount schedule under Attachment B of Price Proposal which has been submitted under separate cover, as required by provisions of this RFP

## BAS Program RFP Sec. 2.b – Service Contract References

### Radford University



### **3 year Service Contract consisting of the following services:**

#### SOFTWARE UPGRADE OPTION

- Automated Logic - Virginia will, under the terms of this agreement, provide and install software upgrades, as made available by the manufacturer, for applicable components of the building automation system itemized in EQUIPMENT LIST I.
- Coverage will be for the duration of this agreement.
- Software upgrades apply to previously purchased software features only. New features or software packages will be invoiced accordingly once authorized by the customer.

#### TECHNICAL ASSISTANCE

- Automated Logic - Virginia will provide telephone assistance during normal business hours on an as needed basis in helping resolve problems, suggest actions, etc. with operation of the building automation system.
- Manufacturers' technical publications, notices, datasheets, etc. pertaining to those components in EQUIPMENT LIST I will be furnished to the customer on an as needed basis.
- Automated Logic - Virginia will provide training to the customer's staff during the regularly scheduled A. SUSTAINABILITY ANALYSIS visits. Alternately, training can be scheduled by the customer at our facility for appropriate members of his staff. Training will include topics identified by interrogations made to the building automation system as described above. Additional items identified by the customer's staff pertaining to system operation, system capabilities, data entry and utilization of the building automation system will be addressed.
- Coverage will be for the duration of this agreement.

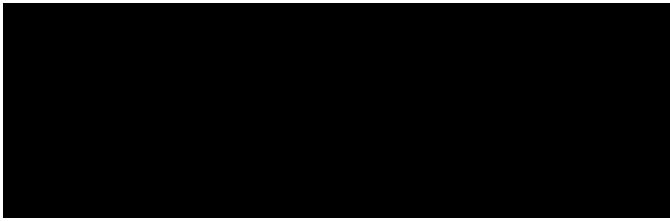
#### 24-HOUR DISPATCH SERVICE

- Automated Logic - Virginia will provide a 24-hour telephone access number to be used by the customer for after-hour emergency contact with our technical support staff.
- Response will be made as soon as possible, but usually no later than two (2) hours after a valid, authorized telephone input.
- No later than the next business day after an emergency call is initiated by the customer, Automated Logic - Virginia will follow up on the emergency request by outlining (1) what was reported as the problem, (2) what was actually found after investigation and/or inquiry, and (3) what was done to resolve and/or stabilize the situation.
- Monthly logs of all emergency service calls will be provided to the customer.
- All labor resulting from a request for emergency service will be invoiced at the labor rates outlined under D. EMERGENCY SERVICE of this agreement.

#### ON-SITE TECHNICIAN

- Automated Logic - Virginia will perform twenty four (24) bi-monthly scheduled service visits limited to eight (8) hours each, to provide assistance and support to the Radford University Automation Manager.

**University of Mary Washington**



**3 year Service Contract consisting of the following services:**

Establishes hourly rates and material pricing for ALC products and services only. VASCUP contract

Automated Logic provides on-demand BAS maintenance, repair, and upgrade services to the university.



**3 year Service Contract consisting of the following services:**

SUSTAINABILITY ANALYSIS

- Automated Logic - Virginia will, under the terms of this agreement, furnish labor and expendable materials necessary to provide the manufacturers' required and/or recommended preventative maintenance on all components of the building automation system itemized in EQUIPMENT LIST I attached.
- Coverage will be for the duration of the contract.
- Calibration and adjustments will be made as needed during regularly scheduled visits.
- Expendable components are defined as lubricants, grease, oil, rags, batteries, fuses, etc. necessary to provide preventative maintenance.
- Records of each maintenance visit will be maintained by Automated Logic - Virginia and made available to the customer on request.

Automated Logic - Virginia will perform two (2) pre-season scheduled service visits limited to forty (40) man hours each, two (2) mid-season scheduled service visits limited to forty (40) man hours each, and eight (8) additional scheduled service visits limited to eight (8) man hours each ( typically one (1) day for each of eight (8) designated months). Labor and expenses for repairs or replacement of components is not included under this section.

SOFTWARE UPGRADE OPTION

- Automated Logic - Virginia will, under the terms of this agreement, provide and install software upgrades, as made available by the manufacturer, for applicable components of the building automation system itemized in EQUIPMENT LIST I.
- Software upgrades apply to previously purchased software features only. New features or software packages will be invoiced accordingly once authorized by the customer.

TECHNICAL ASSISTANCE

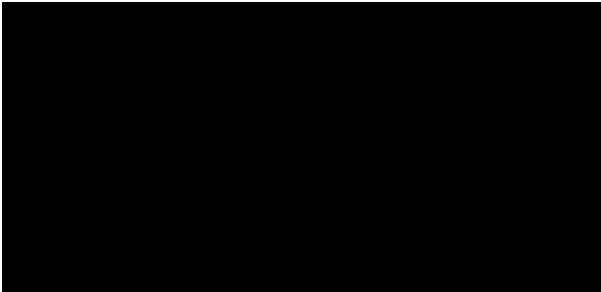
- Automated Logic - Virginia will provide telephone assistance during normal business hours on an as needed basis in helping resolve problems, suggest actions, etc. with operation of the building automation system.
- Manufacturers' technical publications, notices, datasheets, etc. pertaining to those components in EQUIPMENT LIST I will be furnished to the customer on an as needed basis.
- Automated Logic - Virginia will provide training to the customer's staff during the regularly scheduled A. SUSTAINABILITY ANALYSIS visits. Alternately, training can be scheduled by the customer at our facility for appropriate members of his staff. Training will include topics identified by interrogations made to the building automation system as described above. Additional items identified by the customer's staff pertaining to system operation, system capabilities, data entry and utilization of the building automation system will be addressed.

## BAS Program RFP Sec. 2.c – Capital Construction Project References

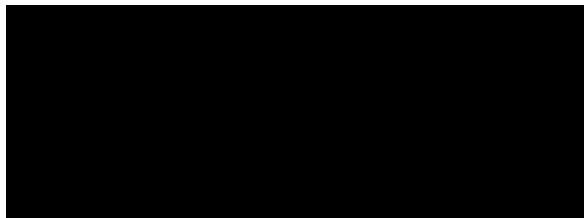
### University of Virginia



### James Madison University



### Radford University



### Project 1

Name: **Battle Children's Hospital**  
Address: **UVA Health Systems**  
Owner's Name: **University of Virginia**  
Architect: **O'Dell & Associates**  
Address: **Charlottesville, VA**

#### Project Description:

**Battle Building is a pediatric facility, with seven floors and 200,000 square feet and house dozens of pediatric specialties, ranging from primary to specialized care in cancer, heart disorders and many other pediatric illnesses.**



### Project 2

Name: **Education Resource Center**  
Address: **UVA Health Systems**  
Owner's Name: **University of Virginia**  
Architect: **CO Architects**  
Address: **Charlottesville, VA**

#### Project Description:

**ERC is a medical education resource facility, 46,000 square feet, occupying four floors. The center provides much-needed lecture space and a procedural simulation center for residents and fellows in all departments. As a result, the Education Resource Center will be the only University area dedicated to multi-specialty Graduate Medical Education. It is expected that all departments and professionals in the Health System will use this space for lectures, seminars, and team-based learning.**



### Project 3

Name: **Jepson Science Center**  
Address: **Fredericksburg, VA**  
Owner's Name: **University of Mary Washington**  
Architect: **Commonwealth Architects**  
Address: **Fredericksburg, VA**

#### Project Description:

**Renovation and addition to existing Science Center, providing a significant increase in research space and collaboration areas.**





#### **Project 4**

Name: **School of Allied Health Professions**

Address: **Richmond, VA**

Size of Project: **154,000 sq ft building**

Owner's Name: **Virginia Commonwealth University**

Architect: **EYP**

Address: **Richmond, VA**



#### **Project Description:**

**The 154,100-square-foot Allied Health building consolidated 14 existing undergraduate, masters, and doctorate degree programs & house a new health-related sciences major. The project is located in downtown Richmond, Virginia, and completed in June, 2019.**

#### **Project 5**

Name: **Ivy Mountain Musculoskeletal Center**

Address: **Charlottesville, VA**

Size of Project: **3 Story, 195,000 sq ft building**

Owner's Name: **University of Virginia**

Architect: **Zimmer Gunsul Frasca**

Address: **Charlottesville, VA**



#### **Project Description:**

**The Ivy Mountain Musculoskeletal Center resides on the site of the former Kluge Children's Hospital on Ivy Road. The 195,000 square foot building will relocate all UVA Orthopedic clinics into one location and includes the new UVA Sports Medicine Center, a joint replacement surgery suite and recovery unit, an imaging center and an education conference center. The project completed in December, 2021.**

#### **Project 6**

Name: **A3 CISAT Lab Renovation**

Address: **Harrisonburg, VA**

Size of Project: **90,000 sq ft building**

Owner's Name: **James Madison University**

Architect: **N/A Owner Direct Project**

Address: **Harrisonburg, VA**



#### **Project Description:**

**The 90,000-SF state-of-the-art academic/research facility houses teaching, research and technology resource space for biotechnology and related interdisciplinary programs. The Bioscience Building is open to more than 800 undergraduate biology majors at JMU. The biology department at the University focuses on undergraduate research and, therefore, facility areas include four special interactive media classrooms and 13 instructional labs devoted to hands-on learning and experience in multi-disciplinary subjects, including an animal facility and research greenhouse. The project was completed in October, 2021.**

## BAS Program RFP Sec. 2.d – Comparable Pricing, Terms, & Warranties

Automated Logic Virginia has committed to providing Virginia Tech pricing, terms, and warranties comparable to, or better than, any terms currently offered to any of our existing customers.

## BAS Program RFP Sec. 2.e – Planned SWaM Utilization

While Automated Logic Contracting Services is not a DBME registered small business, we have a proven record of using small, women, and minority owned business wherever practical. Also, as a traditionally second tier subcontractor, ALCS is not required to report small business participation, however, we strive to meet the stated small business participation goals on every project that has them.

As part of a standard building automation project, there are multiple areas that ALC performs exclusively with subcontractors. Electrical installation, mechanical installation, and panel building are all key portions of the overall project that we regularly subcontract to DBME certified contractors.

Typically, anywhere from 35 - 45% of a project is electrical install. An additional 2-5% is panel building. Often, with retrofit projects, ALC will provide turnkey mechanical services as well. This can include valve replacements, small equipment replacement or modification among other activities. This work can account for up to 45% of a total project budget.

Following is a representative list of projects with small business participation:

- UVA Ivy Mountain Musculoskeletal Center – 40% Small Business Participation
- VCU School of Allied Health Professions – 40% Small Business Participation
- UVA Battle Childrens Hospital – 35% Small Business Participation
- JMU A3 CISAT Lab Renovation – 40% Small Business Participation

## BAS Program RFP Sec. 3 – Service Personnel Resumes

**Name:** Damion Nash  
**Position/Role:** Southeast Service Area Manager  
**Experience:** 20+ years (Automated Logic)  
**Education:** [REDACTED]  
EPA Certified Universal

**Previous related work:** Projects of varying complexity to include large/complex chilled water and hot water plants, variable air volume AHU systems, laboratory spaces, net-zero energy metering/monitoring, chilled beam systems, water-source heat pumps, Data Centers with both DX and evaporative cooling systems, energy conservation. Specialize in BAS retrofit solutions and applications.

**Specific Project References:**  
Oversight of all ALC Service projects with the following customers:  
University of Virginia, University of Mary Washington, Lynchburg University, Arlington County Public Schools, Henrico County Public Schools, Stafford County Government, Elon University, Davidson College, Winston-Salem Forsyth County Schools, Highwoods Properties, Charlotte-Mecklenburg Schools, CISCO, SAS, Cyrus One, ATT, Bank Of America, Georgia Tech University, Duracell, Blue Cross Blue Shield, Coca Cola, Emory, University of Central Florida, Lockheed Martin, Valencia College, Orange County, Norfolk Southern, ADP, Kennesaw State University

**Name:** Trevor Krischan  
**Position/Role:** Service Area Manager  
**Experience:** 5 years – Service Training & Management  
**Education:** [REDACTED]

**Previous related work:** Projects of varying complexity to include ice/heat recovery/high-efficiency chilled water systems, hot water plants, variable air volume AHU systems, laboratory spaces (including BSL), variable refrigerant flow systems, and other typical HVAC systems

**Specific Project References:**  
Oversight of multiple service projects with the following customers:  
Lockheed Martin, University of Toledo, Wayne State University, Oakland University, Owner Community College, Genoa School District, Gibsonburg School District

**Name:** Thomas Yackanin  
**Position/Role:** Southwest Virginia Lead Systems & Support Engineer  
**Experience:** 5 years - Controls Tech & Service Manager (ESI)  
10+ years – Master & Lead Controls Technician (Automated Logic)  
**Education:** [REDACTED]  
**Certifications:** Virginia Electrical Journeyman’s License  
**Previous related work:** Projects of varying complexity to include ice/heat recovery/high-efficiency chilled water systems, hot water plants, variable air volume AHU systems, laboratory spaces (including BSL), variable refrigerant flow systems, and other typical HVAC systems

**Specific Project References:**  
University of Virginia – Darden School of Business, Gilmer Hall Renovations, Ivy Mt. Musculoskeletal Center, Battle Children’s Hospital, MR-5  
Radford University – Kyle Hall (DCOBE), Reed & Curie Hall Renovations  
VCU – College of Health Professions  
JMU – CISAT A3 Lab Controls Upgrade Renovation

**Name:** Jonny Kendrick  
**Position/Role:** Lead System Specialist  
**Experience:** 5 years – Lead Controls Technician (Automated Logic)  
**Education:** [REDACTED]  
**Previous related work:** Projects of varying complexity to include heat recovery/high-efficiency chilled water systems, hot water plants, variable air volume AHU systems, laboratory spaces (including BSL), variable refrigerant flow systems, and other typical HVAC systems

**Specific Project References:**  
University of Mary Washington – Seacobeck Hall, Jepson Science Center, Maury Hall, Virginia Hall  
VCU – College of Health Professions  
T-Mobile Data Center

**Name:** Karol Staniewicz  
**Position/Role:** Master System Engineer  
**Experience:** 15+ years – Master & Lead Controls Technician (Automated Logic)  
**Previous related work:** Projects of varying complexity to include ice/heat recovery/high-efficiency chilled water systems, hot water plants, retrofit applications, variable air volume AHU systems, laboratory spaces (including BSL), variable refrigerant flow systems, Data Centers with both DX and evaporative cooling systems, and other typical HVAC systems

**Specific Project References:**  
University of Maryland Central Steam Plant  
Verizon Data Center New York Stock Exchange  
NSA – Data Center and Navel Research Facility  
Georgetown University – Research Center  
New York University College of Dentistry  
Columbia University – Various Projects

**Name:** Jerry Dement  
**Position/Role:** Lead System Engineer  
**Experience:** 30 years - Controls Tech & Project Engineer (Johnson Controls)  
5 years - Lead Controls Technician (Automated Logic)  
**Previous related work:** Projects of varying complexity to include ice/heat recovery/high-efficiency chilled water systems, hot water plants, retrofit applications, variable air volume AHU systems, laboratory spaces (including BSL), variable refrigerant flow systems, Data Centers with both DX and evaporative cooling systems, and other typical HVAC systems

**Specific Project References:**  
University of Mary Washington - Recommissioning  
Bridgewater College – Campus Renovation  
Virginia Commonwealth University – Medical Hospital  
Cyrus One Data Center – Chilled Water Plant Upgrade

## BAS Program RFP Sec. 4 – Software Tools

Automated Logic's WebCTRL® operating system was developed with ease of use as a primary concern, and the result is a system that can easily be configured and maintained by your facilities staff. All of the necessary software for system setup and modification is available to you as part of your standard WebCTRL® package. Unlike with most vendors, you do not have to purchase additional licenses to have access to this level of control. The software tools for programming control sequences and setting up modules are built right into the server.

In addition to WebCTRL®, below is a brief description of the optional available packages in our software suite:

<b>FDD Reporting &amp; Dashboards</b>	The licensable Fault Detection and Diagnostics Reporting add-on allows you to run reports of Fault Detection and Diagnostic (FDD) alarms reported by your WebCTRL system.
<b>Weather v2.5</b>	The licensable hourly forecasting capability extends the capability of the Weather v2.5 Add-on using data from the AccuWeather.com® Weather Service
<b>LDAP Active Directory</b>	The LDAP/AD add-on is a WebCTRL® authentication provider that allows you to log in to the WebCTRL® system using LDAP (Lightweight Directory Access Protocol) or AD (Active Directory®) credentials.
<b>Open Automated Demand Response</b>	WebCTRL® Open Automated Demand Response (OpenADR) add-on provides a non-proprietary open standardized Demand Response (DR) interface that allows electricity providers to communicate DR signals directly to the WebCTRL system. Product certified and listed with OpenADR Alliance.
<b>BACnet Scheduling</b>	The BACnet Scheduling add-on for the WebCTRL® building automation system extends the system's scheduling capability by allowing third-party devices to read and write schedules via the BACnet protocol.
<b>EMS Scheduling Add-on</b>	EMS Software is a resource and space management platform used by higher education and large corporations. This Add-on integrates the EMS Software platform into WebCTRL by retrieving EMS room bookings at configured times and writing WebCTRL OVERRIDE schedules based on those bookings.
<b>MS Exchange</b>	Enables shared spaces that are schedulable in MS Outlook® such as conference rooms to be treated as normally unoccupied and to change to occupied when the space is reserved. This approach saves energy by ensuring equipment runs only when occupants are in the building space.
<b>Trend Export</b>	The Trend Export add-on allows you to specify, manage, and export trend source data to a .CSV file. You can export the files on-demand at any time or at scheduled intervals allowing you to process or

analyze trend data outside of the WebCTRL building automation system.

## BAS Program RFP Sec. 5 – BAS Integration

Automated Logic has significant experience in the integration of existing legacy systems and 3<sup>rd</sup> party equipment. With our full line of integration products, services and solutions, ALC is positioned well to implement 3<sup>rd</sup> party integration of BAS systems and equipment. With over 300 different integration protocol drivers, we cover a wide range of possible building systems.

As Virginia Tech has multiple facilities with varying editions of legacy BAS hardware and operating systems and protocols, the first step in integrating existing legacy BAS systems is conducting a detailed survey of the existing system, to include protocols utilized (BACnet, LON, P2, etc.), number of individual networks, total number of nodes on each network, and identifying total point counts of the system(s) to be integrated and action (Read/Write or Read Only).

After discovery, a detailed plan is formulated to provide scope of work, scheduling, and total costs involved for the project. ALC will then present solutions to the customer and work to develop a workable execution plan that fits within the customer's budget and time frame.

As all engineering is performed locally, and in-house, ALC has the capability to perform multiple protocol integrations to provide a complete and seamless single pane solution.

We understand that Virginia Tech has a large installed base of Siemen Building Technologies products of varying generations / ages. While the ultimate limiting factor for integrating these systems is the implementation of those systems themselves, and the relative open vs proprietary nature of their existing communications, ALC has developed methods to integrate to Siemens systems for other customers. This may be accomplished via open protocols (BACnet or others) where possible. In systems with proprietary communications, we have partnered with third party suppliers to deploy hardware translation solutions.

All of this is done under the guidance of our local engineering team, with special insight from a former Siemens engineering manager who is a full time member of our regional engineering staff.

Please see Sec. 12 attachments for required hardware and software products.

## BAS Program RFP Sec. 6 – Technical Support

### **Phone Support and 24-7 Support**

Our entire field technical staff is distributed throughout the Commonwealth to ensure a timely response to your service needs and provide telephone assistance during normal business hours on an as needed basis in helping resolve problems, suggest actions, etc. with operation of the building automation system.

ALC has a standard on-call service that supports our customers on a 24-7 basis. A qualified, fully trained technical support person is always available. To simplify the emergency call process, ALC uses an automatic escalation process to ensure that your after-hours calls are addressed in a quick, effective manner.

A single call to the ALC after-hours number starts the emergency response process. At that time, the response system contacts the field support personnel on call. If the call is not acknowledged within a preset time limit, the call is automatically escalated to the Service Operations Manager and then to the Server Department Manager. Within minutes of starting the process, help is available remotely, and if necessary, technical support can be dispatched to the site.

### **Web-Based Support**

Upon approved network access, Automated Logic - Virginia will remotely interrogate the building automation system on an as needed basis. This may include reviewing the operation of mechanical systems, including air handling units, heating systems, cooling systems and individual space terminal equipment controlled or monitored by the building automation system. Access to the building automation system by internet connection is the responsibility of the customer.

### **Additional Support Options**

There would be additional technical assistance and access required if Virginia Tech is seeking access to non-customer specific support case summaries and manufacturer's on-line discussion board along with specific datasheets pertaining to components being developed by Automated Logic. The Technical Assistance proposal included in "Section VII Price Proposal" is offered to provide Virginia Tech additional technical assistance and access to non-customer specific support case summaries and manufacturer's on-line discussion board along with specific datasheets pertaining to components being developed by Automated Logic. This proposal's pricing is included in the separate pricing proposal made part of this RFP.



## BAS Program RFP Sec. 7 – Training

Automated Logic maintains a policy to encourage training for our customers. We feel that we can be of the greatest service to those who fully understand the operation of the system. To that end, training can be scheduled to allow new employees to get up to speed quickly or to serve as a refresher for those who are familiar with the system

Currently, there are three levels of customer training that are offered in the Virginia region. These classes are advertised in advanced by your local branch to make sure that the customer has time to schedule in advanced. On-site and web-based courses are offered in certain situations so customers won't have the expense or lost productivity of week-long trips to an out-of-town training center.

It is important to note that all customer training courses are identical to the training received by Automated Logic Personnel

Please review training options and courses from ALC Training Catalog found in Section 12 Appendix

## BAS Program RFP Sec. 8 – Research and Development

Automated Logic has a strong history of innovation and we are committed to accelerating the development of smart, sustainable and efficient solutions that address our planet's most complex challenges. As we improve our products to anticipate environmental-related regulatory changes, we maintain our focus on developing frontier technologies that can transform healthy, safe, sustainable and intelligent buildings.

Our engineering team is focused on key strategic themes aligned with Automated Logics growth strategy – sustainability, service, digital solutions, all in support of addressing global megatrends, expanding our current markets and growing in adjacent ones. We collaborate with local, regional and global innovation ecosystems, and participate in early-stage innovation with startups, universities, innovation hubs and thought leaders.

Our design process relies on a thorough understanding of the use, performance and longevity of our products. We design with the product lifecycle in mind. We also make continuous improvements to our tools and develop advanced methods to improve quality and reduce time to market. We are investing in new capabilities in systems engineering, sensing and power electronics management, secure network topologies, IOT and Edge computing expansion, Wireless and Blue Tooth Connectivity options, enhancing and expanding serial bus network speeds, wireless, blue tooth and cloud-based services and early stage venture activities in emerging technologies.

Central to Automated Logics growth strategy, digital solutions are empowering our employees, enhancing our experiences and enabling top-line growth opportunities. We are committed to leveraging digital innovation for the benefit of our customers, our channels and our colleagues.

Amazon Web Services Inc. (AWS) is our preferred cloud provider, and product teams are deriving insights from data and unlocking customer value by leveraging AWS services for connectivity, artificial intelligence (AI) and machine learning. AWS also has become a collaborator for digital innovation. new market offerings like developing connected devices that improve user experiences and smooth service delivery.

The largest opportunity for GHG reductions is within the design and use of our products. While we are focused on driving emissions reductions, increasing energy efficiency and promoting sustainability, we are also exploring opportunities and enacting strategies across our product and service lifecycles, from the materials we use to end-of-life management.

ALC continues to develop solutions and technologies that reduce energy consumption and GHG emissions of our products in use. And we are actively engaged with regulatory authorities, trade associations and other stakeholders, working collaboratively to pursue and implement industry-wide policies and initiatives that drive sustainability by promoting greater energy efficiency and lower GHG emissions.

We have consistently invested in energy-efficient technologies and solutions to assist our customers in lowering energy demand and associated GHG emissions and measure the results from these investments.

Our service businesses are also providing customers with opportunities to reduce their own emissions through the reduced consumption of electricity, natural gas, propane, steam and other energy sources, and the use of combined heat and power plants to efficiently generate electricity and thermal energy. We will continue to develop and enhance our IntelliSuite family of digital products to include Internet of Things (IoT)-enabled solutions to digitally transform building and equipment operations, in supporting customers by using data insights to help drive optimal equipment performance. In 2020, one of our digital services delivered over half a billion kWh savings to customers – equal to the GHG emissions avoided by switching more than 15 million incandescent lightbulbs to LEDs.

## BAS Program RFP Sec. 9 – Cybersecurity

Protecting our company, employees and customers begins with our Cybersecurity team, a part of our Digital Technology organization, which advances a cyber-defense strategy seeking to detect, mitigate and respond to cyberthreats. Automated Logic has built a forward-looking program comprised of industry experts to continually improve cyber capabilities and processes. We conduct regular assessments to validate defensive measures, employing a comprehensive risk management framework to enable effective escalation and management

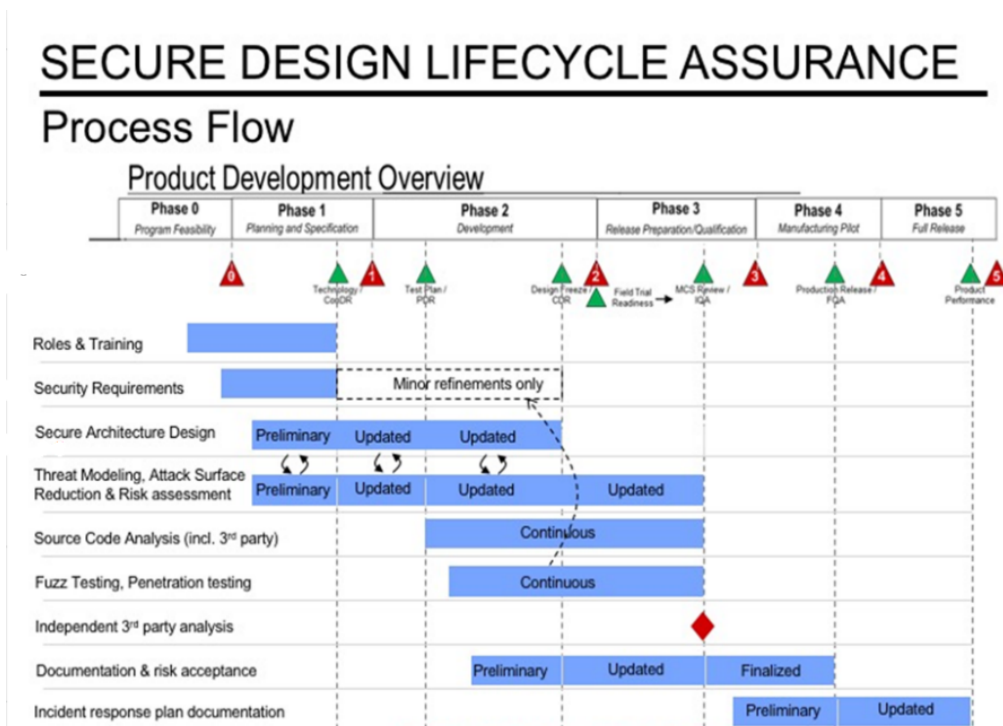
To ensure the security posture of Automated Logic products, we employ domain experts to design for security and continuous improvement. We proactively apply the appropriate methods and controls throughout the development and product support lifecycle. Rigorous testing and analysis in production follow international standards of cybersecurity assurance and Automated Logics requirements for customer mission success.

### Automated Logic WebCTRL Information Security v8

Automated Logic Corporation (ALC) employs a rigorous software development lifecycle management process (SLDC) that is predicated on an agile framework-based development method. It consists of 6 general phases which are continually cycling from sprint to sprint. Those phases are:

- Requirements Gathering
- Design
- Development
- Testing
- Deployment
- Review

This process has been enhanced by a security assessment step at each phase and is demonstrated in the diagram in Figure 1 below:



**What security testing is done as part of the SDLC (e.g., SAST, DAST) and what is the scope of that testing (e.g., hardware, software, firmware)?**

WebCTRL source code is subjected to source code analysis and independent third-party penetration testing as part of our software development lifecycle process.

All third-party libraries are scanned for known vulnerabilities.

All firmware source code is subjected to source code analysis and independent third-party penetration testing as part of our software development lifecycle process.

All firmware is digitally signed, and our hardware does not allow unsigned firmware updates.

Testing is done in house (SAST) as a part of the standard test and validation process as well as by 3d party penetration testing applications (DAST).

**How does ALC ensure any open source software used in WebCTRL is up to date and free from vulnerabilities?**

All third-party libraries are scanned for known vulnerabilities.

The WebCTRL server application uses its own built-in web server engine based on a locked-down version of Apache Tomcat. This greatly reduces the chance of an undiscovered Apache Tomcat vulnerability.

The WebCTRL server application does NOT use Microsoft's IIS web server.

The web server renders only WebCTRL pages. It cannot be used as a general-purpose web server to render pages from other systems on the building network.

All database queries use a single internal interface that protects against common SQL injection attacks. As of v6.0, this includes Write to Database alarm actions.

As of v6.0, the WebCTRL server application no longer uses Java® Applets or Java Web Start which have been the source of Java vulnerabilities to desktop computers.

As of v7.0, the WebCTRL server application will, by default, allow only add-on applications provided and signed by Automated Logic®. You can remove this restriction, but any add-on application not provided by Automated Logic® should be carefully reviewed for source and content before using with the WebCTRL server application.

**How long does it normally take for updates in open source software to be incorporated into your WebCTRL? (e.g., open source update -> product update time)**

Each new version of WebCTRL incorporates the latest version of Java and embedded Tomcat web server along with all associated security enhancements and fixes. Typical new version cycle is 12-18 months.

In between major version releases, cumulative updates are released every 3-6 months. They contain a collection of various bug fixes and security fixes and enhancements.

For emergency security fixes, individual vulnerability addressing patches are released as needed.

Security vulnerabilities are dispositioned with the highest priority within the sustaining team and are addressed as soon as the vulnerability is identified. Depending on the complexity of the issue, the time to release can vary

to allow for appropriate development and regression testing time. Typically, the patches are delivered in a matter of days or weeks.

Identifying security vulnerabilities is taken very seriously and in addition to internal testing and 3<sup>rd</sup> party testing, we also publicly encourage our users and the general public to submit any findings they come across.

To that end we provide a public web site where anyone can submit security concerns about our products.

[https://www.automatedlogic.com/Pages/Security\\_commitment.aspx](https://www.automatedlogic.com/Pages/Security_commitment.aspx)

#### **How do you prevent malware from entering WebCTRL from your suppliers?**

All software development is done either by in-house developers or by pre-authorized outside subcontractors.

All source code goes through the same security assessment and testing before it is included in the product.

#### **Are there 3<sup>rd</sup> party penetration tests performed against WebCTRL? If so, how are the findings addressed in SDLC and re-evaluated?**

Yes, there are multiple, different 3<sup>rd</sup> party penetration tests performed on all software and firmware products.

Some are software security penetration tests and others are performed by contracted 3<sup>rd</sup> party security companies which specialize in software security testing.

Before any product, or product update, is released, all high and medium findings are addressed, and all low findings are evaluated and addressed if deemed applicable or important.

After the identified issues are addressed, the product goes through the testing process again to ensure that the applied fix has sufficiently addressed any vulnerability before it is released to distribution.

**ALC does not release vulnerability or penetration testing results.**

#### **3<sup>rd</sup> party ICS security compliance/certification (e.g., ISASecure, ISA/IEC 62443) for products/systems include:**

Cyber security Gap Assessment performed on our products and methodologies follows the Open SAAM (Open Source Software Assurance Maturity Model) model.

We are compliant with the DoD RMF standards.

We follow the NIST SP 800-53 Rev 4 standards.

We are CFR 21 Part 11 compliant.

Any additional and specific certifications a customer requires can be pursued on a case by case basis.

#### **If WebCTRL was attacked by ransomware, how would WebCTRL be recovered back to an operating state?**

Base application can be easily re-installed on a new server instance and the full functionality can be quickly restored from the system file and central database backups.

Field devices do not require the server to function. If the server was off-line or unavailable, visibility into and the ability to make changes to the system would be unavailable, but the controls would operate as designed.

All controllers have their own memory, onboard clock and ability to run independently of the server.

Additionally, with VM snapshotting capability or a 3<sup>rd</sup> party high availability and disaster recovery solutions, the ransomware, DOS attacks or other, non-malicious failures can be quickly dealt with.

**How does WebCTRL protect itself from installation of malicious or invalid firmware? (e.g., signed firmware, etc.)**

Only firmware developed by Automated Logic can be loaded into our controllers.

All firmware images are digitally signed and require an exact match and verification prior to a download to a controller.

**How do you prevent reverse engineering of WebCTRL (software, firmware, hardware) to obtain sensitive information such as passwords, keys, algorithms, etc.?**

All database queries use a single internal interface that protects against common SQL injection attacks. As of v6.0, this includes Write to Database alarm actions.

Built-in support for Secure Socket Layer (SSL) communications provides 256-bit encryption for all communications to ensure unauthorized 'eavesdroppers' cannot obtain passwords or other sensitive information passed between the web server and server.

All network traffic between the WebCTRL server application and the browser can be encrypted using a locally created certificate. The WebCTRL software suite offers tools to recreate these self-signed certificates at any time, export to a third-party Certificate Authority (CA) and re-import the signed certificate.

As of v6.0, operator passwords are "salted" and "hashed" using SHA512 and therefore cannot be reversed-engineered and are not exposed if the WebCTRL database is compromised. This also means that Automated Logic® cannot recover lost passwords.

As of v6.0, passwords which the WebCTRL server application uses to access other systems use AES-128 bit encryption. This includes database passwords, hierarchical server passwords, and Email and Write to Database alarm action passwords.

As of v7.0, all patches to the WebCTRL software are signed for authentication and to prevent tampering.

All software and firmware source code is maintained on company owned network servers with strict access controls and access management.

**How do the components in WebCTRL mutually authenticate themselves to protect against rogue devices?**

Native communication protocol for the ALC controls system is BACnet.

For the communication to operate properly, BACnet binding, device mapping and addressing and communication configuration from the physical through the application layers must be precisely managed.

3<sup>rd</sup> party devices can coexist with native controls and we often integrate them into our overall solution.

To prevent unauthorized devices from accessing any information, we have enabled our IP controllers with a BACnet firewall capability which whitelists only the defined and approved devices and prevents all others from interfering.

Additionally, if there are rogue devices attempting DOS style attacks, firmware has built in protection which recognizes invalid communication and ignores it on the network.

Additionally, we are developing, and will soon have full support for BACnet SC, which will allow for a full end-to-end encryption for all BACnet communication on both the IP and serial communication networks

**In the event of a failure in any component of WebCTRL, do the field systems operate in a “fail safe” mode?**

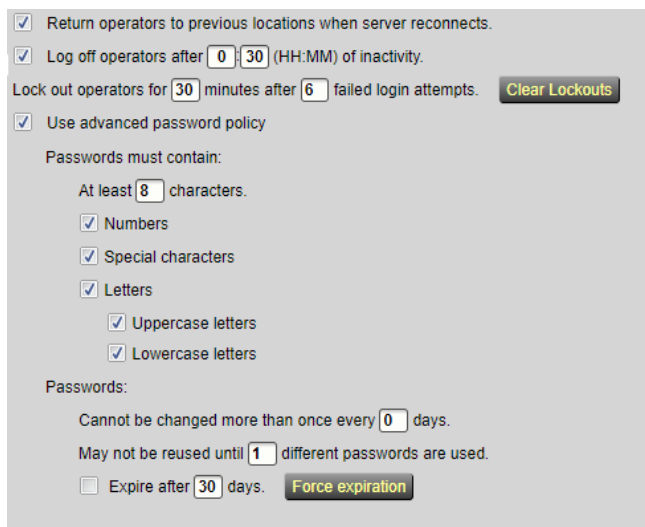
All controllers and control programs are designed to have a minimally acceptable operating capability in the case of server, communication or component loss.

Controllers have their own memory, non-volatile storage, internal clock and programming which allow them to operate independently from the WebCTRL server and other network accessible devices.

All I/O is configured to fail in an acceptable way. Inputs fail to a value which will have a minimum negative impact to the system operation and outputs are configured and wired to fail in the most acceptable operating state.

**Does WebCTRL support secure password practices? (no default passwords, password length and complexity, password secure storage, password rotation, etc.)**

Local passwords allow for strong password enforcement (minimum length, character types etc), minimum and maximum password age, number of unique passwords, expiration periods etc. (from System)

The image shows a screenshot of a web-based configuration interface for password policies. It features several checkboxes and input fields. At the top, there are three checked options: 'Return operators to previous locations when server reconnects.', 'Log off operators after 0:30 (HH:MM) of inactivity.', and 'Lock out operators for 30 minutes after 6 failed login attempts.' A 'Clear Lockouts' button is visible to the right of the lockout settings. Below these, the 'Use advanced password policy' checkbox is also checked. Under the heading 'Passwords must contain:', there are several checked options: 'At least 8 characters.', 'Numbers', 'Special characters', 'Letters', 'Uppercase letters', and 'Lowercase letters'. At the bottom, under the heading 'Passwords:', there are three settings: 'Cannot be changed more than once every 0 days.', 'May not be reused until 1 different passwords are used.', and 'Expire after 30 days.' with a 'Force expiration' button next to it.

**Does WebCTRL support Active Directory for identity management (credentials)? If so, then is this via direct AD access or is it based on synchronizing with AD?**

Optional LDAP integration is available. LDAP integration add-on allows WebCTRL operators to be authenticated against a local instance of LDAP. This is accomplished through an LDAP connection. AD credentials are not stored locally. Integration is used for authentication only and once the session is authenticated, the connection to the LDAP server is ended and no local caching is done. Privileges within the system are managed inside WebCTRL. LDAP integration is used for authentication only. Typically, we require information about the LDAP server, including the encryption and authentication types, search strings, server URL and password.

**How are access to HMI and process models secured? What controls are proposed to prevent injection of invalid inputs to running process models (e.g., between HMI and PLC's)?**

HMIs can have open and password protected screens depending on the screen functionality. Multiple levels of access can be configured as needed. The screens themselves are defined with a finite functionality and they cannot be altered outside of the system. The HMI itself doesn't hold the information about the interface. It is a part of the controller image and as such can only be changed remotely by an authorized operator. HMIs themselves run custom firmware which is digitally signed and cannot be tampered with.

**Does the WebCTRL architecture segment the network by logical type as in the Purdue model (e.g., field network, supervisory network, management network, enterprise network) and implement a "default deny" between logical network zones?**

Each system is unique, and the network design reflects that reality. As a rule, there is a separation between the field devices, servers and operators. Controllers can perform a whitelisting BACnet firewall which can be configured in a default deny model. Internal customer requirements typically drive the network design and separation. The system can comply with multiple subnet setups, firewall and traffic management solutions and various other network security requirements. Because of its base structure, it is easy to set up firewall rules as the controllers and the server only use a handful of specific protocols.

Port	Transfer	Protocol/User	Use
80 (default) **	TCP	http (Web server)	Client/Server
443 (default)	TCP	https (Web server)	Client/Server
47806 (default)	TCP	Alarm Notification Client	Client/Server (optional)
47808	UDP	BACnet/IP	Server/Gateway
47808	TCP	Diagnostic Telnet *	Client/Server

*\*disabled by default \*\*can be disabled or configured for auto redirect to https*

**Is the field network hardened against anything from simple scanning to Denial of Service attacks?**

Yes, controller firmware has built in logic which recognizes both malicious and accidental DOS traffic. It continually scans the traffic and on a ¼ sec interval recalculates if the traffic is valid or not.

If the traffic thresholds are exceeded, the excess communication is ignored until the next calculation period is reached. This method prevents the controller from having its operation affected by the DOS attack. While the communication may be affected, the controller itself and the program execution remains unaffected.

**Does the field network utilize encrypted field protocols (e.g., "Modbus/TCP security", "BACnet/SC", vendor proprietary encrypted protocols, etc**

The current standard protocol is BACnet. We are currently in the process of developing BACnet/SC and have released Cloud base iterations and In the near future, the full BACnet/SC capability will be available.



Automated Logic is one of the founding members of BACnet international and some of our personnel are on the committees which have helped define the BACnet/SC standard. We are fully committed to having the full support throughout our product line.

**Does WebCTRL use devices such as firewalls or data diodes to ensure field network traffic flows only in designed direction? (e.g., to prevent attacks originating from the field network or malicious field traffic spoofing/injection)**

Our network devices provide a built in BACnet firewall on the IP level which can provide a clear whitelist of all devices which are allowed to communicate to the ALC controllers.

A lot of the communication is bidirectional by design, but in those instances where it is not allowed to be, we are compatible with all network security devices which manage the network communications.

**Does WebCTRL utilize any wireless technology? If so, how is Denial of Service (e.g., via jamming) mitigated?**

Wireless communication is typically limited to non-controlling and non-critical, monitoring only temperature and RH sensors. These sensor networks are typically air gapped and do not have direct connection to the rest of the controls system. They are generally provided by a 3<sup>rd</sup> party and can be evaluated from a security perspective on a case by case basis.

**What logging/monitoring capabilities are included in WebCTRL? Can logs be ingested into a SIEM (security event monitoring system)?**

WebCTRL has a full audit log, application log and integrated alarming covering both the system and field alarms.

Audit log is stored in a relational database and automated reports can be scheduled and generated in PDF, and CSV formats.

Reports can also be retrieved via an XML/SOAP web service.

All application logs are in a fixed location on the server in a plain text format and can be retrieved by a 3<sup>rd</sup> party.

Security audit log tracks every system login, change and action based on user credentials, time/date stamp and objects changed including the prior and new value state.

**Are there standards-based ways (e.g., JSON/XML over REST/SOAP API) to obtain point data and alarms from WebCTRL so that devices need not be directly polled?**

Devices are not polled for alarms. They deliver alarms directly to the server when they occur.

The server can perform many different reporting actions when an alarm arrives including a web service based (json PUT or POST) action to write a pre-formatted XML payload to a web service listening for a message.

Additionally, e-mail reporting action as well as direct writes to a standard relational database can be performed.

**Does WebCTRL include a historian? If so, where in the network architecture is it located? How is it secured?**

Yes. Each controller has on-board memory which stores a limited amount of trend history. Trend can be configured for any analog or binary value in the system. For values which need to be stored long term, trends can be configured to deliver data to the WebCTRL server for the long-term storage in a database.

Trends can be configured for sample rate or COV sampling. Thresholds are configured for typically 40% of the overall controller buffer before the payload is sent to the server for storage.

Server will hold the trend data in the database for a user configured period. This period is limited by the disk space on the database server and not in any other way.

Historian data is stored in a binary blob data type and is digitally signed to prevent external manipulation. This data can be exported for use by a 3<sup>rd</sup> party in a variety of different ways.

**Describe any external network access required (e.g., Internet, dialup, VPN) for installation, normal operation, support, upgrades, and patching of the solution.**

Typical configurations will be on-premise

Our access to the system is determined by the customer. Remote access, if permitted, is typically via a VPN or an SSL remote access solution which allows a 2-factor credentialed access to the system.

Different users require varying levels of access. For standard operator access, a simple https access to the front end is sufficient.

Advanced access is necessary for significant system changes, patching and updates / upgrades. In this instance, remote desktop access to the server may be needed for a limited number of users.

Operators within the system are defined in a way which determines their level of access and are controlled via owner defined privilege sets.

Number of users in the system is unlimited, thus enabling every user to have a unique set of credentials which are never shared.

**For on-premise installation, upgrades, and patching, how will any necessary data be “cleansed” when introduced to owner network or devices? (Assume that USB drives are not allowed, and vendor devices cannot be plugged into owner network)**

This process is not pre-determined. We will follow whatever processes the owner requires us to follow. In the past we’ve used approved file transfer services which include file scanning which ensures that the files are free of viruses and malware.

Access type will drive the data transfer method. Direct file copy via RDP session or other remote-control methods has been utilized in the past.

Central “jump-server” options have been utilized as well.

Our solution and personnel are flexible based on the preferred method determined by owner.

Automated Logic is committed to the security of our products, and we investigate all reports of security vulnerabilities. Ensuring against current and potential cybersecurity threats is a critical component of our product development lifecycle.

## BAS Program RFP Sec. 10 – Other Information

Automated Logic is committed to providing the most comprehensive and industry leading BAS system software and hardware systems. Our sole focus is building automation solutions. It is all we do.

All software applications and tools offered to our customers are the same as those utilized by our systems engineers and design engineering staff. We pride ourselves on our transparency and willingness to provide the necessary tools and training for the successful development, implementation, and service of a full BAS system by the end user.

For these reasons, Automated Logic has become preferred suppliers of BAS systems and solutions to the likes of University of Virginia, James Madison University, Microsoft, Google, Apple, and many more.

## BAS Program RFP Sec. 11 – SWaM Information DGS-30-360

ALCS has provided a completed DGS-30-360 form in the Appendix Section of this proposal.

Please refer to Sec. 2.e for planned SWaM utilization.

## BAS Program RFP Sec. 12 – Appendix

RFP 218672306 BAS – Acknowledged

Sec. 2 Company Financial Information

Sec. 2 Automated Logic Org Chart

Sec. 3 Automated Logic Preventative Maintenance Suite of Services

Sec 3 Automated Logic Service Equipment Task List(s)

Sec. 3 Sample Functional Testing Checklist(s)

Sec. 5 BAS Integration Hardware & Software

Sec. 7 ALC Training Catalog

Sec. 11 SWaM DGS Form

**RFP # 218672306, Building Automation Systems (BAS) Program**

**INCLUDE THIS PAGE WITH YOUR PROPOSAL, SIGNATURE AT SUBMISSION IS REQUIRED  
GENERAL INFORMATION FORM**

**DUE DATE:** Proposals will be received until December 2<sup>nd</sup>, 2022 at 3:00 PM. Failure to submit proposals to the correct location by the designated date and hour will result in disqualification.

**INQUIRIES:** All inquiries for information regarding this solicitation should be directed to Bryan Holloway, Phone: (540) 231-8545; e-mail: [bryanh91@vt.edu](mailto:bryanh91@vt.edu). All inquiries will be answered in an addendum. Inquiries must be submitted by 3:00PM on November 14<sup>th</sup>, 2022. Inquiries must be submitted to the procurement officer identified in this solicitation.

**OPTIONAL PRE-PROPOSAL CONFERENCE:** A non-mandatory virtual pre-proposal conference will be held via Zoom on Thursday, November 10th, 2022 at 10:00AM. See RFP Section IX, Pre-proposal Conference for additional information.

**PROPOSAL SUBMISSION:**

**Proposals may NOT be hand delivered to the Procurement Office.**

Virginia Tech has partnered with Bonfire Interactive to create a new procurement portal that will allow you to access business opportunities and submit bids and proposals to Virginia Tech digitally.

**Proposals must be submitted electronically at:**

<https://procurement-vt.bonfirehub.com/>.

Vendors are requested to visit the new Procurement Portal then follow the link to the Bonfire vendor registration page to register your company. Registration is easy and free. If you have any challenges with the registration process, please contact Bonfire Interactive Support at [support@gobonfire.com](mailto:support@gobonfire.com).

**It is encouraged for all vendors to register prior to the proposal submission deadline to avoid late submissions.** Log into your Bonfire Vendor account to access the opportunity and begin preparing your submission. Upon completion you will be directed to your Submission Receipt. Virginia Tech will not confirm receipt of proposals. It is the responsibility of the offeror to make sure their proposal is delivered on time.

For a quick tutorial on how to upload a submittal, visit: [https://support.gobonfire.com/hc/en-us/articles/360011034814-Creating-and-Uploading-a-Submission-for-Vendors-?\\_ga=2.42375717.1472165071.1588110542-997330893.1585332052](https://support.gobonfire.com/hc/en-us/articles/360011034814-Creating-and-Uploading-a-Submission-for-Vendors-?_ga=2.42375717.1472165071.1588110542-997330893.1585332052)

Hard copy or email proposals will not be accepted. Late proposals will not be accepted, nor will additional time be granted to any individual Vendor.

**Attachments must be smaller than 1000MB in order to be received by the University.**

*In compliance with this Request For Proposal and to all the conditions imposed therein and hereby incorporated by reference, the undersigned offers and agrees to furnish the goods or services in accordance with the attached signed proposal and as mutually agreed upon by subsequent negotiation.*



AUTHORIZED SIGNATURE:

Date: December 2, 2022

**[INCLUDE THIS PAGE]**

**I. PURPOSE:**

The purpose of this Request for Proposal ("RFP") is to solicit proposals to establish a contract through competitive negotiations for Virginia Polytechnic Institute and State University ("Virginia Tech"), an agency of the Commonwealth of Virginia.

Virginia Tech seeks to procure one or more experienced firms to provide Building Automation Systems ("BAS") for 1) future, yet-to-be determined projects in various locations at the University and 2) on-demand maintenance and repair services of existing BAS systems. Details describing the scope of the services required can be found in Section VII of this request for proposal.

This request does not intend to describe all aspects of the BAS. Descriptions of the software, hardware, and services associated with the BAS are outlined within this request to ensure that the overall goal of Virginia Tech is achieved. This request therefore, serves only as a guideline to solicit proposals from qualified firms.

For ease of reference, each firm receiving this RFP is referred to as a "Firm" or collectively as "Firms." The Firm(s) selected to provide the BAS for Virginia Tech is referred to as the "Selected Firm(s)." This RFP states the instructions for submitting proposals, the procedure and criteria by which a Firm may be selected, and the contractual terms by which Virginia Tech proposes to govern the relationship between it and the Selected Firm(s).

**II. SMALL, WOMAN-OWNED AND MINORITY (SWaM) BUSINESS PARTICIPATION:**

The mission of the Virginia Tech supplier opportunity program is to foster inclusion in the university supply chain and accelerate economic growth in our local communities through the engagement and empowerment of high quality and cost competitive small, minority-owned, women-owned, and local suppliers. Virginia Tech encourages prime suppliers, contractors, and service providers to facilitate the participation of small businesses, and businesses owned by women and minorities through partnerships, joint ventures, subcontracts, and other inclusive and innovative relationships.

For more information, please visit: <https://www.sbsd.virginia.gov/>

**III. CONTRACT PERIOD:**

The term of this contract is for one (1) year(s), or as negotiated. There will be an option for nine (9) one (1) year renewals, or as negotiated.

If Virginia Tech elects to exercise the option to renew the contract for any additional one-year period, the contract price(s) for the additional year shall not exceed the contract prices of the previous contract year costs increased/decreased by no more than the percentage increase/decrease of the All Items category of the CPI-W section of the Consumer Price Index of the United States Bureau of Labor Statistics for the latest twelve months for which statistics are available or 2.5%, whichever is less, or as negotiated. Price increases will be permitted only at the time of renewal.

**IV. EVA BUSINESS-TO-GOVERNMENT ELECTRONIC PROCUREMENT SYSTEM:**

The eVA Internet electronic procurement solution streamlines and automates government purchasing activities within the Commonwealth of Virginia. Virginia Tech, and other state agencies and institutions, have been directed by the Governor to maximize the use of this system in the procurement of goods and services. *We are, therefore, requesting that your firm register as a vendor within the eVA system.*

There are transaction fees involved with using eVA. These fees must be considered in the provision of quotes, bids and price proposals offered to Virginia Tech. Failure to register within the eVA system may cause the quote, bid or proposal from your firm being rejected and the award made to another vendor who is registered in the eVA system.

Registration in the eVA system is accomplished on-line. Your firm must provide the information. Please visit the eVA website portal at <http://www.eva.virginia.gov/pages/eva-registration-buyer-vendor.htm> and **register both with eVA and Ariba**. *This process needs to be completed before Virginia Tech can issue your firm a Purchase Order or contract.* If your firm conducts business from multiple geographic locations, please register these locations in your initial registration.

For registration and technical assistance, reference the eVA website at: <https://eva.virginia.gov/>, or call 866-289-7367 or 804-371-2525.

**V. CONTRACT PARTICIPATION:**



It is the intent of this solicitation and resulting contract to allow for cooperative procurement. Accordingly, any public body, public or private health or educational institutions, or Virginia Tech's affiliated corporations and/or partnerships may access any resulting contract if authorized by the contractor.

Participation in this cooperative procurement is strictly voluntary. If authorized by the Contractor, the resultant contract may be extended to the entities stated above to purchase at contract prices in accordance with contract terms. The Contractor shall notify Virginia Tech in writing of any such entities accessing the contract, if requested. No modification of this contract or execution of a separate contract is required to participate. The Contractor will provide semi-annual usage reports for all entities accessing the Contract, as requested. Participating entities shall place their own orders directly with the Contractor and shall fully and independently administer their use of the contract to include contractual disputes, invoicing and payments without direct administration from Virginia Tech. Virginia Tech shall not be held liable for any costs or damages incurred by any other participating entity as a result of any authorization by the Contractor to extend the contract. It is understood and agreed that Virginia Tech is not responsible for the acts or omissions of any entity, and will not be considered in default of the contract no matter the circumstances.

Use of this contract precludes no participating entity from using other contracts or competitive processes as the need may be.

**VI. STATEMENT OF NEEDS/SCOPE OF WORK:**

**A. Overview**

Virginia Tech intends to select one or more Firms to provide Building Automation System ("BAS") engineering/installation and/or material on 1) an as-needed basis for new buildings

and systems, and 2) on-demand repair and preventive maintenance services of existing or newly installed systems. The work related to this procurement could be located at any Virginia Tech site. Currently, Virginia Tech's Blacksburg campus has over 200 buildings, of which, over 130 have DDC BAS installed and controlling various mechanical and HVAC systems. Several buildings utilize a combination of pneumatic and electronic controls while a few are completely pneumatic or standalone. Our current building automation system (BAS) consists of several servers for both Siemens Insight and Desigo CC, 700+ field panels, 7000+ terminal unit controllers, 400+ fume hood controllers, 375,000+ points, and over 3,000 graphics. We currently operate our BAS on a private network housed and maintained by Virginia Tech's Facilities Instrumentation, Controls, and Metering ("ICM") shop.

Virginia Tech does not guarantee a minimum volume of work to the Selected Firm(s) due to the nature of when projects take place and when equipment may need maintenance or repair and undetermined future maintenance budgets.

If the Firm can offer tiered pricing for material based on annual quantities purchased, Virginia Tech will consider this approach upon review of the Firm's proposal. The Selected Firm(s) will provide these services:

1. Provide Virginia Tech the capability of having pre-qualified BAS contractors under agreement to submit written proposals, or bids, on an "as-needed basis" for new construction or renovations that include replacing existing BAS.
2. Be available, upon request, to perform minor BAS work, promptly, to ensure that Virginia Tech's peak workload and high priority requirements for controls can be maintained in good working order.
3. Provide on-demand maintenance and repair work on BAS systems in a competent manner to maintain the quality of educational services and business operations of Virginia Tech and minimize the interruption of such services. See Service Level standards for additional details on response times and expectations.
4. Provide readily available BAS products/ material and software/ licenses to Virginia Tech for in-house design, installation, configuration, and programming.

## **B. Price Proposals and Future Awards**

Specific project price proposals are not part of this RFP because future projects are yet to be determined. However, the Firm is to provide material costs and labor rates per hour within its proposal as listed in **Attachment B – Price Proposal/ Labor Rates & Material Pricing ("Attachment B")**. The rates identified in **Attachment B** shall be the maximum allowed, for both service and construction work, however, Selected Firm may utilize lower rates when pricing work. In addition, the Selected Firm(s) should include any other costs it deems necessary to complete the project when submitting a proposal

Following the conclusion of the selection process and award of Agreements resulting from this RFP, Virginia Tech may periodically issue requests for quotation or Invitations for Bids (IFB) for BAS projects. The Selected Firm(s) may be requested to submit a Proposal/Bid in response to the IFB or request for quotations.

For purposes of construction, including capital construction or renovations, being priced by third-party CM/GCs, Virginia Tech also reserves the right to list the Selected Firm(s) for BAS work in the respective construction project drawings and specifications. Only Selected

Firm(s) may provide a proposal to the CM/GCs or mechanical contractors competing for the project. Alternatively, Virginia Tech may procure the work and assign the work to the CM/GC.

Virginia Tech may use any procurement type (e.g. fixed fee, guaranteed maximum price, etc.) for the procurement of on-demand services contemplated herein. Virginia Tech's designated representative will issue an IFB or request for quotations for each project. The Selected Firm(s) shall submit a written Proposal/ Bid within the time requested. Virginia Tech will base the award on its evaluation process of the Proposal(s)/Bid(s). However, Virginia Tech reserves the right to complete any project with its own forces; reject any proposal; cancel the procurement at any time; or take any action deemed to be in Virginia Tech's best interest. If time for completion of the work is to be a determining factor of award, Virginia Tech will establish the completion date. Once an agreement for the Work has been reached, and the procurement is approved by the Virginia Tech Procurement Department, Virginia Tech will issue a Project Order to the Selected Firm with the agreed upon completion date. The Selected Firm may be required to attend meetings relating to work which they are selected to provide.

Decisions related to awards under capital projects shall be made by the respective capital construction procurement and project staff managing the work.

**C. Preventive Maintenance, On-Demand and Construction Scope of Service**

The Selected Firm(s) shall provide high quality BAS work. This includes prompt response to requests for quotations and completion of projects in a timely fashion (as determined by Virginia Tech) once schedules are established. Virginia Tech will inspect Work in progress, periodically, for adherence to Virginia Tech's quality standards and compliance with project specifications. If Virginia Tech's standards conflict with project specifications or industry best practice, the Selected Firm shall make this known to Virginia Tech, via a written request for clarification to Virginia Tech's procurement office, project manager and/or the Virginia Tech Automation Services group, as applicable.

The Selected Firm shall identify a contract lead that shall be responsible for the day-to-day performance of the Contract ("Contract Lead"). This Contract Lead will have 24 hour per day responsibility for the work performed. Responsibility includes, but is not limited to supervision, scheduling, maintenance, and repair of the BAS and associated controls.

The Selected Firm's Contract Lead shall meet with Virginia Tech representatives at a location directed by Virginia Tech, every month to review reports, maintenance progress, maintenance schedule, repairs and any other topics requested by Virginia Tech. The Selected Firm's Contract Lead shall maintain communication with Virginia Tech representatives, and shall provide the aforementioned responsibilities for all shifts.

Virginia Tech reserves the right of approval and acceptability of the Selected Firm's Contract Lead and any other personnel, including but not limited to, technicians, project managers, engineers, etc. for the duration of the contract. The Selected Firm shall present to Virginia Tech, its candidate for Contract Lead for consideration by Virginia Tech no less than three weeks prior to the start of the Contract.

1. **Equipment Performance Requirements.** All equipment and systems under this contract shall meet the following requirements:
  - a. Shall be installed, maintained and/or repaired as originally specified, designed, manufactured and upgraded.



- b. Materials and parts required for the performance of installation, repair and/or maintenance of this Contract must be of equivalent material, strength and design as originally designed and installed or as specified by Virginia Tech.
- c. All work and materials supplied under this Contract shall be guaranteed against defects for a minimum of one (1) year from the date of final acceptance by Virginia Tech. Any work that is required to be corrected due to the Selected Firm's faulty workmanship, equipment, tools, or materials, shall be done at no additional expense to Virginia Tech.

2. **BAS Preventive Maintenance and Repair Services.** The Selected Firm shall provide all supervision, labor, materials, tools, equipment, insurance and expertise required for the maintenance, service, repair, and testing of the BAS system on a regularly scheduled basis to ensure proper operating condition.

For the purpose of this document, Preventative Maintenance work is defined as the maintenance tasks required to be performed on a regular basis to maintain the BAS in proper operating condition. Preventive Maintenance includes but is not limited to the following:

- Maintaining BAS private network and or provide network support where NI&S maintains the network;
- Perform routine server maintenance and install updates in a timely manner;
- Provide parts and labor for the repair and replacement of electronic components of the BAS;
- Verify panel communication with front-end and field level devices;
- Check/replace panel battery and or UPS where applicable;
- Perform a backup of panel database;
- Check for failed points;
- Check for active alarms;
- Confirm program execution;
- Verify control devices (AOP's, PxP's, etc.); and
- Document all findings in a report provided to appropriate VT representative;
- Inspection, testing, repair, adjustment and replacement of component parts on a regularly scheduled basis, in order to maintain the operating efficiency for the Building Automation System and its components.

The Selected Firm shall perform all preventative maintenance between the hours of 6:00 AM to 6:00 PM, Monday-Friday unless specifically directed otherwise by Virginia Tech. All working hours shall be approved by Virginia Tech in advance. All labor, materials, supplies, tools, equipment, transport, permits, and all incidental items not specified, but reasonably necessary for Preventative Maintenance services, shall be included in the lump sum pricing.

The Selected Firm will be responsible to work with Virginia Tech to identify items that require preventative maintenance on a Monthly, Quarterly and Semi-Annual or other basis.

Once the Selected Firm and Virginia Tech agree to the proposed preventive maintenance items, a preventative maintenance schedule will be created in conjunction with both the Selected Firm and the corresponding department. All Preventative Maintenance work shall be scheduled with Virginia Tech department

representatives in coordination with each academic calendar. Preventative Maintenance shall be scheduled and a copy of the schedule dates shall be provided by the Selected Firm for each year.

During the performance of the preventative maintenance, the Selected Firm will be required to complete preventative maintenance work orders and to produce and complete checklists, for the work, as part of their preventative maintenance process. Checklists and reports are to be furnished to Virginia Tech representatives as preventative maintenance is completed. Checklists shall be approved by Virginia Tech; reviewed annually; and updated to reflect changes in the BAS. All changes to the schedule, preventative maintenance items or check-lists must be approved by Virginia Tech, in writing.

The Selected Firm will also be required to note and report to Virginia Tech any repairs that are needed or made. The Selected Firm shall notify the department designee of any needed repairs and the representative shall generate a work order to document those repairs. Repairs that exceed sixty (60) minutes shall not be completed by the preventative maintenance technician, instead it will be addressed as a Routine Repair (defined below) and repaired by a qualified technician as scheduled with Virginia Tech. If the preventative maintenance technician discovers a repair that does not exceed the sixty (60) minute threshold, but the technician is not qualified to conduct the repair, this repair will be treated as a Routine Repair and scheduled accordingly with Virginia Tech. (Defined below).

The intent of the sixty (60) minute cap is only to differentiate between who completes the repair and not whether the repair is covered under the Contract. A repair that is covered by the Contract and is anticipated to last less than sixty (60) minutes should be completed by the Preventive Maintenance Technician. Otherwise, all Routine Repairs anticipated to 1) last longer than sixty (60) minutes; or 2) is less than sixty minutes and is above the skillset of the preventative maintenance technician shall be handled by an alternate technician so as not to hamper the daily preventative maintenance schedules/requirements.

- a. **Routine Repairs.** Routine repairs, as specified herein, include repairs for all items except those considered non-routine as defined in Paragraph 3 below. Routine repairs shall be performed on a 24-hour, 365-day basis at the discretion of Virginia Tech. Regular working hours are defined as 6 AM to 6 PM Monday-Friday, excluding established Virginia Tech Holidays.

Selected Firm shall provide all labor, supervision, materials, replacement parts, supplies, tools, equipment, transport, travel, shipping, permits, expenses, and incidental items not specified but reasonably necessary for all repairs, replacements and adjustments defined as routine per this specification but necessary to maintain the operation and condition of the BAS included in this contract.

The Selected Firm shall provide documentation to the appropriate designated Virginia Tech Management team at the time any repair is needed.

Virginia Tech's personnel shall confirm the work with a work order number or by email anytime service is needed and in advance of any work performed. If a shutdown is required, the schedule of said work shall be approved by Virginia Tech prior to commencement.

When a repair is complete, the Selected Firm's project manager shall submit a work ticket that includes the time required for the repair and a detailed itemized list of parts used. The work ticket must include the names of the technicians performing the required work along with the confirming work order number.

The Selected Firm shall make every effort possible to complete all repairs within 24 hours. If any repairs cannot be made within 24 hours, the Selected Firm shall notify Virginia Tech's representative within the initial 24-hour period.

In the event of repetitive failures, Virginia Tech reserves the right to bring in another contractor to perform repairs and deduct charges from the contract amount.

Labor and materials provided under "Routine Repairs" shall not be deemed part of the hours per year, per unit required for Preventative Maintenance, unless the need for the repair is discovered during Preventative Maintenance, and that repair takes no longer than 60 minutes. All labor and material costs shall be included in the Preventive Maintenance pricing since there is full coverage and labor is required to be available.

- b. Spare Parts Inventory.** Selected Firm shall provide and maintain a sufficient inventory of genuine original manufacturer's spare parts and components, in order to provide effective maintenance, service and repair under the terms of this RFP. Spare parts are the property of the Selected Firm and as such, the Selected firm is expected to carry the cost of all components and will provide a replacement part for each type of system at their own cost. Spare parts provided by the contractor as specified will be returned to the Selected Firm(s) at the conclusion of the contract. Inventory should include spare parts and components, failure of which could result in extended down time or loss of which could require extended time period for replacement. This inventory of spare parts shall be kept on campus or at a nearby location so that, in the event an immediate need arises, the spare part is available without delay. In order to support the provision of spare parts, Selected Firm shall:

- 1) Store spare parts at a location or locations directed by Virginia Tech. A separate inventory is to be provided for each site. This would currently include Virginia Tech's main campus in Blacksburg, Virginia as well as the Alson H. Smith, Jr. Agricultural Research and Extension Center in Winchester, Virginia and the Marion duPont Scott Equine Medical Center in Leesburg, Virginia.
- 2) Provide approved parts cabinets for the orderly storage of replacement parts.
- 3) Selected Firm shall provide approved UL rated storage cabinet for storage of any combustible materials.
- 4) Provide Virginia Tech with a monthly inventory report of parts. Inventory report should include:

- i. Location of part(s);
- ii. Quantity on hand;
- iii. Quantity on order; and
- iv. Quantity used.

Report shall be reconciled monthly to assure accuracy.

**3. Emergency, On-Demand/Non-Routine Repairs and Upgrades.**

1. **Emergency Services.** Emergency Services, as specified herein, are for responses to emergency calls. Emergency services shall be provided for all BAS including new installations and systems that may be under warranty by others. Any emergency service provided to any system will be billable at the rates outlined in the price schedule.

The Selected Firm(s) shall provide BAS work to meet the needs of Virginia Tech with minimum disruption to the educational, operational, and research mission of Virginia Tech. The Selected Firm(s) should normally plan their work between 7:00 a.m. and 5:00 p.m., Monday through Friday, except established holidays observed by Virginia Tech. Virginia Tech may require work to be performed during off-hours, which will be separately coordinated.

The Selected Firm(s) shall provide emergency service, to include after-hours, as needed and as determined by Virginia Tech Facilities Management. Selected Firm(s) shall respond by phone within thirty (30) minutes and if needed, be on-site within two (2) hours of receiving an emergency call from Facilities Management.

The Selected Firm(s) shall furnish contact information for qualified service personnel who can be reached to respond to an emergency call. Virginia Tech generally defines emergency service as response to failure of the BAS or any of its components where such failure may cause hazard to life or property or have significant business impact as determined by Virginia Tech. Such service may include, but is not limited to Failure of the system to communicate, monitor or control, etc.

The above emergency service shall apply to projects where the Selected Firm has been procured through a CM/GC and/or Virginia Tech-assigned work. Determining an emergency rests solely with the Virginia Tech and the Selected Firm(s) shall respond accordingly.

- b. **On-Demand/Non-Routine Repairs and Upgrades.** On-demand/Non-routine repairs, as specified herein, are repairs made:
  - 1) As a result of Virginia Tech's request to modernize or upgrade equipment;
  - 2) Repairs necessary due to Acts of God or vandalism; and

All non-routine repairs shall be authorized in advance by Virginia Tech, as negotiated. Non-routine repairs shall be scheduled at the discretion of

Virginia Tech. Service shall be available on a 24-hour, 365-day basis. All non-routine repairs shall be billable at the rates established in the price schedule.

The Selected Firm:

- i. Shall notify the appropriate Virginia Tech Management team, in writing, at the time of any non-routine repair is required;
- ii. May be requested to furnish photos documenting any damage resulting in charges to Virginia Tech; and
- iii. Shall provide Virginia Tech with estimates for repairs.

Upon approval, the Virginia Tech representative shall confirm the work with an email or work order number provided to the Selected Firm in advance of any work being performed. The email or work order number shall serve as verification that authorization for repairs has been received. Failure of the Selected Firm to obtain the required approval, prior to start of work, will constitute unauthorized work and shall release Virginia Tech from responsibility to pay for the repair.

When a repair is complete, the Selected Contractor's project manager shall submit a work ticket that includes the time required for the repair and a detailed itemized list of parts used. The work ticket must include the names of the technicians performing the required work along with the confirming work order number.

Transportation, travel time, and other expenses shall not be paid for separately, but must be included in the hourly rate.

All labor, materials, parts and supplies required in the performance of non-routine repairs shall be provided by the Selected Firm and billed to Virginia Tech per rates established in this contract.

#### **4. Construction**

Virginia Tech reserves the right to list the Selected Firm(s) for BAS work in future construction project drawings and specifications. Only Selected Firm(s) may provide a proposal to the CM/GCs or mechanical contractors competing for the project. Alternatively, Virginia Tech may procure the work and assign the work to the CM/GC. See Paragraph VI.B.

- D. Work Conditions.** The Selected Firm(s) will have to work under the same conditions as does Virginia Tech's Facilities Management. This includes, but is not limited to: information technology (IT) policies; building/ room access requirements; immunization requirements; parking arrangements arranged through Virginia Tech's Transportation Services/Parking Services; adhering to Commonwealth of Virginia and Virginia Tech building or safety codes and standards, and scheduling work around Virginia Tech special events and holidays.
- E. Inferred Quality.** On many projects, drawings and specifications may be limited. Under these circumstances, the quality of materials and workmanship should conform with the highest quality control standards and the total scope of work would be that which can be reasonably implied and inferred from the bid/construction documents.

All work performed on Virginia Tech facilities shall meet the standards specified by the equipment manufacturer, all applicable local, state, and federal standards, applicable building and safety codes, Virginia Tech's Design and Construction Standards Manual ("DCSM"), and Virginia Tech BAS Standards. At the time of installation, all parts furnished under this contract shall be new and genuine manufacturer's recommended or authorized replacement parts. Virginia Tech strictly prohibits the use of used parts. Virginia Tech may authorize the use of manufacturer-rebuilt parts and components, provided these parts and components carry the same warranty and meet the current specification for new parts. Before using manufacturer-rebuilt parts, approval by Virginia Tech is required on a case-by-case basis

- F.** The Selected Firm(s) shall furnish all necessary labor, supervision, travel, tools, supplies, parts, and materials to provide a complete and functional system.
- G.** The Selected Firm(s) shall maintain a sufficient quantity of material or repair parts on hand or have ready access to material and parts to prevent unnecessary downtime.
- H.** Any changes to Selected Firm's personnel during the term of this contract shall be submitted in writing no less than five (5) days prior to any change. Any changes in personnel are subject to approval by Virginia Tech.
- I.** Virginia Tech reserves the right to inspect Firm's audited financial statements or other financial information which may be requested by Virginia Tech prior to making an award to Firm.
- J.** At Virginia Tech's discretion, the Selected Firm(s) may have to provide a plan of operation on future projects to demonstrate to Virginia Tech how it plans to accomplish the respective projects. This should include, but not be limited to, personnel that the Selected Firm(s) will allocate to the project, inspection by the Selected Firm(s), provisions for warranty and maintenance integrity, and a schedule.
- K.** The Selected Firm(s) shall provide a competent and well-trained workforce that exhibits professionalism, demonstrated experience and service excellence.
- L.** The Selected Firm(s) shall maintain a clean worksite. Virginia Tech may inspect the ongoing work and finished project and approve or disapprove the completed work. If Virginia Tech does not approve the completed project or any portion thereof, Virginia Tech may withhold final payment or a portion of final payment until the Selected Firm(s) finishes the project in a manner acceptable to Virginia Tech.
- M.** The Selected Firm(s) shall work with Virginia Tech to clarify plans and/or specifications provided to the Selected Firm(s) by Virginia Tech. Virginia Tech will endeavor to supply the Selected Firm(s) with the most complete documents possible. Virginia Tech may request Selected Firm(s) to make site visits and schedule meetings to obtain clarifications on the scope of work on projects.
- N.** The Selected Firm(s) should provide sufficient representation in the Blacksburg area to adequately meet Virginia Tech's needs. Representatives from the Selected Firm(s) will have to provide aid, expedite work, correct deficiencies, and handle many other miscellaneous problems that may occur during work-in-progress. "Representation" is not intended to imply a requirement of a local office to be considered for award. Virginia Tech will be looking for each Firm to show they can provide adequate and sufficient representation/manpower to satisfy the obligations listed in the request for proposal at all of our statewide locations. By

way of example, having sufficient manpower to respond to the emergency service response time requirements.

- O.** All employees of the Selected Firm(s) must wear uniforms or other appropriate attire at all times to designate their affiliation with the Selected Firm(s). Virginia Tech requires such identification for security purposes and may prohibit access if Virginia Tech personnel do not recognize the identification provided.
- P.** After completion of a project, the Selected Firm(s) shall supply Virginia Tech, in electronic format, all necessary documents, drawings, databases, and software/ licenses for record keeping or other purposes as deemed necessary by Virginia Tech. Drawings shall be provided in portable document format (PDF) and electronic editable format, such as Microsoft Visio or CAD, to allow Virginia Tech to edit the drawings for future work.

At a minimum, this shall include:

1. Control drawings,
  2. Points lists,
  3. Sequence of operations,
  4. Letter of warranty,
  5. Confirmation that appropriate alarms have been put in place,
  6. Confirmation that appropriate trends have been put in place,
  7. Confirmation that system graphics have been put in place,
  8. Confirmation that training has been provided to Systems Control Center operators and Instrumentation Technicians, and
  9. A list of any outstanding (punch list) items.
- Q.** The Selected Firm(s) shall take proper safety and health precautions to protect at a minimum, students, faculty, staff, construction workers, and visitors to Virginia Tech, and the Selected Firm's work and the property of others.
  - R.** All projects shall be performed in a manner that will not adversely affect the integrity of a building's structural, mechanical, electrical, fire protection, and life safety systems, or any other building systems or utilities that may overload or render useless any portion of the building without first seeking approval by Virginia Tech's designated representative.

Building and utility shutdowns/ outages must be coordinated in advance with Virginia Tech's designated representative. Shutdowns generally require notice a minimum of five (5) days in advance.

- S.** The Selected Firm(s) must supply Virginia Tech with all warranty and other manuals after the completion of each project. Additionally, the Selected Firm(s) shall guarantee all material and workmanship for a period of at least one (1) year or the Manufacturer's warranty period, whichever is longer. For purposes of new construction (either renovations or capital construction), the one (1) year period shall begin at Beneficial Occupancy regardless of whether the equipment was used prior to Substantial Completion. For all other

work including preventative maintenance services, the warranty period shall occur after approval of the final payment by Virginia Tech.

- T. The Selected Firm (s) shall provide Virginia Tech with current manuals and other documentation as required to ensure that all personnel operate equipment and software in accordance with appropriate manufacturers' recommendations.
- U. The Selected Firm(s) shall provide the name and contact information for the individual who will act as the single point of contact for Virginia Tech for each Project.
- V. The Selected Firm(s) shall provide Virginia Tech with all hardware, software, licenses, and access rights to fully modify and maintain any system installed at Virginia Tech by the Selected Firm.
- W. Virginia Tech expects that any proposals submitted for construction projects will be valid for the time specified in Selected Firm's Proposal or as required by the bid documents. Cost increases will be handled per the terms of the procurement and associated contract for the work.
- X. The Selected Firm(s) shall be required to participate in a pilot demonstration during the negotiation phase of this solicitation. The purpose of this demonstration is to allow the prospective vendor(s) the opportunity to prove their integration capabilities across various platforms. More information about this demonstration will be provided at a later date.

## **VII. PROPOSAL PREPARATION AND SUBMISSION:**

All Proposals will consist of a technical proposal ("Technical Proposal") and a price proposal ("Price Proposal") (the Technical Proposal and the Price Proposal may be referred to collectively as "Proposal"). Descriptions of these can be found below. Proposals should be as thorough and detailed as possible so that Virginia Tech may properly evaluate your capabilities to provide the required goods or services. Firms are required to submit the following information/items as a complete proposal. If the Firm(s) fail to submit all information requested herein, Virginia Tech may require prompt submission of missing information after the receipt of Proposals or deem the proposal as non-responsive.

### **A. Price Proposal:**

- 1. The Firm shall provide **Attachment B**. Virginia Tech recognizes that not all Firms may be able to provide support for existing systems. To the extent this is the case, Virginia Tech requests Firms, to the extent possible, to describe how preventive maintenance pricing would be developed for a location or project if a BAS project is completed using the specific manufacturer's control equipment.

### **B. Technical Proposal:**

- 1. **Proposed Contractual Provisions.**
  - a. State the Firm's acceptance of the **Contractual Provisions**.
  - b. State the Firm's acceptance and understanding, with any proposed modifications, of **Section VII – Statements of Needs / Scope of Work**. Any proposed modifications shall be conspicuously identified in the proposal.
  - c. Provide the Contractor's Class A license number.



**2. The Firm and Its Proposed Operations.**

- a. Describe the Firm, its size, number of employees, and annual sales. This should include:
  - 1) An organizational chart indicating which individuals or positions would have knowledge of an Agreement with Virginia Tech, and the degree to which each person would be responsible to the Virginia Tech's account, including names of project managers and superintendents;
  - 2) The Firm's commitment to the Virginia Tech in terms of resources, personnel, investment, etc.; and
  - 3) Submit a copy of the Firm's most recent price catalog along with the discount that Virginia Tech will receive.
- b. Provide, at minimum, a list of three (3) of the Firm's clients comparable to Virginia Tech indicating the length of service contract and the nature of each effort. Include and identify clients where you were required to integrate into a pre-existing system.
  - 1) The following reference information shall be provided for no less than three (3) of the comparable clients:
    - a) Name of Client Contact;
    - b) Title of Client Contact;
    - c) Address;
    - d) Phone number; and
    - e) Email address.
- c. Provide, at minimum, a list of three (3) of the Firm's clients comparable to Virginia Tech describing work on new capital (or major) construction and the nature of each effort.
  - 1) The following reference information shall be provided for no less than three (3) of the comparable clients:
    - a) Name of Client Contact;
    - b) Title of Client Contact;
    - c) Address;
    - d) Phone number; and
    - e) Email address.

- d. The Firm represents that the prices, terms, warranties, and benefits specified in its proposal are comparable to or better than the equivalent terms being offered by the Firm to any present customer.
  - e. Provide the Firm's plan for utilization of Small, Women-owned, and Minority-owned businesses.
3. **BAS Preventive Maintenance Technicians Experience.** The importance of maintaining the BAS and associated equipment in line with its original design and upgraded performance requires the service to be performed by an experienced and competent Firm who has satisfactorily maintained equipment of this type and to the degree included in these specifications
- a. Any technician used by the Selected Firm for the performance of this work shall be experienced and trained in the maintenance and repair of BAS systems and associated equipment, and shall be capable and qualified in performing the repair and service work.
  - b. The Selected Firm shall have and maintain technical support assistance for the assigned technicians and be available at all times.
  - c. Any technician, or other personnel, proposed by the Selected Firm shall be subject to approval by Virginia Tech.

4. **Software Tools**

The Firm shall provide a plan for allowing Virginia Tech personnel direct access to all software components and licenses necessary for Virginia Tech personnel to design, engineer, configure, and maintain projects or work using the Firm's products. Software components include, but are not limited to, engineering software for developing live and interactive engineering drawings of controllers, programming software, server configuration software, graphics software, database configuration software, web applications, and field utility applications for maintenance of controllers/ components.

5. **BAS Integration**

The Firm shall provide a detailed plan for how it intends to integrate their system into the existing BAS infrastructure and operational processes currently in place at Virginia Tech as well as a detailed explanation of all required hardware/ software components for a long-term fully functional system. This should include a list and description of any necessary servers, software, licenses, software contracts, service contracts, etc. A description of the existing BAS infrastructure on Virginia Tech's main campus can be found in Section VI.A - Overview.

6. **Technical Support**

The Firm shall provide a plan for allowing Virginia Tech personnel direct access to technical support information, including but not limited to, technical support cases, product briefings, and software updates.

7. **Training**

Provide the Firm's plan for providing ongoing training to Virginia Tech staff, including specific training topics and costs.

8. **Research and Development**

The Firm's proposal shall include a section detailing the research and development efforts of the company regarding technology innovation in the field of BAS. This section should describe the firm's upcoming product releases, and a description of how the Firm will communicate technological advancements to Virginia Tech.

9. **Cybersecurity**

- a. The Firm's proposal shall include a section detailing the cybersecurity features of their material and software/ application. This section should include a description of logging capabilities of the software/ application as well as recommended cybersecurity best practices for their system.
- b. The Firm's proposal shall list the system's information technology hardware and software (firmware, operating systems, and applications) components and the expected lifespan of each component.
- c. The Firm's proposal shall detail how the Firm, across the entire expected lifespan of the system:
  - 1) Will provide firm or third-party supported firmware, operating systems, and applications for the system;
  - 2) Will deliver application, operating system and firmware security updates and patches as they are released by the supporting party (e.g. the firm, Microsoft, etc.) and tested by the firm; and
  - 3) Will install antivirus or antimalware on systems that are capable of running such software.
- d. The Firm's proposal shall describe the process by which they ensure removal/ disablement of all unnecessary network-available services from the system; default passwords are changed on the system; and the types of system security alerts that are available for configuration and use.
- d. The Firm's proposal shall describe what data the system generates or handles, where the data travels, and how it secures the data in processing, in transit, and at rest.
- e. The Firm's proposal shall describe options regarding on-premises components of the system and components of the system that reside or communicate with hosts external to the Virginia Tech network, including any "cloud" infrastructure. Systems that involve cloud infrastructure (vs. only on-premises infrastructure) shall require detailed justification and additional security screening.

10. **Other Information**

Provide any other information that Virginia Tech should consider in evaluating the Firm's proposal. This should include information relating to Virginia Tech's stated interest in self-performance of BAS projects.

11. **Participation of Small, Women-owned and Minority-owned Business (“SWaM”) Business**

If your business cannot be classified as SWaM, describe your plan for utilizing SWaM subcontractors if awarded a contract. Describe your ability to provide reporting on SWaM subcontracting spend when requested. If your firm or any business you plan to subcontract with can be classified as SWaM, but has not been certified by the Virginia Department of Small Business and Supplier Diversity (“SBSD”), it is expected that the certification process will be initiated no later than the time of the award. If your firm is currently certified, you agree to maintain your certification for the life of the contract. For assistance with SWaM certification, visit the SBSD website at <http://www.sbsd.virginia.gov/>

The Firm(s) must submit all information requested by this RFP on the ownership, utilization, and planned involvement of SWaM firms in accordance with this SWaM **Form DGS-30-360** ([https://dgs.virginia.gov/globalassets/business-units/bcom/documents/forms/dgs-30-360\\_06-20\\_small-and-diverse-businesses-participation.xlsx](https://dgs.virginia.gov/globalassets/business-units/bcom/documents/forms/dgs-30-360_06-20_small-and-diverse-businesses-participation.xlsx)) including any source list of SWaM equipment and material vendors and construction subcontractors that may be suitable to participate in the construction of BAS.

12. **General Information and Addenda**

The return of the General Information Form and addenda, if any, signed and filled out as required.

**C. General Requirements**

1. **RFP Response:** In order to be considered for selection, Firms shall submit a complete response to this RFP to include;
  - a. A signed **Technical Proposal** and **Price Proposal**.
    - 1) The Technical Proposal [one (1) original digital submission] and Price Proposal (Labor Rates & Material Pricing) [one (1) digital submission] shall be prepared as two separate packages, and identified and appropriately marked as "Technical Proposal" and "Price Proposal," respectively.
  - b. Summary of Offeror's Proposal and proposed team on a double-sided place matt type 11" X 17" format.
  - c. Proposals shall be uploaded through the Bonfire online submission portal. Refer to page 2 for instructions.
    - 2) Any proprietary information should be clearly marked in accordance with 2.c. below.
  - d. Should the proposal contain **proprietary information**, provide **one (1) redacted electronic copy** of the proposal and attachments **with proprietary portions removed or blacked out**. This redacted copy should follow the same upload procedures as described on Page 1 of this RFP. This redacted copy should be clearly marked "*Redacted Copy*" within the name of the document. The classification of an entire proposal document, line item prices and/or total proposal prices as proprietary or trade secrets is not acceptable. Virginia Tech shall not be

responsible for the Firm's failure to exclude proprietary information from this redacted copy.

No other distribution of the proposals shall be made by the Firm.

**2. Proposal Preparation:**

- a. Proposals shall be signed by an authorized representative of the Firm. All information requested should be submitted. Failure to submit all information requested may result in Virginia Tech requiring prompt submission of missing information and/or giving a lowered evaluation of the proposal. Proposals which are substantially incomplete or lack key information may be rejected by Virginia Tech at its discretion. Mandatory requirements are those required by law or regulation or are such that they cannot be waived and are not subject to negotiation.
- b. Proposals should be prepared simply and economically providing a straightforward, concise description of capabilities to satisfy the requirements of the RFP. Emphasis should be on completeness and clarity of content.
- c. Proposals should be organized in the order in which the requirements are presented in the RFP. All pages of the proposal should be numbered. Each paragraph in the proposal should reference the paragraph number of the corresponding section of the RFP. It is also helpful to cite the paragraph number, subletter, and repeat the text of the requirement as it appears in the RFP. If a response covers more than one page, the paragraph number and subletter should be repeated at the top of the next page. The proposal should contain a table of contents which cross references the RFP requirements. Information which the Firm desires to present that does not fall within any of the requirements of the RFP should be inserted at an appropriate place or be attached at the end of the proposal and designated as additional material. Proposals that are not organized in this manner risk elimination from consideration if the evaluators are unable to find where the RFP requirements are specifically addressed.
- d. Ownership of all data, material and documentation originated and prepared for Virginia Tech pursuant to the RFP shall belong exclusively to Virginia Tech and be subject to public inspection in accordance with the Virginia Freedom of Information Act. Trade secrets or proprietary information submitted by a Firm shall not be subject to public disclosure under the Virginia Freedom of Information Act. However, to prevent disclosure the Firm must invoke the protections of Section 2.2-4342F of the Code of Virginia, in writing, either before or at the time the data or other materials is submitted. The written request must specifically identify the data or other materials to be protected and state the reasons why protection is necessary. The proprietary or trade secret material submitted must be identified by some distinct method such as highlighting or underlining and must indicate only the specific words, figures, or paragraphs that constitute trade secret or proprietary information. The classification of an entire proposal document, line item prices and/or total proposal prices as proprietary or trade secrets is not acceptable and may result in rejection of the proposal.

3. **Oral Presentation:** Firms who submit a proposal in response to this RFP may be required to give an oral presentation of their proposal to Virginia Tech.-This will provide an opportunity for the Firm to clarify or elaborate on the proposal but will in no way change the original proposal. Virginia Tech will schedule the time and location of these presentations. Oral presentations are an option of Virginia Tech and may not be conducted. Therefore, proposals should be complete.

## **VIII. SELECTION CRITERIA AND AWARD:**

### **A. Selection Criteria**

Proposals will be evaluated by Virginia Tech using these criteria:

<b><u>Maximum Point Criteria</u></b>	<b><u>Value</u></b>
1. Quality of products/services offered and suitability for the intended purposes	30
2. Qualifications and experiences of Firm in providing the goods/services	20
3. Specific plans or methodology to be used to provide the Services	30
4. Cost (or Price)	10
5. Participation of Small, Women-Owned and Minority (SWAM) Business	10
<b>Total</b>	<b>100</b>

### **B. Award**

Selection shall be made of two or more Firms deemed fully qualified and best suited among those submitting proposals based on the evaluation factors in the Request for Proposal, including price, if so stated in the Request for Proposal. Negotiations shall then be conducted with the Firms so selected. Price shall be considered, but need not be the sole determining factor. After negotiations have been conducted with each Firm so selected, Virginia Tech shall select the Firm(s) which, in its opinion, has made the best proposal, and shall award the contract to that Selected Firm(s). Virginia Tech may cancel this Request for Proposal or reject proposals at any time prior to an award. Should Virginia Tech determine in writing and in its sole discretion that only one Firm has made the best proposal, a contract may be negotiated and awarded to that Firm. The award document will be a contract incorporating by reference all the requirements, terms and conditions of this solicitation and the Contractor's proposal, as negotiated.

Virginia Tech reserves the right to award multiple contracts as a result of this solicitation.

## **IX. OPTIONAL PRE-PROPOSAL CONFERENCE:**

An optional pre-proposal conference will be held virtually via Zoom on November 10<sup>th</sup>, 2022 at 10:00AM. In order to receive an invitation for this teleconference, please email Bryan Holloway directly at [bryanh91@vt.edu](mailto:bryanh91@vt.edu). The purpose of this conference is to allow potential Offerors an opportunity to present questions and obtain clarification relative to any facet of this solicitation.

While attendance at this conference will not be a prerequisite to submitting a proposal, offerors who intend to submit a proposal are encouraged to attend.

Bring a copy of this solicitation with you. Any changes resulting from this conference will be issued in a written addendum to this solicitation.

**It is strongly recommended that you obtain a Virginia Tech parking permit for display on your vehicle prior to attending the conference. Parking permits are available from the Virginia Tech Parking Services Department located at 505 Beamer Way, phone: (540) 231-3200, e-mail: [parking@vt.edu](mailto:parking@vt.edu).**

**X. INVOICES:**

Invoices for goods or services provided under any contract resulting from this solicitation shall be submitted by email to [vtinvoices@vt.edu](mailto:vtinvoices@vt.edu) or by mail to:

Virginia Polytechnic Institute and State University ("Virginia Tech")  
Accounts Payable  
North End Center, Suite 3300  
300 Turner Street NW  
Blacksburg, Virginia 24060

**XI. METHOD OF PAYMENT:**

Virginia Tech will authorize payment to the contractor as negotiated in any resulting contract from this Request for Proposal.

Payment can be expedited through the use of the Wells One AP Control Payment System. Virginia Tech strongly encourages participation in this program. For more information on this program please refer to Virginia Tech's Procurement website: <http://www.procurement.vt.edu/vendor/wellsone.html> or contact the procurement officer identified in the RFP.

**XII. ADDENDUM:**

Any addendum issued for this solicitation may be accessed at <http://www.apps.vpfin.vt.edu/html.docs/bids.php>. Since a paper copy of the addendum will not be mailed to you, we encourage you to check the web site regularly.

**XIII. COMMUNICATIONS:**

Communications regarding this solicitation shall be formal from the date of issue, until either a Contractor has been selected or the Procurement Department rejects all proposals. Formal communications will be directed to the procurement officer listed on this solicitation. Informal communications, including but not limited to request for information, comments or speculations regarding this solicitation to any University employee other than a Procurement Department representative may result in the offending Firm's proposal being rejected.

**XIV. CONTROLLING VERSION OF SOLICITATION:**

The posted version of the solicitation and any addenda issued by Virginia Tech Procurement Services is the mandatory controlling version of the document. Any modification of/or additions to the solicitation by the Firm shall not modify the official version of the solicitation issued by Virginia

Tech Procurement Services. Such modifications or additions to the solicitation by the Firm may be cause for rejection of the proposal; however, Virginia Tech reserves the right to decide, on a case by case basis, in its sole discretion, whether to reject such a proposal.

**XV. TERMS AND CONDITIONS:**

This solicitation and any resulting contract/purchase order shall be governed by the attached terms and conditions, see **Attachment A**.

**XVI. CONTRACT ADMINISTRATION:**

- A. A Contract Administrator shall be identified by Virginia Tech and such Contract Administrator and shall use all powers under the contract to enforce its faithful performance.
- B. The Contract Administrator, or their designee, shall determine the amount, quantity, acceptability, fitness of all aspects of the services and shall decide all other questions in connection with the services. The Contract Administrator, or their designee, shall not have authority to approve changes in the services which alter the concept or which call for an extension of time for this contract. Any modifications made must be authorized by the Virginia Tech Procurement Department through a written amendment to the contract.

**XVII. ATTACHMENTS:**

**Attachment A** – Terms and Conditions

**Attachment B** – Price Proposal / Labor Rates and Material Pricing

**Attachment C** – Virginia Tech BAS Standards



## ATTACHMENT A

### TERMS AND CONDITIONS

#### RFP GENERAL TERMS AND CONDITIONS

See: [http://procurement.vt.edu/content/dam/procurement\\_vt\\_edu/docs/terms/GTC\\_RFP\\_09242021.pdf](http://procurement.vt.edu/content/dam/procurement_vt_edu/docs/terms/GTC_RFP_09242021.pdf)

#### ADDITIONAL TERMS AND CONDITIONS

1. **ADDITIONAL GOODS AND SERVICES:** The University may acquire other goods or services that the supplier provides other than those specifically solicited. The University reserves the right, subject to mutual agreement, for the Contractor to provide additional goods and/or services under the same pricing, terms and conditions and to make modifications or enhancements to the existing goods and services. Such additional goods and services may include other products, components, accessories, subsystems, or related services newly introduced during the term of the Agreement.
2. **AUDIT:** The Contractor hereby agrees to retain all books, records, and other documents relative to this contract for five (5) years after final payment, or until audited by the Commonwealth of Virginia, whichever is sooner. Virginia Tech, its authorized agents, and/or the State auditors shall have full access and the right to examine any of said materials during said period.
3. **AVAILABILITY OF FUNDS:** It is understood and agreed between the parties herein that Virginia Tech shall be bound hereunder only to the extent of the funds available or which may hereafter become available for the purpose of this agreement.
4. **CANCELLATION OF CONTRACT:** Virginia Tech reserves the right to cancel and terminate any resulting contract, in part or in whole, without penalty, upon 60 days written notice to the Contractor. In the event the initial contract period is for more than 12 months, the resulting contract may be terminated by either party, without penalty, after the initial 12 months of the contract period upon 60 days written notice to the other party. Any contract cancellation notice shall not relieve the Contractor of the obligation to deliver and/or perform on all outstanding orders issued prior to the effective date of cancellation.
5. **CONTRACT DOCUMENTS:** The contract entered into by the parties shall consist of the Request for Proposal including all modifications thereof, the proposal submitted by the Contractor, the written results of negotiations, the Commonwealth Standard Contract Form, all of which shall be referred to collectively as the Contract Documents.
6. **IDENTIFICATION OF PROPOSAL EMAIL:** Virginia Tech will only be accepting electronic submission of proposals. All submissions must be submitted to <https://procurement-vt.bonfirehub.com/>. Upon completion you will be directed to your Submission Receipt. Virginia Tech will not confirm receipt of proposals. It is the responsibility of the Firm to make sure their proposal is delivered on time. **Attachments must be smaller than 1000MB in order to be received by the University.** Proposals may **NOT** be hand delivered to the Procurement Office.
7. **NOTICES:** Any notices to be given by either party to the other pursuant to any contract resulting from this solicitation shall be in writing via email.
8. **SEVERAL LIABILITY:** Virginia Tech will be severally liable to the extent of its purchases made against any contract resulting from this solicitation. Applicable entities described herein will be severally liable to the extent of their purchases made against any contract resulting from this solicitation.

9. **CLOUD OR WEB HOSTED SOFTWARE SOLUTIONS:** For agreements involving Cloud-based Web-hosted software/applications refer to link for additional terms and conditions: [http://www.ita.vt.edu/purchasing/VT\\_Cloud\\_Data\\_Protection\\_Addendum\\_final03102017.pdf](http://www.ita.vt.edu/purchasing/VT_Cloud_Data_Protection_Addendum_final03102017.pdf)
10. **ADVERTISING:** In the event a contract is awarded for supplies, equipment, or services resulting from this solicitation, no indication of such sales or services to Virginia Tech will be used in product literature or advertising. The contractor shall not state in any of the advertising or product literature that the Commonwealth of Virginia or any agency or institution of the Commonwealth has purchased or uses its products or services.
11. **AS-BUILT DRAWINGS:** The Contractor shall provide Virginia Tech a clean set of reproducible "as built" drawings and wiring diagrams, marked to record all changes made during installation or construction. The Contractor shall also provide Virginia Tech with maintenance manuals, parts lists and a copy of all warranties for all equipment. All "as built" drawings and wiring diagrams, maintenance manuals, parts lists and warranties shall be delivered to Virginia Tech upon completion of the work and prior to final payment.
12. **ASBESTOS:** Whenever and wherever during the course of performing any work under this contract, the Contractor discovers the presence of asbestos or suspects that asbestos is present, he shall stop the work immediately, secure the area, notify the Building Owner and await positive identification of the suspect material. During the downtime in such a case, the contractor shall not disturb any surrounding surfaces but shall inform all employees that the suspect material is not to be disturbed, and shall vacate and secure the area until an identification has been made if suspect debris is present. In the event the contractor is delayed due to the discovery of asbestos or suspected asbestos, then a mutually agreed extension of time to perform the work shall be allowed the contractor but without additional compensation due to the time extension.
13. **MATERIALS CONTAINING ASBESTOS:** The contractor shall not incorporate any materials into the work containing asbestos. The contractor shall not incorporate any material known by the contractor to contain a substance known to be hazardous to health when the building is occupied unless specifically approved by Virginia Tech or required by the specifications. If the contractor becomes aware that a material required by the specifications contains asbestos, it shall notify Virginia Tech immediately and shall take no further steps to acquire or install any such material
14. **OPTIONAL PERFORMANCE AND PAYMENT BONDS:** The University reserves the right in its own discretion to require performance and payment bonds prior to execution of the Contract. The successful Firm/bidder shall be prepared to deliver executed Commonwealth of Virginia Standard Performance and labor and Material Payment Bonds if so requested each in the sum of the contract amount, with the Commonwealth of Virginia, Virginia Polytechnic Institute and State University as obligee. The surety shall be a company or companies approved by the State Corporation Commission to transact surety business in the Commonwealth of Virginia. No payment shall be due and payable to the contractor, even if the contract has been performed in whole or in part, until the bonds have been delivered to and approved by the procurement office. Standard bond forms will be provided by the procurement office if the University does so request a performance and payment bond.

Determination of the requirement to submit performance and payment bonds will be made by the University at its sole discretion based on the following:

- Complexity of the project
- Timeline of the project
- Evaluation of the contractor's references provided
- Past history of work performance at the University

All Firms/bidders shall be prepared to provide said bonds upon request. If requested, cost to obtain these bonds will then be added to the contractor's base price.

15. **CONTRACTOR/SUBCONTRACTOR LICENSE REQUIREMENT:** By my signature on this solicitation, I certify that this firm/individual and/or subcontractor is properly licensed for providing the goods/services specified

Contractor Name: Automated Logic Contracting Services

License #: 2705078725      Type: Contractor Class A

16. **CONTRACTOR'S TITLE TO MATERIALS:** No materials or supplies for the work shall be purchased by the Contractor or by any Subcontractor subject to any chattel mortgage or under a conditional sales or other agreement by which an interest is retained by the seller. The contractor warrants that he has clear title to all materials and supplies for which he invoices for payment.
17. **CRIMINAL CONVICTION CHECKS:** All criminal conviction checks must be concluded prior to the Contractor's employees gaining access to the Virginia Tech Campus. Employees who have separated employment from Contractor shall undergo another background check prior to re-gaining access to the Virginia Tech campus. Contractor shall ensure subcontractors conduct similar background checks. Virginia Tech reserves the right to audit a contractor's background check process at any time. All employees have a duty to self-disclose any criminal conviction(s) occurring while assigned to the Virginia Tech campus. Such disclosure shall be made to Contractor, which in turn shall notify the designated Virginia Tech contract administrator within 5 days. If at any time during the term of the contract Virginia Tech discovers an employee has a conviction which raises concerns about university buildings, property, systems, or security, the contractor shall remove that employee's access to the Virginia Tech campus, unless Virginia Tech consents to such access in writing. Failure to comply with the terms of this provision may result in the termination of the contract.
18. **ELECTRICAL INSTALLATION:** All equipment/material shall conform to the latest issue of all applicable standards as established by National Electrical Manufacturer's Association (NEMA), American National Standards Institute (ANSI), and Underwriters' Laboratories, Incorporated (UL) or other Nationally Recognized Testing Laboratories (NRTL) currently listed with the US Department of Labor. All equipment and material, for which there are NEMA, ANSI, UL or other NRTL standards and listings, shall bear the appropriate label of approval for use intended.
19. **FINAL INSPECTION:** At the conclusion of the work, the contractor shall demonstrate to the authorized owner's representatives that the work is fully operational and in compliance with contract specifications and codes. Any deficiencies shall be promptly and permanently corrected by the contractor at the contractor's sole expense prior to final acceptance of the work.
20. **INSTALLATION:** All items must be assembled and set in place, ready for use. All crating and other debris must be removed from the premises.
21. **INSURANCE PROVISIONS:** The insurance requirements identified below are the minimum requirements. Individual projects may require additional insurance coverage and/or limits. By signing and submitting a Proposal/Bid under this solicitation, the Firm/bidder certifies that if awarded the contract, it will have the following insurance coverages at the time the work commences. Additionally, it will maintain these during the entire term of the contract and that all insurance coverages will be provided by insurance companies authorized to sell insurance in Virginia by the Virginia State Corporation Commission.

During the period of the contract, Virginia Tech reserves the right to require the contractor to furnish certificates of insurance for the coverage required.

**INSURANCE COVERAGES AND LIMITS REQUIRED:**

- A. Worker's Compensation - Statutory requirements and benefits.
- B. Employers Liability - \$100,000.00
- C. General Liability - \$2,000,000.00 combined single limit. Virginia Tech and the Commonwealth of Virginia shall be named as an additional insured with respect to goods/services being procured. This coverage is to include Premises/Operations Liability, Products and Completed Operations Coverage, Independent Contractor's Liability, Owner's and Contractor's Protective Liability and Personal Injury Liability.
- D. Automobile Liability - \$500,000.00
- E. Builders Risk – For all renovation and new construction projects under \$100,000 Virginia Tech will provide All Risk – Builders Risk Insurance. For all renovation contracts, and new construction from \$100,000 up to \$500,000 the contractor will be required to provide All Risk – Builders Risk Insurance in the amount of the contract and name Virginia Tech as additional insured. All insurance verifications of insurance will be through a valid insurance certificate.
- F. The contractor agrees to be responsible for, indemnify, defend and hold harmless Virginia Tech, its officers, agents and employees from the payment of all sums of money by reason of any claim against them arising out of any and all occurrences resulting in bodily or mental injury or property damage that may happen to occur in connection with and during the performance of the contract, including but not limited to claims under the Worker's Compensation Act. The contractor agrees that it will, at all times, after the completion of the work, be responsible for, indemnify, defend and hold harmless Virginia Tech, its officers, agents and employees from all liabilities resulting from bodily or mental injury or property damage directly or indirectly arising out of the performance or nonperformance of the contract.

- 22. MAINTENANCE MANUALS:** The contractor shall provide with each piece of equipment an operations and maintenance manual with wiring diagrams, parts list, and a copy of all warranties.
- 23. SUBCONTRACTS:** No portion of the work shall be subcontracted without prior written consent of Virginia Tech. In the event that the contractor desires to subcontract some part of the work specified herein, the contractor shall furnish Virginia Tech the names, qualifications and experience of their proposed subcontractors. The contractor shall, however, remain fully liable and responsible for the work to be done by his subcontractor(s) and shall assure compliance with all requirements of the contract.
- 24. SAFETY:** The contractor bears sole responsibility for the safety of its employees. The contractor shall take all steps necessary to establish, administer, and enforce safety rules that meet the regulatory requirements of the Virginia Department of Labor and Industry (VDLI) and the Occupational Safety and Health Administration (OSHA). The contractor shall take steps as necessary to protect the safety and health of university employees, students, and visitors during the performance of their work. In addition, the contractor must also provide the university with a written safety program that it intends to follow in pursuing work under this contract. By entering into a contract with Virginia Tech, the contractor and its subcontractors agree to abide by the requirements described in Safety Requirements for Contractors and Subcontractors located on Virginia Tech's Environmental, Health and Safety Services (EHSS) web site at this URL [http://www.ehss.vt.edu/programs/contractor\\_safety.php](http://www.ehss.vt.edu/programs/contractor_safety.php). A copy of the publication may also be obtained by contacting EHSS at 540/231- 5985. No work under this contract will be permitted until the university is assured that the contractor has an adequate safety program in effect.

25. **SPECIAL OR PROMOTIONAL DISCOUNTS:** The Contractor shall extend any special promotional sale prices or discounts immediately to Virginia Tech during the term of the contract. Such notice shall also advise the duration of the specific sale or discount price.
26. **TURF POLICY:** Parking or driving on campus turf or sidewalk is strictly prohibited, except as specifically directed or otherwise allowed by the Physical Plant Grounds Department. In this case, a turf permit must be obtained from Virginia Tech Parking Services and displayed by the vehicle. Turf parking is not allowed under the canopy of any tree on campus. Any vehicle parked illegally on turf or sidewalks shall be subject to ticketing and fines.
27. **TRANSPORTATION AND PACKAGING:** By signing their Proposal/Bid the Firm/bidder certifies and warrants that the Proposal/Bid price offered for FOB destination includes only the actual freight rate costs at the lowest and best rate and is based upon the actual weight of the goods to be shipped. Except as otherwise specified herein, standard commercial packaging, packing and shipping containers shall be used. All shipping containers shall be properly and legibly marked or labeled on the outside with the commodity description and number, size and quantity of the contents.
28. **WARRANTY (COMMERCIAL):** The contractor agrees that the supplies or services furnished under any award resulting from this solicitation shall be covered by the most favorable commercial warranties the contractor gives any customer for such supplies or services and that the rights and remedies provided therein are in addition to and do not limit those available to Virginia Tech by any other clause of this solicitation. A copy of this warranty must be furnished with the Proposal/Bid.
29. **WORK SITE DAMAGES:** Any damage to existing utilities, equipment or finished surfaces resulting from the performance of this contract shall be repaired to the Owner's satisfaction at the contractor's expense.



# MEET THE MOMENT

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2021 ANNUAL REPORT







# Driving sustainability. Inspiring confidence.

The time to shape a more healthy, safe, sustainable and intelligent world is now. At Carrier, we are meeting the moment. In the face of critical challenges, we are driving sustainability through ambitious goals, bold initiatives and innovative solutions that empower our customers to make a positive impact. We are living and breathing our commitment to an inclusive, diverse culture. We are promoting the health and safety of indoor spaces where people live, work, learn and play, and helping preserve, protect and extend the supply of food and medicine across the globe. In moments big and small, Carrier is inspiring confidence.

## Contents

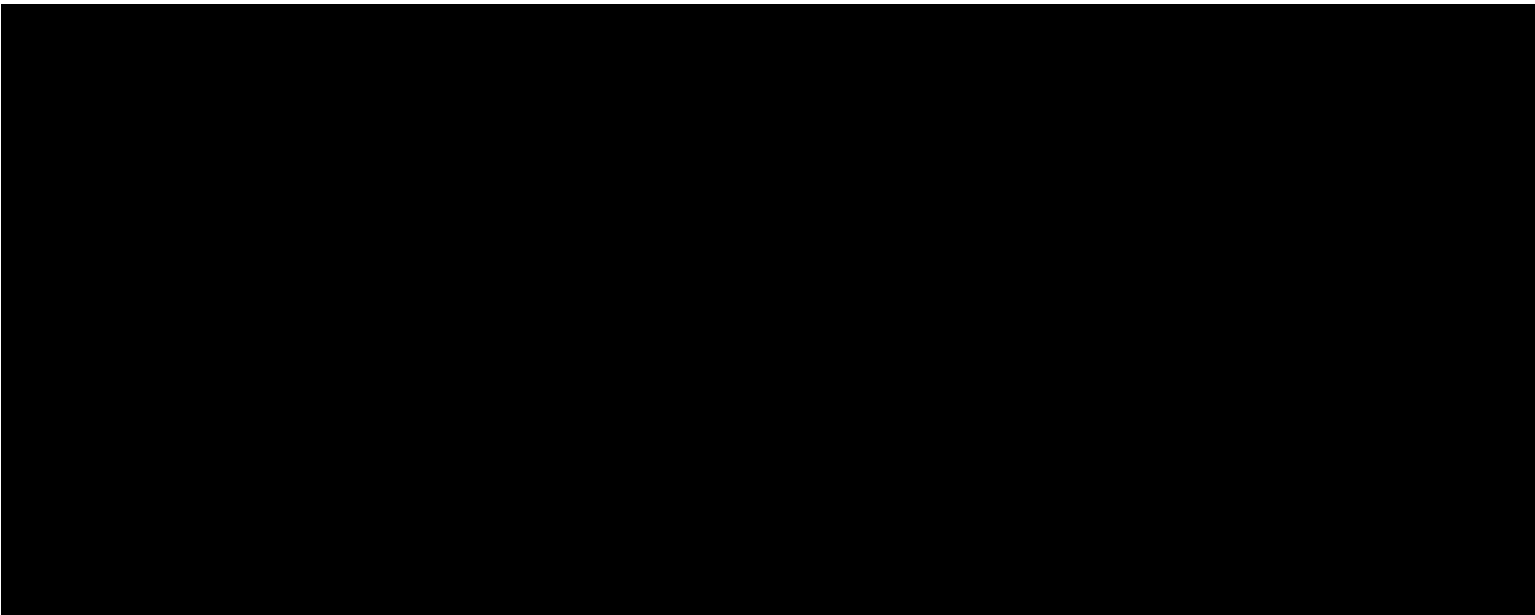
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# About Carrier

Carrier is the leading global provider of healthy, safe, sustainable and intelligent building and cold chain solutions, with a diverse and world-class workforce. Through our performance-driven culture, we are driving long-term shareowner value by growing sales and investing strategically to strengthen our position in the markets we serve.

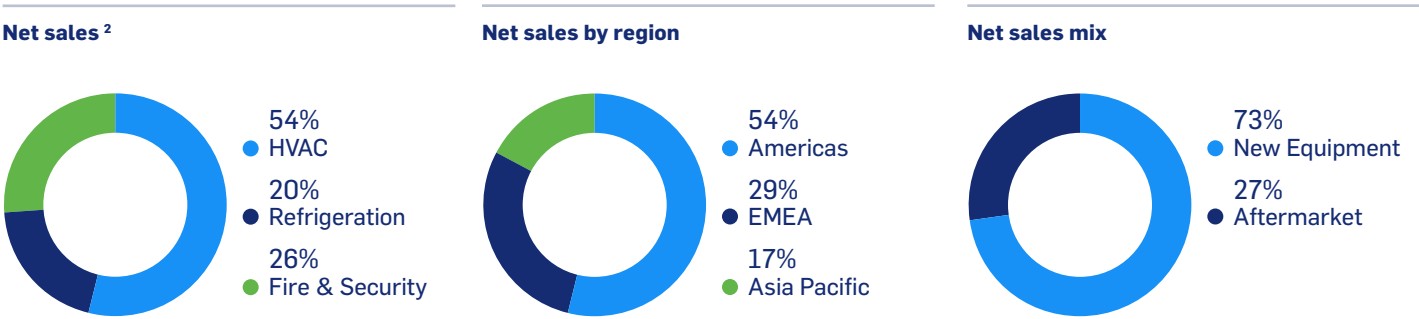


## Financials at a Glance



<sup>1</sup> See page 65 for additional information regarding non-GAAP measures.

## 2021 Net Sales Breakdown



<sup>2</sup> Segment sales include intercompany sales.





David Gitlin, Chairman &  
Chief Executive Officer

# Dear Fellow Shareowners,

Looking back on 2021, our first full year as an independent public company, Carrier successfully executed on our growth initiatives, accelerated technological and digital innovation and delivered differentiated results for our stakeholders, including customers and shareowners. It is just the beginning. Carrier is uniquely positioned to address some of the most critical challenges facing people and our planet, and I am proud that our team continues to meet the moment to make a profoundly positive impact on both.

## **Innovating to Meet Business Challenges**

Amid the ongoing COVID-19 pandemic, and confronted with supply chain disruptions and broad-based inflation, Carrier delivered strong performance and notable year-over-year growth. Our growth was fueled by our position at the epicenter of important secular trends – including an increased focus on healthy indoor air environments, effective cold chain distribution and, of course, sustainability.

In 2021, we booked approximately \$500 million in healthy building orders. We are confident this demand will not only continue, but accelerate, as building owners play an increasingly important role in ensuring the health and safety of their occupants. Recent studies confirm that improved building filtration and ventilation can significantly reduce the spread of COVID-19 and other airborne-spread illnesses, and that people are more productive in healthier indoor environments. To lead as a solutions provider, we launched Abound, a cloud-based building platform that enables owners, tenants and visitors to assess and improve indoor air quality. This open-technology platform aggregates data from different systems and sensors, and provides transparency into actionable insights about air quality, thermal comfort and other performance data to help enhance occupant experiences while achieving sustainability targets. Customer feedback on Abound has been very positive, and we are excited about the future of this new and innovative offering.

In addition to shining a light on the importance of healthy indoor environments, COVID-19 has also underscored the criticality of having an effective and connected cold chain that preserves, protects and extends the supply of vaccines and food. We responded by providing end-to-end visibility across the cold chain through Lynx, our cloud-based digital offering, developed in collaboration with Amazon Web Services. Lynx was recognized by Fast Company as one of 2021's World Changing Ideas, based on its ability to enable the safe movement, monitoring and storage of vaccines around the world.

<sup>1</sup> See page 65 for additional information regarding non-GAAP measures.

## Embracing Sustainability

We continue to embrace global environmental, social and governance (ESG) and are very well positioned to address customers' sustainability needs. We are deeply committed to our aggressive and important ESG goals, which include carbon neutrality across our operations by 2030 and reducing our customers' carbon footprint by more than 1 gigaton over the same period. To that end, more than 30% of our 2021 residential heating sales in North America consisted of heat pumps, reflecting consumer demand for energy efficiency. We launched an air-cooled chiller heat pump platform in Europe with 70% lower global warming potential than our previous platforms. We were first to market with electrically powered refrigeration units for trailers and began offering zero-emission electric truck refrigeration technology. Whether we are designing sustainable product offerings or building a more robust cold chain to help reduce food waste, we are seizing the moment to have an outsized positive impact on the planet.

Underlying our success at Carrier is an engaged culture that embraces inclusion and diversity across our global workforce, a vital part of our core values as an employer of choice. We believe a diverse workforce is a better workforce and, in 2021, we continued to reduce the gap and recruit more diverse talent into the company, working toward our ultimate goal that our workforce at Carrier reflects the communities in which we work.

## Continuing Our Strong Performance

Our strong performance in 2021 demonstrated successful execution against our growth initiatives. We delivered net sales of \$20.6 billion, including 15% organic growth, adjusted operating profit of \$2.8 billion and an adjusted diluted earnings per share increase of 36% in the face of raw material constraints, supplier price increases, chip shortages and logistics costs.<sup>1</sup> We generated \$2.2 billion of cash from operations and free cash flow of \$1.9 billion, or 114% of net income.<sup>1</sup> The net debt to adjusted EBITDA ratio improved from 2.8X to 2.1X, and net debt was lower than the prior year.<sup>1</sup>

Even though 2021 was one of the most challenging supply chain environments that I can recall, we supported our customers and drove outsized top-line growth thanks to the tremendous efforts of our global team members. I cannot thank our team enough for their industry-leading performance.

In addition to strong financial results, we were purposeful in driving more recurring revenues. Subscriptions of digitally enabled aftermarket offerings increased in 2021, reflecting strong demand for our differentiated IoT solutions. Our attachment rate in commercial HVAC increased over 2020, and we had more than 60,000 chillers under service maintenance agreements, up approximately 10,000 units from the year before. Sales of BluEdge service agreements were also strong in our refrigeration business for European truck trailers. The total addressable market for our expanding aftermarket business is not simply an important growth lever, it represents an opportunity for a steady, recurring revenue stream.

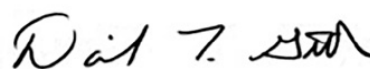
## Disciplined Capital Allocation to Create Long-term Shareowner Value

Finally, we continue to take a very disciplined approach to capital allocation. Having completed the Chubb divestiture on January 3, 2022, our net debt has decreased from about \$10 billion at our spin in April 2020 to about \$4 billion in early 2022.<sup>1</sup> With a strong balance sheet, we are now playing offense on capital deployment. We invested an incremental \$150 million in organic growth in 2021. We acquired tremendous technology and talented new employees through our acquisitions of Giwee Group, Nlyte Software, BrokerBay and Cavius. We also announced a 25% increase to the dividend and our plan to repurchase \$1.6 billion in shares in 2022.

In short, Carrier is very well positioned to capitalize on key secular trends, and we are energized by the opportunities ahead. We have the right people, strategy, expertise and offerings to lead the way by delivering solutions that matter to people and our planet.

Thank you for your confidence in Carrier. I am proud of our accomplishments in the past year, and I know that our best days are ahead.

Sincerely,



**David Gitlin**

Chairman & Chief Executive Officer  
Carrier

At Carrier, we are innovating to address the needs of people and our planet through our key programs – Healthy Buildings, Healthy Homes and Connected Cold Chain. These programs bring together Carrier's expertise in healthy, safe, sustainable and intelligent solutions to inspire confidence every day and help solve global challenges.

## HEALTHYBUILDINGS

We are shaping a healthier future through our Healthy Buildings Program. With solutions and services that help optimize indoor environments for health, safety and security, we positively impact occupant experiences in places where people live, work, learn and play, while helping to enhance sustainability and improve operational efficiency.

As K-12 schools looked to safely resume in-person learning, Carrier provided guidance on how U.S. schools can use federal stimulus funding to implement healthy building solutions. We also rolled out a BluEdge K-12 service program that provides an outcome-based approach to help schools select and implement the best indoor air quality upgrades for their needs.

Carrier supported research led by the Harvard T.H. Chan School of Public Health, which found that buildings can play a significant role in improving cognitive function, health and productivity. The global study identifies higher ventilation rates and enhanced filtration as critical public health strategies. Carrier also collaborated with a major U.S. university to create a custom risk assessment tool for buildings, with research showing how tactics such as managed occupancy, increased filtration and ventilation, air scrubbers and air purifiers can work together to reduce the risk of airborne transmission of pathogens by up to 80%.

Carrier implemented a comprehensive suite of healthy, safe, sustainable and intelligent building technologies at the Emory Musculoskeletal Institute in Atlanta, Georgia. The state-of-the-art facility selected Carrier HVAC solutions, Automated Logic's WebCTRL building automation system, fire detection and security solutions from Edwards and LenelS2, an occupant app and the Abound cloud-native platform for building health and performance. The solutions work together to enhance occupant experiences while achieving sustainability targets.





## HEALTHYHOMES

Carrier's Healthy Homes Program includes a suite of targeted solutions that can help improve the overall health and safety of homes and the people inside.

Our businesses continue to introduce innovations that give people greater awareness and control of their home's health. Our new plug-in air monitor helps users understand the quality of the air they breathe and connects with the Carrier Home app for remote notifications and monitoring. In addition, Kidde launched alarms and detectors with smart features that connect to mobile apps to alert homeowners to potential safety issues, even when they are not at home.

We launched new efforts to educate consumers on the importance of creating healthy home environments since, on average, most people spend over 65% of their time inside their home. We continue to develop resources and share recommendations, such as changing air filters frequently, adjusting room temperature settings, keeping fire extinguishers on every floor and installing smoke and carbon monoxide alarms throughout the home.



Carrier launched a Wi-Fi-enabled smart air purifier with HEPA filtration. The solution combines three different filtration technologies to create healthier indoor air and allows for monitoring of a home's indoor air quality from anywhere.

## CONNECTEDCOLDCHAIN

We are making the cold chain more healthy, safe, sustainable and intelligent through our Connected Cold Chain Program. Our solutions help preserve, protect and extend the supply of food, medicine and other perishables across the globe.

Carrier was key to the rollout of COVID-19 vaccines. We helped safely move, monitor and store vaccines around the world.

Our Lynx Fleet digital solution is improving connectivity throughout the cold chain to optimize asset utilization, lower logistics costs and operational carbon footprint, and help customers reduce food and medicine loss.

We remain committed to thought leadership and advancing dialogue around the global cold chain. Carrier co-sponsored the World Cold Chain Symposium convened by the Global Food Cold Chain Council and the United Nations Environment Programme. We discussed ways we are helping combat world hunger and helping customers avoid greenhouse gas emissions.



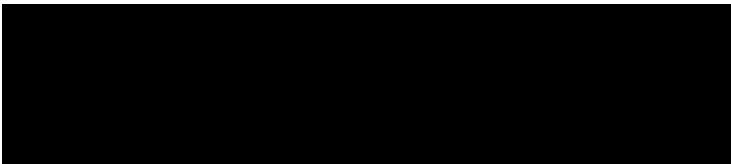
A&M Cold Storage chose Carrier Pods monitored by Sensitech to help meet an increase in demand for refrigerated storage capacity in support of vaccine distribution efforts. The solution integrates with Carrier's Lynx digital platform, ensuring end-to-end cold chain visibility.





## HVAC

Carrier's HVAC segment provides solutions globally to meet the heating, ventilating and cooling needs of residential and commercial customers, while enhancing building performance, energy efficiency and sustainability. Through an industry-leading family of brands, we offer an innovative and complete portfolio of products and solutions, including digital offerings, building automation and services that help optimize indoor environments to enhance human health, safety and productivity.



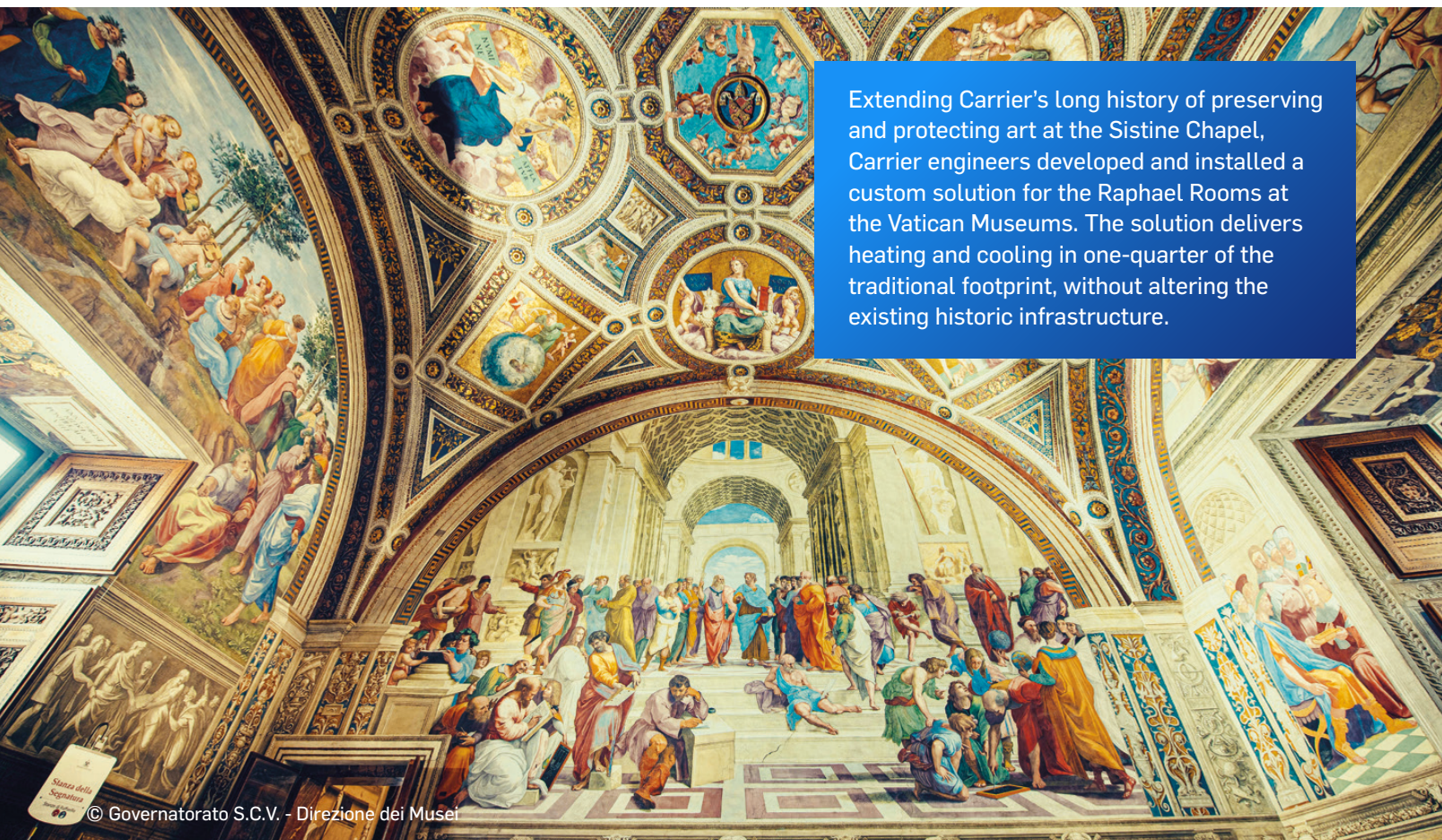
<sup>1</sup> See page 65 for additional information regarding non-GAAP measures.

Our HVAC businesses are constantly innovating solutions that matter for people and our planet.

As part of our Healthy Homes offerings, Carrier launched the Infinity return air purifier to improve indoor air quality and inactivate 99% of certain airborne viruses and pathogens in filtered air.<sup>2</sup> The solution is installed and mounted in the return air duct, allowing for convenient filter cartridge replacement.

Carrier introduced the AquaEdge 19MV, a water-cooled centrifugal chiller available with oil-free magnetic bearings and a compact footprint for easy installation. The chiller provides an expanded operating range, performing reliably and efficiently even in extreme conditions and when there is heavy cooling demand. It features an intelligent control panel that connects to building automation systems. Carrier's BluEdge digital service offerings help achieve optimal performance and a smaller carbon footprint.

The Carrier XCT7 variable refrigerant flow (VRF) system launched in Europe as well as India and Malaysia. It delivers high energy efficiency and the ability to scale to meet climate control needs, from single-family



Extending Carrier's long history of preserving and protecting art at the Sistine Chapel, Carrier engineers developed and installed a custom solution for the Raphael Rooms at the Vatican Museums. The solution delivers heating and cooling in one-quarter of the traditional footprint, without altering the existing historic infrastructure.

© Governatorato S.C.V. - Direzione dei Musei



residences to commercial high-rise buildings. The system is easy to install and connects to smart home systems for remote, intelligent control.

The HVAC segment attained many key wins throughout the year.

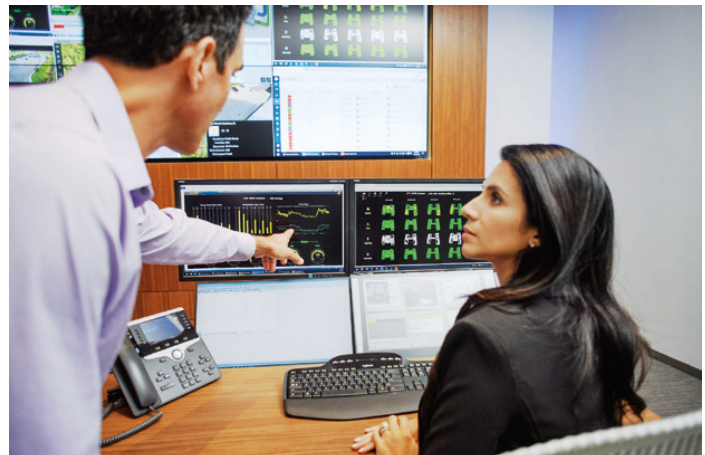
Tamdeen Group selected Carrier to supply HVAC solutions for the development of The Warehouse Mall in Kuwait – one of Carrier's largest Healthy Buildings project wins in the Middle East. It includes chillers, fan coil units and air-handling units with UVC emitters, which help deactivate bacteria, viruses and other pathogens in the air.

Meritage Homes chose Carrier as its exclusive HVAC provider, becoming the first publicly traded homebuilder to offer a multispeed HVAC system as the standard in new homes in the United States. The system is more energy-efficient than traditional single-stage systems, and is designed to reduce operating costs and environmental impact.

We also completed strategic acquisitions in our HVAC business portfolio.

Carrier acquired Guangdong Giwee Group to accelerate growth in the rapidly expanding VRF and light commercial market. The acquisition combines Giwee Group's technology with Carrier's significant technical capabilities and global networks.

We acquired Nlyte Software. Nlyte's data center infrastructure management software and Automated Logic's WebCTRL building automation technology create an integrated solution that monitors and controls power and cooling systems to optimize data center operations and improve energy efficiency. The intelligent solution also provides opportunities for digitally enabled recurring revenues.



Automated Logic released WebCTRL for Life Sciences, an indoor environmental control system that helps pharmaceutical, biotechnical and biomedical firms ensure compliance with United States Food and Drug Administration (FDA) requirements for electronic records. The system closely monitors and controls temperature, humidity, pressure and airflow in FDA-regulated facilities such as hospitals and laboratories.

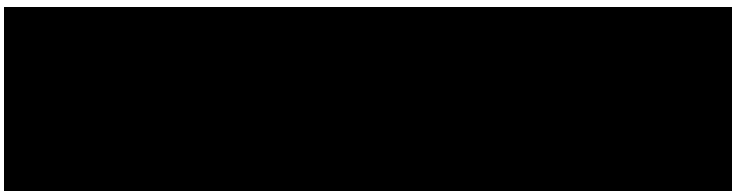
<sup>2</sup> The Infinity air purifier has demonstrated effectiveness against the murine coronavirus, based on third-party testing (2020) showing a >99% inactivation, which is a virus similar to the human novel coronavirus (SARS-CoV-2) that causes COVID-19. Therefore, the Infinity air purifier can be expected to be effective against SARS-CoV-2 when used in accordance with its directions for use. Third-party testing (2012, 2007) also shows ≥99% inactivation for the type of virus that causes common colds, *Streptococcus pyogenes* and human influenza. Airborne particles must flow through your HVAC system and be trapped by the MERV 15 Infinity filter to be inactivated at 99%. Learn how it works at [carrier.com/purifier](https://carrier.com/purifier).



Abound, a cloud-based building solution and platform, was launched as part of Carrier's Healthy Buildings offerings to help provide occupants with confidence in their indoor environments. The platform connects directly to existing building systems and sensors and provides real-time actionable data in a smart, simple interface. Building operators can measure performance related to air quality, ventilation and humidity against thresholds, including the WELL Building Standard, a leading global benchmark for healthy buildings.

# Refrigeration

Carrier's Refrigeration segment provides a more healthy, safe, sustainable and intelligent cold chain through the reliable transport and preservation of food, medicine and other perishable goods. Our refrigeration and monitoring products, services and digital solutions strengthen the connected cold chain and are designed for trucks, trailers, shipping containers, intermodal applications, food retail and warehouse cooling.



<sup>1</sup> See page 65 for additional information regarding non-GAAP measures.

Our Refrigeration businesses continue to innovate electric transport solutions that help customers avoid greenhouse gas emissions and comply with evolving regulations.

In North America, Carrier introduced innovations that drive sustainability. The Supra zero-emission electric truck refrigeration unit delivers performance on par with conventional diesel systems while eliminating the associated fuel consumption and noise. Carrier also developed a lithium-ion auxiliary power unit to reduce engine idling while keeping drivers comfortable.

In Europe, Carrier collaborated on a zero-emission refrigerated transport project that entered road testing. The project's refrigeration unit, which is powered by a hydrogen fuel cell, offers a more sustainable alternative to diesel engines.

Carrier also entered a strategic agreement with AddVolt to use the company's battery-electric technology to develop sustainable transport refrigeration solutions for customers in Europe. AddVolt's technology is compatible with Carrier's Lynx digital platform, which was developed in collaboration with Amazon Web Services Inc. and allows



Carrier's PowerCO<sub>2</sub>OL system won the gold Innovation of the Year award at ATMosphere's Natural Refrigerants Trade Show. The award recognizes products expected to have a significant impact on the industry and the environment. The PowerCO<sub>2</sub>OL system for high-capacity applications uses natural carbon dioxide refrigeration and provides up to 30% energy savings.



customers to leverage data to improve the effectiveness, efficiency and sustainability of their supply chains.

The Refrigeration segment achieved several key wins throughout the year.

Original equipment manufacturer Gray & Adams completed the first field trial program for the Carrier Vector eCool system, the industry's only fully autonomous, all-electric refrigerated trailer. It produces no direct carbon dioxide or particulate emissions and complies with regulations that limit operating noise. Following the trial, long-standing Carrier distributor THT New Cool B.V. became the first rental company in Europe to supply trailers equipped with Vector eCool units. By the end of 2021, Vector eCool units were on the road in 10 European countries.

## ~1.8M Carrier transport refrigeration UNITS IN OPERATION worldwide

Cleveron selected Carrier NaturaLINE refrigeration units to provide sustainable cooling for its touchless grocery kiosks. NaturaLINE is the world's first and only container refrigeration system to use natural refrigerant carbon dioxide, which has the lowest global warming potential among all container system refrigerants in use. The units are helping Cleveron's customers, including large multinational grocery retailers, achieve their sustainability goals, such as carbon neutrality.

Xin Yu Lou Department Store Group Co. Ltd. selected Carrier to provide an energy-efficient refrigeration system to preserve perishable goods at its new flagship store in China, extending the company's relationship with Carrier. The system features patented defrosting technology



Carrier's Lynx digital platform was recognized among Fast Company's 2021 World Changing Ideas, which focuses on social good and solutions that make the world better.

SeaCube became the first intermodal equipment leasing company to incorporate Carrier's Lynx Fleet solution into its operations to deliver enhanced digital capabilities for 2,000 PrimeLINE refrigerated container units. The system includes proprietary technology that intelligently monitors transport refrigeration unit performance from anywhere in the world, and provides actionable diagnostics and predictive analytics to improve cold chain operations, improve fleet uptime, reduce operational costs and reduce cargo spoilage.

that reduces energy consumption and temperature fluctuations to help keep food at optimal temperatures. In addition, remote monitoring services enhance performance and efficiency.



Tribe Transportation, one of the fastest-growing minority-owned carriers in North America, significantly expanded its fleet of trailers equipped with Carrier X4 refrigeration units to help meet the growing demand for the safe storage and transport of pharmaceutical products. The agreement also includes sustainable solutions, such as solar charging systems and ComfortPro auxiliary power units that help reduce emissions.





## Fire & Security

Carrier's Fire & Security segment provides a wide range of residential, commercial and industrial technologies designed to help save lives and protect people and property. Our globally recognized brands provide comprehensive solutions, including installation and maintenance, web-based and mobile applications, and cloud-based services.

Our Fire & Security businesses continue to develop innovative solutions that strategically advance our product portfolio.

In the commercial fire business, Edwards introduced the latest update of EST4, an advanced networked fire alarm and emergency communications platform. The upgrade supports larger installations and offers customers flexibility for future growth. The system integrates with other building systems such as the LenelS2 OnGuard access control system.

With sustainability in mind, Kidde Fire Systems added new fire suppression agent options to its Natura Inert Gas System. They include pure inert gases and blends that are found naturally in the atmosphere, with an ozone depletion potential of zero and a global warming potential of zero. The system is efficient to install and has an economical refill cost after a discharge.

In China, the innovative Kidde MOON series of smart, safe and healthy home devices launched, marking Kidde's entrance into China's growing market for smart home products. The series includes smoke detectors as well as

<sup>1</sup> See page 65 for additional information regarding non-GAAP measures.



Kidde launched a smoke and carbon monoxide alarm with smart features that allow customers to manage their alarms from anywhere using the new Kidde app. The alarm can connect to Kidde's hardwired interconnected alarms and will sound and send a mobile notification if an alarm in any room goes off.<sup>2</sup>

<sup>2</sup> Alarms only connect with other Kidde alarms that have hardwired AC interconnect capability.

gas, temperature, relative humidity, water leak and motion detectors, for an enhanced holistic home health experience and convenient monitoring through connectivity to a mobile application.

The Fire & Security businesses secured several key wins throughout the year.

Marioff installed a HI-FOG water mist fire protection system in Germany's tallest residential building in Frankfurt am Main. The sustainable system fights fires as effectively as traditional sprinkler systems, but with less water. It helps protect the Grand Tower's apartments and technical areas, parking garage, retail shops, the grand entrance area and a live cooking show area on a roof terrace. The project includes HI-FOG sprinklers and technologically advanced modular sprinkler pump units to ensure compliance with local codes for high-rise buildings.

Supra extended its agreement with the California Regional Multiple Listing Service. Real estate professionals who subscribe to the service can use the eKEY mobile app to connect with Supra lockboxes, facilitating seamless property access. Through the eKEY app, agents can securely set access hours, track lockbox inventory, customize codes and get real-time notifications on showings.

We optimized our Fire & Security business portfolio through strategic moves, including acquisitions and a divestiture.

We sold our Chubb business. The sale, which was completed in early 2022, enables us to focus on our core businesses and reinvest in strategic priorities.

The acquisition of BrokerBay, a leading digital real estate solutions provider, positioned Carrier to strategically combine Supra's market-leading mobile credentialing technology with BrokerBay's advanced, cloud-based real estate office management software. The integrated access solution optimizes scheduling for sellers, buyers



Edwards introduced ESTMobile, a software-as-a-service (SaaS) solution that remotely and securely connects service providers to Edwards iO fire control panels. The digital productivity tool is designed to provide insight into fire systems to improve responsiveness, predict service needs, reduce service costs and improve customer satisfaction.

and agents; provides real-time communication; delivers actionable insights; and helps improve agent productivity. These enhanced capabilities will drive recurring revenue.

Carrier also acquired Cavius, an innovative Danish residential alarm company that provides a complete range of smoke, heat, flood and carbon monoxide alarms, including the world's smallest photoelectric smoke alarm. Cavius further enhances Carrier's Healthy Homes fire safety product offerings with additional interconnected technologies.



LenelS2 released the Elements system, a cloud-based access control and video surveillance solution. By leveraging the cloud, business customers benefit from automated updates, reduced on-site maintenance, predictable monthly billing and minimized training requirements.

# Aftermarket

Aftermarket is central to Carrier's growth strategy and a key differentiator across our businesses. We offer a broad portfolio of aftermarket solutions and services, including spare parts, preventive maintenance, repairs, modifications and upgrades, rentals, remote monitoring and other digital services to support customers across the entire product lifecycle.

We continued to expand our BluEdge service platform offerings and geographical reach to support customers globally. Digital solutions are enabling our BluEdge offerings to increase service coverage and traction across our three segments. We have signed nearly 30,000 BluEdge agreements since mid-2020 when we launched the program, and longer-term customer relationships are also growing our mix of recurring revenues.

Our commercial HVAC business had over 60,000 chillers under service contracts in 2021, and Carrier and CIAT launched BluEdge in Europe to help customers maximize equipment performance.

We also launched a digital tiered service offering that can stand alone or be added to existing BluEdge service agreements. It connects HVAC equipment to Carrier's cloud-based Internet of Things platform, providing advanced analytics and actionable insights to visualize, optimize and make recommendations on machine health and lifecycle outcomes.

Our Refrigeration segment launched BluEdge for truck trailer customers in North America in 2020 and has since expanded to Europe and Australia. The platform leverages actionable intelligence from Lynx to maximize uptime and operational efficiencies. Carrier signed a three-year BluEdge service contract with Scott's Refrigerated Logistics, Australia's largest national refrigerated transport fleet.

In our Fire & Security segment, Det-Tronics and Autronica launched the BluEdge service platform to provide service over the lifecycle of customers' equipment and systems.



Carrier achieved **double-digit** aftermarket growth in 2021, and our service coverage levels are at all-time highs.

# Digital

Carrier is harnessing the power of digital technologies to make the places people live, work, learn and play more resilient and responsive.

At Carrier, we are unlocking siloed equipment data, creating intelligence through advanced analytics and launching connected platforms that solve critical challenges for customers.

Digital is driving business growth by enabling recurring revenues and empowering our teams to innovate at scale. Our turnkey suite of cloud-based services helps us connect equipment and accelerate software development.

Our new Abound cloud-native platform unlocks and unites building data to create more healthy, safe, sustainable and intelligent solutions for indoor spaces. It gathers data

from disparate systems, sensors and sources; identifies opportunities to optimize performance; and works with healthy building solutions to improve occupant experiences. Abound's suite of SaaS applications provides opportunities to produce subscription-based revenue for Carrier and to expand our installed base of connected devices.

We continued our collaboration with Amazon Web Services on Lynx, Carrier's digital platform that supports end-to-end visibility across the cold chain, and we launched Lynx Fleet in Europe to provide customers with transparency into asset location and performance.

Carrier is increasingly recognized as a digital leader. Our EcoEnergy Insights business won Best Predictive Analytics Platform by AI Breakthrough, a market intelligence organization. As our digital transformation continues, industry-leading cybersecurity remains essential. Carrier was designated as a Common Vulnerabilities and Exposures Numbering Authority by the Cybersecurity and Infrastructure Security Agency.



# Innovation

Building upon our history of innovation, Carrier is accelerating the development of healthy, safe, sustainable and intelligent building and cold chain solutions. We develop frontier technologies, design with the product lifecycle in mind and continuously enhance our products to anticipate changes in environmental regulations.

At Carrier, we enable growth by aligning innovation with key secular trends, expanding our current markets and growing in adjacent ones.

In 2021, we released more than 130 new products. We have approximately 9,000 active patents and pending patent applications worldwide combined, and in the last three years, we have invested over \$1.3 billion in research and development.

Recent innovations include differentiated solutions that use refrigerants with a lower global warming potential,

a chiller available with oil-free magnetic bearings, digital solutions and platforms that provide greater control of home and building health, and electric transport equipment that helps customers avoid greenhouse gas emissions.

We continue to invest in new capabilities and education to foster innovation across our company. We are advancing knowledge in controls, systems engineering and electrification, and reimagining our tools that help release software products faster, enhance customer satisfaction and optimize engineering costs.

Carrier is also committed to partnerships that support technology advancements around the world. We participate in early-stage innovation with thought leaders, startups, universities and innovation hubs. This includes research leading to insights that can create healthier indoor environments, along with our involvement in the U.S. Department of Energy's Cold Climate Heat Pump Technology Challenge, which aims to reduce the carbon footprint of cold climate heating solutions by improving the efficiency and affordability of new heat pumps.

# Operations

Carrier Excellence is our continuous improvement engine that drives operational excellence across our company, enhances customer experiences, enables growth and engages employees in problem-solving to achieve breakthrough performance results.

We continue to advance a sustainable performance culture across our supply chain and throughout our facilities.

Carrier has devoted significant resources to enhance supply chain management and localized certain categories to keep costs down and reduce logistics cost and complexity. We expanded dual sourcing of critical components and invested in digital tools that increase visibility and drive proactive actions across our factories and supply chain.

As we strive for operational excellence, we also remain dedicated to ESG efforts. We are actively engaging with our

In 2021, we invested more than **\$30 million** in automation projects and had more than **3 million** aggregate manufacturing hours under automation.

suppliers to develop a world-class supplier sustainability program, and we met our initial goal of assessing 80% of our direct factory spend against ESG topic areas, including labor practices, human rights, ethics, energy, climate, water and more.

In addition, we are focused on product safety and quality, along with health and safety excellence throughout our facilities. Our factories undergo an in-depth quality assessment to ensure compliance with our standards, and our Lead with Safety program includes nine safety commitments that empower our employees to stop work if any task cannot be performed safely. The program helps us uphold our 2030 ESG goal to maintain world-class safety metrics.

# 2030 Environmental, Social & Governance Goals

Our 2030 ESG goals underscore our commitment to the things that matter and to continuously challenge ourselves to think bigger and to be better. Expanding on three decades of environmental targets, our goals include measures to improve our planet, our people and our communities. We strive to be a catalyst for positive and sustainable change as we innovate, empower our people and operate with integrity. That is *The Carrier Way*.

Learn about our progress at  
[corporate.carrier.com/esg-report](https://corporate.carrier.com/esg-report)

## Our Planet

Climate change is among the most significant issues facing humanity. HVAC contributes an estimated 15% of the world's greenhouse gas emissions. More than one-third of all food produced is wasted every year, resulting in an estimated 4.4 gigatons of greenhouse gas emissions.

**We recognize the potential for smart, sustainable innovation, and are committed to setting science-based emissions targets aligned with the goals of the Paris Agreement.**

- Reduce our customers' **carbon footprint** by **more than 1 gigaton**.
- Invest over **\$2 billion** to develop **healthy, safe, sustainable and intelligent building and cold chain solutions** that incorporate **sustainable design principles and reduce lifecycle impacts**.
- Achieve **carbon neutral** operations.
- Reduce **energy intensity** by 10% across our operations.
- Achieve **water neutrality** in our operations, prioritizing water-scarce locations.
- Deliver **zero waste** to landfill from manufacturing locations.
- Establish a **responsible supply chain program** and assess key factory suppliers against program criteria.

## Our People

Our greatest strength is the diversity of our employees and their ideas. We are a company of innovators and problem-solvers who are united by *The Carrier Way* – our purpose, values and culture.

- Exceed benchmark **employee engagement**.
- Achieve **gender parity** in senior leadership roles.
- Achieve a **diverse workforce** that represents the communities in which we live and work.
- Foster the growth of **Employee Resource Groups (ERGs)** to drive social impact.
- Maintain world-class **safety metrics**.

## Our Communities

Decades of leadership in sustainability have guided Carrier to the forefront of healthy buildings, healthy homes and a more connected cold chain. Throughout our global operations, we are reducing our environmental footprint and making investments that have a positive impact on society.

- Positively impact communities by enabling access to **safe and healthy indoor environments, alleviating hunger and food waste, and volunteering our time and talent**.
- Invest in **science, technology, engineering and math education** programs that promote **diversity and inclusion**.
- Promote **sustainability** through education, partnerships and climate resiliency programs.

# Sustainability

At Carrier, we are driving sustainability in buildings and homes and across the cold chain. We continue to deliver innovative products and services that help customers avoid greenhouse gas emissions, while reducing our own environmental footprint throughout our global operations. By meeting the moment, we are inspiring confidence in a brighter future.

We are helping address global challenges by innovating solutions and services that enable our customers to achieve their sustainability goals and by making sustainable enhancements across our operations.

Our efficient solutions and intelligent building systems reduce energy consumption and resulting emissions, and the use of advanced, connected technologies and lower global warming potential refrigerants are contributing to a more healthy, safe, sustainable and intelligent cold chain. These solutions, along with our overall ESG progress, led to Newsweek recognizing Carrier as one of America's Most Responsible Companies.

Carrier is advancing toward our goal of helping our customers avoid more than 1 gigaton of greenhouse gas emissions by 2030. Learn more at [corporate.carrier.com/gigaton-goal](https://corporate.carrier.com/gigaton-goal)

In Indianapolis, our manufacturing site achieved zero waste to landfill certification by converting waste to energy and other uses. Carrier set a goal to deliver zero waste to landfill for more than 50 global manufacturing sites as part of our 2030 ESG goals.

Carrier is helping advance global progress toward sustainability and energy efficiency through research and thought leadership. We participated in events such as the World Cold Chain Symposium, the India Green Building Council's Green Building Congress and Energy Action Day. We also sponsored a study from Dodge Data & Analytics that confirms healthy and sustainable buildings remain a priority for the global design and construction industry.



Carrier's Center for Intelligent Buildings became the first commercial building in Florida to earn the highest designation in the areas of health and well-being, as well as energy and environmental performance. The building was awarded the WELL Platinum Certification from the International WELL Building Institute. It was previously recognized as the first commercial building in the state to earn Leadership in Energy and Environmental Design Platinum Certification. It is one of six commercial buildings in the country with both designations.

# Our People & Culture

At Carrier, our diverse employees are our greatest strength and source of innovation as we work as one team toward a common purpose – united by *The Carrier Way*.

As an employer of choice, Carrier is committed to attracting, developing and retaining world-class talent, and fostering a diverse and inclusive culture that drives teamwork and sparks innovation for our customers.

*The Carrier Way* is the foundation of everything we do. It defines our vision, reaffirms our values, describes the behaviors that create a winning culture, and establishes how we work and win together. We introduced a series of new education courses to reinforce behaviors in *The Carrier Way* that are critical to our success, such as having a passion for customers and building the best teams.



We continue to advance our inclusion and diversity (I&D) strategy. Carrier remains steadfast in our goal to create a workplace that is truly and genuinely inclusive, and where all employees feel like they *\_belong*,

which is our I&D philosophy and brand. Our strategy consists of four key tenets: Reduce the Gap, Develop & Sponsor, Drive Inclusion and Lean Forward.

To ensure continued progress in these areas, we are holding ourselves accountable by increasing transparency through additional metrics and reporting. We added more disclosures to our ESG Report and connected executive incentive compensation to progress against our ESG goals. To supplement our existing team of Ethics & Compliance Officers, we established a unique I&D Champions Program featuring a global group of trained professionals who are available if employees have concerns about actions related to our I&D commitments.

To strengthen our diverse talent pipeline, we participated in recruiting events with the National Society of Black Engineers, where we serve on the Board of Corporate Affiliates, and with the Society of Hispanic Professional Engineers and the Society of Women Engineers. Additionally, we established several new scholarship programs at historically Black colleges and universities (HBCUs), including North Carolina Agricultural & Technical State University and Spelman College, and through a collaboration with the Atlanta University Center Consortium, the country's largest and oldest consortium of HBCUs.

Carrier remains dedicated to listening to our employees, reviewing their feedback and taking action to achieve continuous improvement. We conduct our *Pulse* global engagement survey multiple times a year. In 2021, we launched our first stand-alone Diversity, Inclusion & Belonging *Pulse* online global engagement survey and introduced an inclusion score to measure our progress in creating an environment for employees of all backgrounds to thrive at Carrier. Our inclusion score ranked above external benchmarks, an encouraging sign in our journey toward ensuring that our employees feel like they *\_belong* at Carrier. Through our new "You Said. We Did." internal campaign, we highlight improvements made across the company in response to employee feedback.

We also create opportunities for open dialogue between employees and executives. As part of our ongoing commitment to the CEO Action for Diversity & Inclusion pledge, we held a "Day of Understanding" where Carrier executives and employees engaged in conversations about driving I&D into our company's DNA and creating a culture of allyship.

## Our Progress on Reducing the Gap

	2015	2021
Global executive diversity*	27%	48%
Global women executives	20%	32%
U.S. People of Color executives	13%	27%
U.S. People of Color professionals	18%	24%

\* Global women or U.S. People of Color.



At Carrier, we invest in our people through employee development and continuous learning programs. Our **ELEVATE: Women in Leadership** development program, which engages women around the world in continued leadership learning and education, graduated its second cohort of participants, and our first cohort of professionals graduated from **ELEVATE: Blacks in Leadership**.

Carrier achieved a perfect score on the Human Rights Campaign Foundation's 2021 Corporate Equality Index and a **Best Place to Work for LGBTQ Equality** designation.

We significantly increased participation in our global Talent Possible programs that support leadership development at three critical career stages: early career, mid-career and senior leadership. Other new programs include a global mentorship program for all employees and a New People Manager Program for employees with less than two years of experience managing others. Our people manager program helps participants learn to embody and lead with *The Carrier Way* values, enabling themselves and their teams to be successful.



In partnership with our **Carrier Hispanics & Latinos Employee Engagement Resource group**, Carrier signed the Hispanic Promise, joining other Fortune 500 companies in the pledge to hire, retain and support the development of Hispanics in the workplace.



HISPANICS\_belong

Our other Employee Resource Groups also led grassroots efforts to solve problems and enhance our position in the marketplace.



BLACKS\_belong

- **Carrier Black Alliance** donated books written by Black authors to elementary schools and visited schools to read to students.



MILITARY & VETERANS\_belong

- **Military & Veterans ERG** hosted discussions about leadership in adversity and about Carrier's Employee Assistance Program.



LGBTQIA+\_belong

- **Global Pride ERG** organized flag-raising ceremonies at over 20 Carrier locations around the world in support of our LGBTQIA+ employees.



WOMEN\_belong

- **Women Empowerment at Carrier** held events in 22 countries to help accelerate women's leadership and empower women to address unique workplace challenges.



ASIANS\_belong

- **United Carrier Asian Network** launched as a new ERG.



# Corporate Responsibility

Carrier is committed to making the world more healthy, safe, sustainable and intelligent for generations to come. As we innovate to solve for the planet's critical challenges, we remain focused on our responsibility to positively impact society by empowering our employees and enriching communities.

In 2021, Carrier supported more than 200 civic, cultural, economic and social welfare organizations around the world. We invested over \$6 million in our communities through cash and in-kind donations, including over \$1.2 million through the Carrier Employee Matching Gifts Program, a dollar-for-dollar charitable donation program.

During a staggering rise in COVID-19 cases in India, employees donated to relief efforts through a matching gifts campaign that helped send healthcare workers and equipment to communities in need.

Carrier donated OptiClean air scrubber units to the Syracuse City School District in New York to improve indoor air quality for students and staff. The portable units pull in air, scrub it using a HEPA filter and then exhaust cleaner air back into the classroom, delivering a more healthy, safe and productive learning environment.

We are empowering and developing future HVAC technicians through a new collaboration with the Building Talent Foundation. The programs promote HVAC careers

Our philanthropic giving aligns with our 2030 ESG goals. Focus areas include:

Sustainability

Safety and security

Inclusion and diversity

Science, technology, engineering and math

Healthy buildings and healthy homes

Hunger and food waste

Disaster relief

Vibrant communities

to youth and underrepresented populations, align training with industry needs and build engagement through career advancement opportunities.

Our company has provided local Habitat for Humanity organizations with financial support, product donations from our Healthy Homes suite of indoor air quality solutions and countless employee volunteer hours. In 2021, Carrier made a \$250,000 donation to Habitat's Home is the Key campaign to help families build safe, affordable homes.

We continue to support research that examines the benefits of healthy indoor environments. A new study on healthy buildings found that enhanced ventilation can improve the cognitive function and health of occupants. In addition, we supported research by the 21st Century School Fund, the International WELL Building Institute and the National Council on School Facilities that shined a light on the need for air quality and safety upgrades in schools.



Carrier is helping The Nature Conservancy make cities more resilient, healthy and equitable. As part of our ongoing three-year, \$3 million commitment, Carrier employees participated in a beach cleanup. Volunteers collected trash to help beautify the area and protect wildlife, including sea turtles that use the preserve as a nesting beach.

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# Financials

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The financial information included herein should be read in conjunction with the financial statements and notes in our Annual Report on Form 10-K for calendar year 2021.

# Management's Discussion and Analysis

## BUSINESS OVERVIEW

### Business Summary

Carrier Global Corporation is a leading global provider of healthy, safe, sustainable and intelligent building and cold chain solutions. Our portfolio includes industry-leading brands such as Carrier, Kidde, Edwards, LenelS2, Carrier Transicold and Automated Logic that offer innovative HVAC, refrigeration, fire, security and building automation technologies to help make the world safer and more comfortable. We also provide a broad array of related building services, including audit, design, installation, system integration, repair, maintenance and monitoring. Our operations are classified into three segments: HVAC, Refrigeration and Fire & Security.

Our worldwide operations are affected by global and regional industrial, economic and political factors and trends. These include the mega-trends of urbanization, climate change and increasing requirements for food safety driven by the food needs of our growing global population and the rising standards of living in emerging markets. We believe that our business segments are well positioned to benefit from favorable secular trends, including these mega-trends and from the strength of our industry-leading brands and track record of innovation. In addition, we regularly review our markets to proactively identify trends and adapt our strategies accordingly.

Our business is also affected by changes in the general level of economic activity, such as changes in business and consumer spending, construction and shipping activity as well as short-term economic factors such as currency fluctuations, commodity price volatility and supply disruptions. However, we continue to invest in our business, take pricing actions to mitigate supply chain and inflationary pressures, develop new products and services in order to remain competitive in our markets and use risk management strategies to mitigate various exposures. We believe that we have industry-leading global brands, which form the foundation of our business strategy. Coupled with our focus on growth, innovation and operational efficiency, we expect to drive long-term future growth and increased value for our shareowners.

### Recent Developments

#### Supply Chain Challenges

The ongoing global economic recovery from the COVID-19 pandemic has caused significant challenges for global supply chains resulting in inflationary cost pressures, component shortages and transportation delays. As a result, we have incurred incremental costs for commodities and components used in our products as well as component shortages and higher freight costs that have negatively impacted our sales and results of operations. We expect that these challenges will continue to have an impact on our business for the foreseeable future.

We continue to take proactive steps to limit the impact of these challenges and are working closely with our suppliers to ensure availability of products and implement other cost savings initiatives.

In addition, we continue to invest in our operations and supply chain to improve its resilience with a focus on automation, dual sourcing of critical components and localized manufacturing when feasible. To date, there has been moderate disruption to the availability of our products, though it is possible that more significant disruptions could occur if these supply chain challenges continue.

#### Sale of Chubb Fire & Security Business

On January 3, 2022, we completed the sale of Chubb to APi pursuant to a stock purchase agreement for an enterprise value of \$3.1 billion. Chubb, reported within our Fire & Security segment, delivers essential fire safety and security solutions from design and installation to monitoring, service and maintenance across more than 17 countries around the globe. As a result, the operations of Chubb are included in our 2021 consolidated results of operations. However, the assets and liabilities of Chubb are presented as held for sale in the accompanying Consolidated Balance Sheet as of December 31, 2021. The purchase price is subject to working capital and other adjustments as provided in the Chubb Sale Agreement. Consistent with our capital allocation strategy, the net proceeds of approximately \$2.6 billion will be used to fund investments in organic and inorganic growth initiatives and capital returns to our shareowners as well as for general corporate purposes.

#### Separation from United Technologies Corporation

On April 3, 2020, UTC completed the Separation of Carrier into an independent publicly traded company. In connection with the Separation, we issued an aggregate principal balance of \$11.0 billion of debt and transferred approximately \$10.9 billion of cash to UTC on February 27, 2020 and March 27, 2020. In addition, we entered into several agreements with UTC and Otis that govern various aspects of the relationship among us, UTC and Otis following the Separation and the Distribution including the TSA (which expired on March 31, 2021), the TMA, an employee matters agreement and an intellectual property agreement. Income and expense under these agreements are not material. On April 1, 2020 and April 2, 2020, we received cash contributions totaling \$590 million from UTC related to the Separation.

Our financial statements for periods prior to the Separation and the Distribution are prepared on a "carve-out" basis and include all amounts directly attributable to Carrier. Net cash transfers and other property transferred between UTC and us, including related party receivables and payables between us and other UTC affiliates, are presented as *Net transfers to UTC*. In addition, the financial statements include allocations of costs for administrative functions and services performed on our behalf by centralized groups within UTC. All allocations and estimates in the Consolidated Financial Statements are based on assumptions that management believes are reasonable. Our financial statements for the periods subsequent to April 3, 2020 are consolidated financial statements based on the reported results of Carrier as a stand-alone company. See Note 2 – Basis of Presentation in the accompanying Notes to the Consolidated Financial Statements in this Annual Report on Form 10-K for additional information.

### Impact of the COVID-19 Pandemic

In early 2020, the World Health Organization declared the outbreak of a respiratory disease known as COVID-19 as a global pandemic. In response, many countries implemented containment and mitigation measures to combat the outbreak, which severely restricted the level of economic activity and caused a significant contraction in the global economy. As a result, we temporarily closed or reduced production at manufacturing facilities across the globe to ensure employee safety and instructed non-essential employees to work from home. In addition, we took several preemptive actions during 2020 to manage liquidity as demand for our products decreased. Despite the adverse impacts of the pandemic on our results beginning in the first quarter of 2020, manufacturing operations resumed and several restorative actions were completed during 2020 including the reinstatement of annual merit-based salary increases and continued investment to support our strategic priorities.

We continue to focus our efforts on preserving the health and safety of our employees and customers as well as maintaining the continuity of our operations. In addition, we continue to actively monitor our liquidity position and working capital needs and believe that our overall capital resources and liquidity position are adequate. The preparation of financial statements requires management to use judgments in making estimates and assumptions based on

the relevant information available at the end of each period, which can have a significant effect on reported amounts. However, due to significant uncertainty surrounding the pandemic, including a resurgence in cases and the spread of COVID-19 variants, management's judgments could change. While our results of operations, cash flows and financial condition could be negatively impacted, the extent of any continuing impact cannot be estimated with certainty at this time.

### RESULTS OF OPERATIONS

This discussion summarizes the significant factors affecting our consolidated results of operations, financial condition and liquidity for the year ended December 31, 2021 compared with December 31, 2020. This discussion should be read in conjunction with Item 8, the Consolidated Financial Statements and the accompanying Notes to the Consolidated Financial Statements in this Annual Report on Form 10-K. A detailed discussion of the year ended December 31, 2020 compared with December 31, 2019 is not included herein and can be found in the Management's Discussion and Analysis section in the Company's 2020 Annual Report on Form 10-K, filed with the SEC on February 9, 2021, under the heading "Results of Operations," which is incorporated herein by reference.

### Year Ended December 31, 2021 Compared with Year Ended December 31, 2020

The following represents our consolidated *net sales* and operating results:

#### Net Sales

For the year ended December 31, 2021, *Net sales* was \$20.6 billion, an 18% increase compared with 2020. The components of the year-over-year change were as follows:

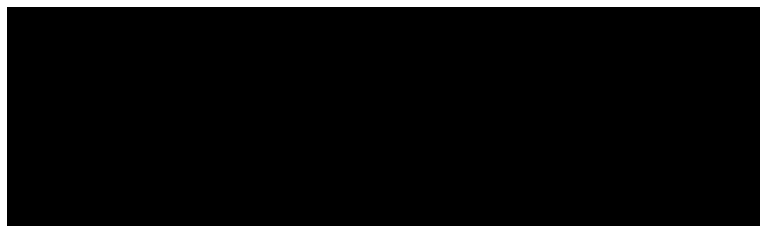
	2021
Organic / Operational	15%
Foreign currency translation	2%
Acquisitions and divestitures, net	1%
<b>Total % change</b>	<b>18%</b>

For the year ended December 31, 2021, higher volumes and pricing improvements in each of our segments increased organic sales by 15% compared with 2020. The organic increase was primarily driven by our HVAC segment with strong demand in our North America residential and light commercial business and improved global end-markets in our Commercial HVAC business. Higher sales in our Refrigeration and Fire & Security segments were driven by improved global end-markets. Results for 2021 reflected a significant rebound in demand after initial weakness during the first half of 2020 due to the COVID-19 pandemic and current demand remains strong. However, supply chain and logistic constraints continue to be

challenging, negatively impacting our sales and results of operations. For additional discussion on the segment results for 2021, see the section entitled "Segment Review."

### Gross Margin

For the year ended December 31, 2021, gross margin was \$6.0 billion, a 17% increase compared with the same period of 2020. The components were as follows:

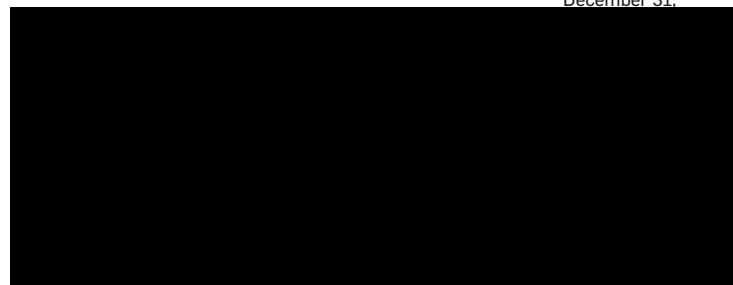


The increase in gross margin for the year ended December 31, 2021 was primarily driven by continued improvement in the global economic climate during the current period. Higher volumes and pricing improvements in each of our segments outpaced operational costs as we continued to focus on Carrier 700 cost containment actions. However, each of our segments was impacted by the rising cost for commodities and components used in our products, certain supply chain constraints and higher freight costs particularly in the second half of the year. As a result, gross margin as a percentage of *Net sales* decreased by 30 basis points compared with the same period of 2020.

### Operating Expenses

For the year ended December 31, 2021, operating expenses, including *Equity method investment net earnings*, was \$3.3 billion, a 65% increase compared with the same period of 2020. The components were as follows:

For the Year Ended  
December 31,



For the year ended December 31, 2021, *Selling, general and administrative* expenses were \$3.1 billion, an 11% increase compared with the same period of 2020. At the onset of the COVID-19 pandemic, we initiated various cost containment initiatives in order to help mitigate the impacts on our business, which included reducing discretionary spending, employee furloughs and temporarily closing or limiting the presence of our workforce in our facilities. As a result, the increase in *Selling, general and administrative* expense in the current period reflects the gradual return to our operational spending levels prior to the COVID-19 pandemic. In addition, higher

compensation and restructuring costs as well as transaction costs of \$43 million associated with the divestiture of our Chubb business further contributed to the year-over-year increase. Costs associated with the Separation were \$20 million for the year ended December 31, 2021 compared with \$141 million for the same period of 2020.

*Research and development* costs relate to new product development and new technology innovation. Due to the variable nature of program development schedules, year-over-year spending levels can fluctuate. In addition, we continue to invest to prepare for future energy efficiency and refrigerant regulation changes and in digital controls technologies.

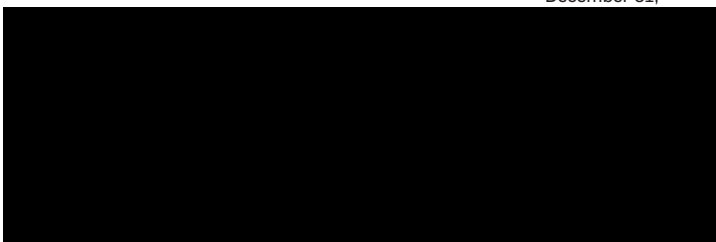
Investments over which we do not exercise control, but have significant influence, are accounted for using the equity method of accounting. For the year ended December 31, 2021, *Equity method investment net earnings* were \$249 million, a 20% increase compared with the same period of 2020. The increase was primarily related to higher earnings in HVAC joint ventures in Asia, the Middle East and North America as end-markets improved compared with the same period of 2020 and the absence of a 2020 product performance matter at one of our HVAC joint ventures. These increases were partially offset by the reduction in earnings resulting from the sale of our investment in Beijer REF AB ("Beijer") in 2020.

*Other income (expense), net* primarily includes the impact of gains and losses related to the sale of interests in our equity method investments, foreign currency gains and losses on transactions that are denominated in a currency other than an entity's functional currency and hedging-related activities. The twelve months ended December 31, 2020 included a \$1.1 billion gain on sale of our investment in Beijer. The gain was partially offset by a \$71 million other-than-temporary impairment charge on a minority-owned joint venture, an \$11 million charge resulting from a litigation matter and a \$12 million unfavorable impact for a change in the estimate of certain long-term liabilities. In addition, higher gains on hedging activities were partially offset by deferred compensation costs in the current period.

### Non-Operating Income (Expense), net

For the year ended December 31, 2021, Non-operating income (expense), net was \$245 million, a 7% increase compared with the same period of 2020. The components were as follows:

For the Year Ended  
December 31,



Non-operating income (expense), net includes the results from activities other than normal business operations such as interest expense, interest income and the non-service components of



pension and post-retirement obligations. Interest expense is affected by the amount of debt outstanding and the interest rates on that debt. For the year ended December 31, 2021, interest expense was \$319 million, a 7% increase compared with the same period of 2020. In connection with the Separation and the Distribution, we issued \$11.0 billion of long-term debt in February 2020. As a result, interest expense for the year ended December 31, 2020 only included interest expense incurred on such debt after the issuance date. In addition, we issued \$750 million of 2.70% long-term notes in June 2020. During the year ended December 31, 2021, we incurred a make-whole premium of \$17 million and write-off of \$2 million of unamortized deferred financing costs as a result of the redemption of our \$500 million 1.923% Notes originally due in February 2023.

### Income Taxes

	2021	2020
Effective tax rate	29.1%	29.7%

The effective tax rate for the year ended December 31, 2021 includes a net tax charge of \$157 million primarily relating to the re-organization and disentanglement of certain Chubb subsidiaries executed in advance of the planned divestiture of Chubb, a \$43 million deferred tax charge as a result of the tax rate increase from 19% to 25% in the United Kingdom, partially offset by a favorable tax adjustment of \$70 million due to foreign tax credits generated and expected to be utilized in the current year and \$21 million resulting from the re-organization of a German subsidiary.

Summary performance for each of our segments is as follows:

The effective tax rate for the year ended December 31, 2020 reflects a \$51 million charge related to a valuation allowance recorded against a United Kingdom tax loss and credit carry forward and a charge of \$46 million resulting from our decision to no longer permanently reinvest certain pre-2018 unremitted non-U.S. earnings.

### Segment Review

We have three operating segments:

- The HVAC segment provides products, controls, services and solutions to meet the heating, cooling and ventilation needs of residential and commercial customers while enhancing building performance, health, energy efficiency and sustainability.
- The Refrigeration segment includes transport refrigeration and monitoring products, services and digital solutions for trucks, trailers, shipping containers, intermodal applications, food retail and warehouse cooling, as well as commercial refrigeration products.
- The Fire & Security segment provides a wide range of residential, commercial and industrial technologies designed to help protect people and property.

We determine our segments based on how our Chief Executive Officer, who is the Chief Operating Decision Maker ("CODM"), allocates resources, assesses performance and makes operational decisions. The CODM allocates resources and evaluates the financial performance of each of our segments based on *Net sales* and *Operating profit*. Adjustments to reconcile segment reporting to the consolidated results are included in Note 21 - Segment Financial Data.

Net Sales | Operating Profit | Operating Margin

### HVAC Segment

For the year ended December 31, 2021, *Net sales* in our HVAC segment was \$11.4 billion, a 20% increase compared with the same period of 2020. The components of the year-over-year change were as follows:

	Net sales
Organic / Operational	17%
Foreign currency translation	1%
Acquisitions and divestitures, net	2%
<b>Total % change</b>	<b>20%</b>

The organic increase in *Net sales* of 17% was driven by improved results across each of our HVAC segment's businesses. Increased sales in our North America residential and light commercial business

(22%) were driven by new construction, the demand for our products by the ongoing stay-at-home workforce, higher distributor stocking levels and pricing improvements. Increased sales in our Commercial HVAC business (11%) benefited from the gradual improvement in the global economic environment as our end-markets continue to improve from the prior year impacts of the COVID-19 pandemic. Volume growth in Europe and Asia were the primary drivers of improved results during the period. Results for 2021 reflected a significant rebound in demand after initial weakness during the first half of 2020 due to the COVID-19 pandemic and current demand remains strong. However, supply chain and logistic constraints continue to be challenging, negatively impacting our sales and results of operations.

On June 1, 2021, the Commercial HVAC business completed the acquisition of Giwee. Giwee is a China-based manufacturer offering a portfolio of HVAC products including variable refrigerant flow, modular chillers and light commercial air conditioners. The results of Giwee have been included in our Consolidated Financial Statements since the date of acquisition. The transaction added 2% to *Net sales* for the year ended December 31, 2021. See Note 19 - Acquisitions in the accompanying Notes to the Consolidated Financial Statements in this Annual Report on Form 10-K for additional information.

For the year ended December 31, 2021, *Operating profit* in our HVAC segment was \$1.7 billion, a 29% decrease compared with the same period of 2020. The components of the year-over-year change were as follows:

	Operating profit
Organic / Operational	15%
Foreign currency translation	1%
Acquisitions and divestitures, net	(2)%
Restructuring	(1)%
Other	(42)%
<b>Total % change</b>	<b>(29)%</b>

The operational profit increase of 15% was primarily attributable to higher sales volumes and higher earnings from equity method investments compared with the same period of 2020. In addition, productivity initiatives and favorable product mix further contributed to the segment's results. Pricing improvements offset higher costs for commodities and components used in our products as well as higher freight costs experienced during the year. Higher selling, general and administrative costs and research and development impacted operational profit as our businesses return to normal spending levels as compared with the same period of 2020.

The decrease in Other of 42% primarily reflects the absence of a \$1.1 billion gain on the sale of our investment in Beijer in the prior year. In addition, the amounts reported in Other reflect the absence of a prior period non-cash, other-than-temporary impairment charge of \$71 million on a minority-owned joint venture investment due to a reduction in sales and earnings that were driven by a deterioration in the oil and gas industry (the joint venture's primary market) and the impact of the COVID-19 pandemic.

### Refrigeration Segment

For the year ended December 31, 2021, *Net sales* in our Refrigeration segment was \$4.1 billion, a 24% increase compared with the same period of 2020. The components of the year-over-year change were as follows:

	Net sales
Organic / Operational	21%
Foreign currency translation	3%
<b>Total % change</b>	<b>24%</b>

The organic increase in *Net sales* of 21% was driven by improved results across each of our Refrigeration segment's businesses. Transport refrigeration sales (28%) benefited from the continued recovery associated with the cyclical decline that began in late 2019 as well as a rebound in the demand for global transportation and COVID-19 vaccine-related cargo monitoring products. Commercial refrigeration sales (9%) also increased due to a rebound in demand. Results for 2021 reflected a significant rebound in demand after initial weakness during the first half of 2020 due to the COVID-19 pandemic and current demand remains strong. However, supply chain and logistic constraints continue to be challenging, negatively impacting our sales and results of operations.

For the year ended December 31, 2021, *Operating profit* in our Refrigeration segment was \$476 million, a 33% increase compared with the same period of 2020. The components of the year-over-year change were as follows:

	Operating profit
Organic / Operational	32%
Foreign currency translation	7%
Restructuring	(4)%
Other	(2)%
<b>Total % change</b>	<b>33%</b>

The increase in operational profit of 32% was primarily attributed to higher sales volumes compared with the same period of 2020, which was heavily impacted by the COVID-19 pandemic. In addition, pricing improvements also contributed to the increase. These increases were partially offset by higher costs for commodities and components used in our products and higher freight costs. Higher selling, general and administrative costs and research and development activities further impacted operational profit as our businesses return to normal spending levels compared with the same period of 2020 in addition to incremental investments in product development and expanding our sales force.

### Fire & Security Segment

For the year ended December 31, 2021, *Net sales* in our Fire & Security segment was \$5.5 billion, an 11% increase compared with the same period of 2020. The components of the year-over-year change were as follows:

	Net sales
Organic / Operational	7%
Foreign currency translation	4%
<b>Total % change</b>	<b>11%</b>

The organic increase in *Net sales* of 7% was driven by improved results across each of our Fire & Security segment's businesses. Field service sales (6%) benefited from improved end-markets in regions that were previously impacted by COVID-19, including Europe and Asia. An increase in product sales (8%) was primarily driven by improvements in the Americas, Asia and Europe, which were

impacted by shutdowns related to COVID-19 in the prior year. Results for 2021 reflected a significant rebound in demand after initial weakness during the first half of 2020 due to the COVID-19 pandemic and current demand remains strong. However, supply chain and logistic constraints continue to be challenging, negatively impacting our sales and results of operations.

For the year ended December 31, 2021, *Operating profit* in our Fire & Security segment was \$662 million, a 13% increase compared with the same period of 2020. The components of the year-over-year change were as follows:

	Operating profit
Organic / Operational	10%
Foreign currency translation	3%
Other	—%
<b>Total % change</b>	<b>13%</b>

The operational profit increase of 10% was primarily attributable to higher sales volumes, pricing improvements and favorable mix compared with the same period of 2020, which was heavily impacted by the COVID-19 pandemic. These operational increases were partially offset by higher costs for commodities and components used in our products and higher freight. In addition, higher selling, general and administrative costs and research and development further impacted operational profit as our businesses return to normal spending levels as compared with the same period of 2020 as well as continued investment in selling and engineering.

Other activity recorded in *Operating profit* includes transaction costs associated with the planned divestiture of our Chubb business and the absence of a favorable adjustment related to a product recall matter in the prior year, offset by lower depreciation and amortization, which was ceased on Chubb's assets that were held for sale in accordance with ASC 360, *Property, Plant and Equipment* ("ASC 360").

## LIQUIDITY AND FINANCIAL CONDITION

We assess liquidity in terms of our ability to generate adequate amounts of cash necessary to fund our current and future cash requirements to support our business and strategic initiatives. In doing so, we review and analyze our cash on hand, working capital, debt service requirements and capital expenditures. We rely on operating cash flows as our primary source of liquidity. In addition, we have access to other sources of capital to finance our strategic initiatives and fund growth.

We manage our worldwide cash requirements by reviewing available funds and the cost effectiveness with which those funds can be accessed if held by foreign subsidiaries. As of December 31, 2021, we had cash and cash equivalents of approximately \$3.0 billion, of which approximately 38% was held by Carrier's foreign subsidiaries. On occasion, we are required to maintain cash deposits in connection with contractual obligations related to acquisitions or divestitures

or other legal obligations. As of December 31, 2021 and 2020, the amount of such restricted cash included in *Other current assets* on the accompanying Consolidated Balance Sheet was approximately \$39 million and \$4 million, respectively.

We maintain a \$2.0 billion unsecured, unsubordinated commercial paper program which we can use for general corporate purposes, including the funding of working capital and potential acquisitions. As of December 31, 2021, there were no borrowings outstanding under the commercial paper program.

We maintain a \$2.0 billion revolving credit agreement with various banks that matures on April 3, 2025, as amended (the "Revolving Credit Facility"), which supports our commercial paper borrowing program and cash requirements. This Revolving Credit Facility has a commitment fee of 0.125% that is charged on the unused commitments. Borrowings under the Revolving Credit Facility are available in U.S. Dollars, Euros and Pounds Sterling. Pounds Sterling bears interest at a variable interest rate based on the daily simple Sterling Overnight Index Average ("SONIA") plus 0.0326%, Euros bear interest at the Euro Interbank Offered Rate ("EURIBOR") and U.S. Dollar bears interest at LIBOR, in each case, plus a ratings-based margin, which was 125 basis points as of December 31, 2021. As of December 31, 2021, there were no borrowings on the Revolving Credit Facility.

We believe that our available cash and operating cash flows will be sufficient to meet our future operating cash needs. Our committed credit facilities and access to the debt and equity markets provide additional sources of short-term and long-term capital to fund current operations, dividends, share repurchases, debt maturities and future investment opportunities. Although we believe that the arrangements currently in place permit us to finance our operations on acceptable terms and conditions, our access to and the availability of financing on acceptable terms and conditions in the future will be impacted by many factors, including: (1) our credit ratings or absence of credit ratings; (2) the liquidity of the overall capital markets; and (3) the state of the economy, including the impact of the COVID-19 pandemic and inflation. There can be no assurance that we will be able to obtain additional financing on terms favorable to us, if at all.

The Revolving Credit Facility and the indentures for our long-term notes contain affirmative and negative covenants customary for financings of this type, that among other things, limit Carrier and our subsidiaries' ability to incur additional liens, to make certain fundamental changes and to enter into sale and leaseback transactions. On June 2, 2020, we entered into an amendment of the Revolving Credit Facility, under which certain terms of the facility were amended for a period beginning on June 2, 2020 and ending on December 30, 2021 (the "Covenant Modification"). We terminated the Covenant Modification effective as of August 27, 2021 in accordance with procedures for termination set forth in the Revolving Credit Facility, which returned the consolidated leverage ratio to the limit in effect prior to the Covenant Modification. As of December 31, 2021, we were compliant with all covenants under the agreements governing our outstanding indebtedness.



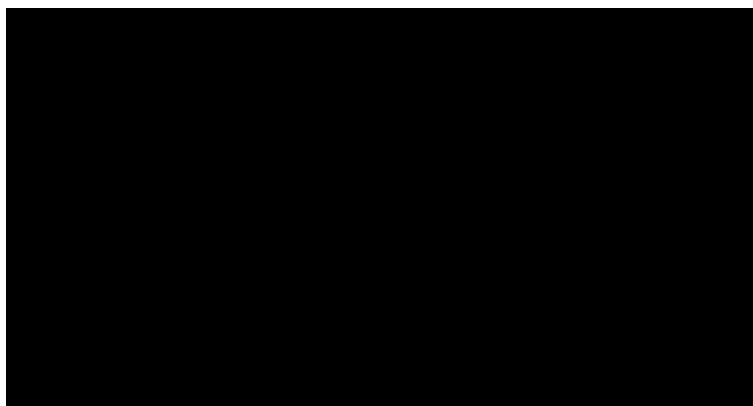
Financing for operational and strategic requirements, not satisfied by operating cash flows, is subject to the availability of external funds through short-term and long-term credit markets. The access to and cost of financing is dependent upon, among other factors, our credit ratings. The following table presents our credit ratings and outlook as of December 31, 2021:

RATING AGENCY	Long-term Rating <sup>(1)</sup>	Short-term Rating	Outlook <sup>(2)</sup>
S&P	BBB	A2	Stable
Moody's	Baa3	P3	Stable
Fitch Ratings	BBB-	F3	Stable

(1) The long-term rating for S&P was affirmed on May 14, 2021, and for Moody's on June 16, 2020. Fitch Ratings' long-term rating was issued on June 3, 2021.

(2) S&P revised its outlook to stable from negative on May 14, 2021.

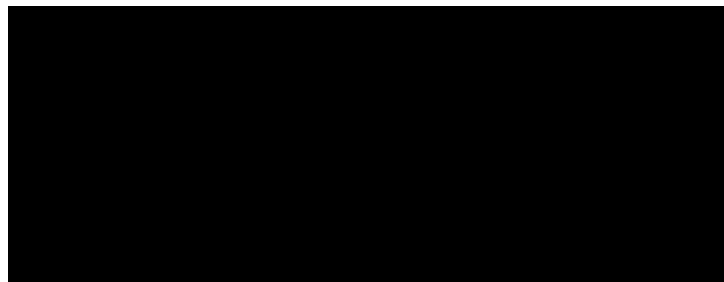
The following table contains several key measures of our financial condition and liquidity:



### Borrowings and Lines of Credit

Our short-term obligations primarily consist of current maturities of long-term debt. Our long-term obligations primarily consist of long-term notes with maturity dates ranging between 2025 and 2050. Interest payments related to long-term notes are expected to approximate \$273 million per year, reflecting an approximate weighted-average interest rate of 2.80%. Any borrowings from the Revolving Credit Facility are subject to variable interest rates. See Note 7 - Borrowings and Lines of Credit in the accompanying Notes to the Consolidated Financial Statements in this Annual Report on Form 10-K for additional information.

Scheduled maturities of long-term debt, excluding amortization of discount, are as follows:



### Share Repurchase Program

During 2021, our Board of Directors approved a stock repurchase program authorizing the repurchase of up to \$2.1 billion of Carrier's outstanding common stock. The repurchase program allows us to repurchase shares from time to time, subject to market conditions and at our discretion in the open market or through one or more other public or private transactions and subject to compliance with our obligations under the TMA and our Revolving Credit Facility. During the year ended December 31, 2021, we repurchased 10.4 million shares of our common stock for an aggregate purchase price of \$529 million, which are held in *Treasury stock* as of December 31, 2021 in the accompanying Consolidated Balance Sheet. On January 4, 2022, we entered into an accelerated share repurchase agreement to repurchase \$500 million of the Company's common stock to be completed in the first quarter of 2022.

### Dividends

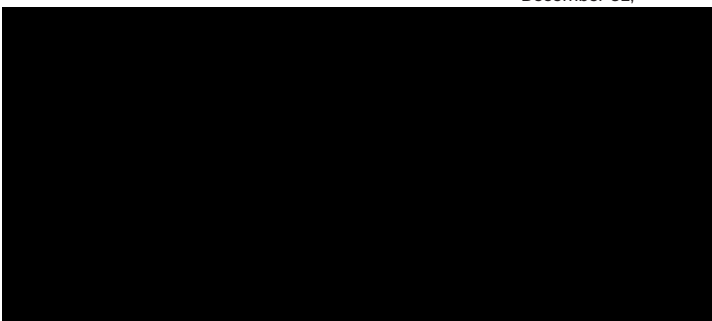
We paid dividends on our common stock of \$0.48 per share during the year ended December 31, 2021, totaling \$417 million. On December 8, 2021, the Board of Directors declared a dividend of \$0.15 per share of common stock payable on February 10, 2022 to shareowners of record at the close of business on December 23, 2021.

### Acquisitions

During the year ended December 31, 2021, we acquired consolidated and minority-owned businesses, including Giwee. The aggregate cash paid for acquisitions, net of cash acquired, totaled \$366 million and was funded through cash on hand. See Note 19 - Acquisitions in the accompanying Notes to the Consolidated Financial Statements in this Annual Report on Form 10-K for additional information.

### Discussion of Cash Flows

For the Years Ended  
December 31,



Cash flows from operating activities primarily represent inflows and outflows associated with our operations. Primary activities include net income from operations adjusted for non-cash transactions, working capital changes and changes in other assets and liabilities. We define working capital as the assets and liabilities, other than cash, generated through our primary operating activities. The year-over-year increase in net cash provided by operating activities was primarily driven by income generated by our operations after adjusting for non-cash transactions. In addition, lower working capital

balances during the current period further added to the increase. Higher inventory levels, driven by continued strong demand and an increase of safety stock due to supply chain constraints were more than offset by higher outstanding accounts payable balances.

Cash flows from investing activities primarily represent inflows and outflows associated with long-term assets. Primary activities include capital expenditures, acquisitions and divestitures. During the year ended December 31, 2021, net cash used in investing activities was \$692 million. The primary driver of the outflow related to the acquisition of several businesses and a minority-owned business, which totaled \$366 million, net of cash acquired and \$344 million of capital expenditures. During the year ended December 31, 2020, net cash provided by investing activities was \$1.1 billion with the primary drivers of the inflow relating to the proceeds received from the sale of our investment in Beijer and the settlement of derivative contracts of \$40 million. These inflows were partially offset by capital expenditures of \$312 million.

Cash flows from financing activities primarily represent inflows and outflows associated with equity or borrowings. Primary activities include debt transactions, paying dividends to shareowners and the repurchase of our common stock. During the year ended December 31, 2021 net cash used in financing activities was \$1.6 billion. The primary drivers of the outflow resulted from the repurchase of \$527 million of our common stock, the redemption of our 1.923% Notes of \$500 million and the payment of \$417 million in dividends to our common shareowners. During the year ended December 31, 2020, net cash used by financing activities was \$681 million with the primary drivers of the decrease relating to the prepayment of the Term Loan Credit Facility of \$1.75 billion. This outflow was partially offset by the issuance of \$750 million of long-term debt and a \$590 million cash contribution from UTC in connection with the Separation.

### Summary of Other Sources and Uses of Cash

We continue to actively manage and strengthen our business and product portfolio to meet the current and future needs of our customers. This is accomplished through research and development activities with a focus on new product development and new technology innovation as well as sustaining activities with a focus on improving existing products and reducing production costs. We also pursue potential acquisitions to complement existing products and services to enhance our product portfolio. In addition, we routinely conduct discussions, evaluate targets and enter into agreements regarding possible acquisitions, divestitures, joint ventures and equity investments to manage our business portfolio. As a result, we acquired consolidated and minority-owned businesses during the year ended December 31, 2021. The aggregate cash paid for acquisitions, net of cash acquired, totaled \$366 million and was funded through cash on hand. In addition, on January 3, 2022, we completed the sale of Chubb to API pursuant to a stock purchase agreement and received net proceeds of approximately \$2.6 billion, subject to customary working capital and other adjustments as provided in the Chubb Sale Agreement.

Rapid changes in legislation, regulations and government policies, including with respect to regulations intended to combat climate change, affect our operations and business in the countries, regions and localities in which we operate and sell our products. We are committed to comply with these regulations and to environmental stewardship. As a result, we have set goals to invest over \$2 billion by 2030 to develop healthy, safe, sustainable and intelligent buildings and cold chain solutions that incorporate sustainable design principles and reduce lifecycle impacts. In addition, to reach our goal to achieve carbon neutrality in our operations by 2030, we expect to incur capital expenditures for climate-related projects including upgrading our facilities, equipment and controls to optimize energy efficiency, transition our energy consumption from a dependency on fossil fuels to renewable energy and expanding the electrification of our fleet vehicles. See section entitled Environmental Goals under the headings "Other Matters Relating to Our Business as a Whole" for additional information.

We also have obligations related to environmental and asbestos matters, pension and post-retirement benefits and taxes. See Note 10 - Employee Benefit Plans, Note 17 - Income Taxes, and Note 23 - Commitments and Contingent Liabilities in the accompanying Notes to the Consolidated Financial Statements in this Annual Report on Form 10-K for additional information.

### CRITICAL ACCOUNTING ESTIMATES

Our financial statements are prepared in accordance with accounting principles generally accepted in the United States. The preparation of financial statements in conformity with those accounting principles requires management to use judgement in making estimates and assumptions based on the relevant information available at the end of each period. These estimates and assumptions have a significant effect on reported amounts of assets, liabilities, sales and expenses as well as the disclosure of contingent assets and liabilities because they result primarily from the need to make estimates and assumptions on matters that are inherently uncertain. Actual results could differ from management's estimates.

### Goodwill and Indefinite-Lived Intangible Assets

In accordance with the Financial Accounting Standards Board ("FASB") Accounting Standards Codification ("ASC") 350, *Intangibles - Goodwill and Other* ("ASC 350"), goodwill and other indefinite-lived intangible assets are tested and reviewed annually for impairment or whenever there is a material change in events or circumstances that indicate that the fair value of the asset is more likely than not less than the carrying amount of the asset. We test our reporting units and indefinite-lived intangible assets for impairment annually as of the first day of our third quarter, or more frequently if events or circumstances occur.

ASC 350 provides entities with an option to perform a qualitative assessment (commonly referred to as "step zero") to determine whether a quantitative analysis for impairment is necessary. In

performing step zero for our impairment test, we are required to make assumptions and judgments, including but not limited to the following: the evaluation of macroeconomic conditions as related to our business, industry and market trends, and the overall future financial performance of our reporting units and future opportunities in the markets in which they operate. If impairment indicators are present after performing step zero, we would perform a quantitative impairment analysis to estimate fair value.

For our 2021 impairment test, we elected to perform a qualitative step zero assessment for goodwill and indefinite-lived intangible assets. This qualitative assessment included the review of certain macroeconomic factors and entity-specific qualitative factors to determine if it was more likely than not that the fair values of our reporting units and indefinite-lived intangible assets were below carrying value. We considered macroeconomic factors including global economic growth, general macroeconomic trends for the markets in which our reporting units operate and where the intangible assets are utilized and the forecasted growth of the global industrial products industry. In addition to these macroeconomic factors, among other things, we considered the reporting units' current results and forecasts, changes in the nature of each business, any significant legal, regulatory, contractual, political or other business climate factors, changes in the industry and competitive environment, changes in the composition or carrying amount of net assets and any intention to sell or dispose of a reporting unit or cease the use of an indefinite-lived intangible assets. Based upon our qualitative analysis, we determined that our goodwill and indefinite-lived intangible assets were not impaired.

#### **Revenue Recognition from Contracts with Customers**

Revenue is recognized when control of a good or service promised in a contract (i.e., performance obligation) is transferred to a customer. Control is obtained when a customer has the ability to direct the use of and obtain substantially all of the remaining benefits from that good or service. A significant portion of our performance obligations are recognized at a point-in-time when control of the product transfers to the customer, which is generally the time of shipment. The remaining portion of our performance obligations are recognized over time as the customer simultaneously obtains control as we perform work under a contract, or if the product being produced for the customer has no alternative use and we have a contractual right to payment.

A performance obligation is a distinct good, service or a bundle of goods and services promised in a contract. Some of our contracts with customers contain a single performance obligation, while others contain multiple performance obligations most commonly when a contract spans multiple phases of a product life-cycle such as production, installation, maintenance and support. We identify performance obligations at the inception of a contract and allocate the transaction price to each distinct performance obligation. Revenue is recognized when or as the performance obligation is satisfied. When there are multiple performance obligations within

a contract, we allocate the transaction price to each performance obligation based on its relative stand-alone selling price.

We primarily generate revenue from the sale of products to customers and recognize revenue at a point in time when control transfers to the customer. Transfer of control is generally based on the shipping terms of the contract. In addition, we recognize revenue on an over-time basis on installation and service contracts. For over-time performance obligations requiring the installation of equipment, revenue is recognized using costs incurred to date relative to total estimated costs at completion to measure progress. Incurred costs represent work performed, which correspond with and best depict transfer of control to the customer. Contract costs include direct costs such as labor, materials and subcontractors' costs and, where applicable, indirect costs.

The transaction price allocated to performance obligations reflects our expectations about the consideration we will be entitled to receive from a customer. We include variable consideration in the estimated transaction price when there is a basis to reasonably estimate the amount and when it is probable that a significant reversal of revenue recognized would not occur when the uncertainty associated with variable consideration is subsequently resolved. In addition, we customarily offer our customers incentives to purchase products to ensure an adequate supply of our products in distribution channels. The principal incentive programs provide reimbursements to distributors for offering promotional pricing for products. We account for estimated incentive payments as a reduction in sales at the time a sale is recognized.

#### **Income Taxes**

We account for income taxes in accordance with ASC 740: Income Taxes ("ASC 740"). Deferred tax assets and liabilities are determined based on temporary differences between financial reporting and tax bases of assets and liabilities, applying enacted tax rates expected to be in effect for the year in which the differences are expected to reverse. We recognize future tax benefits to the extent that realizing these benefits is considered in our judgment to be more likely than not. For those jurisdictions where the expiration date of tax carryforwards or the projected operating results indicate that realization is not likely, a valuation allowance is provided. We review the realizability of our deferred tax asset valuation allowances on a quarterly basis, or whenever events or changes in circumstances indicate that a review is required and will adjust our estimate if significant events so dictate. To the extent that the ultimate results differ from our original or adjusted estimates, the effect will be recorded in the provision for income taxes in the period that the matter is finally resolved.

In the ordinary course of business, there is inherent uncertainty in quantifying our income tax positions. We assess our income tax positions and record tax benefits for all years subject to examination based upon management's evaluation of the facts, circumstances and information available at the reporting date. For those tax positions where it is more likely than not that a tax benefit will be sustained,

we have recorded the largest amount of tax benefit with a greater than 50% likelihood of being realized upon ultimate settlement with a taxing authority that has full knowledge of all relevant information. For those income tax positions where it is not more likely than not that a tax benefit will be sustained, no tax benefit has been recognized in the Consolidated Financial Statements.

### Employee Benefit Plans

We provide a range of benefit plans to eligible current and former employees. We account for our benefits plans in accordance with ASC 715: *Compensation – Retirement Benefits* ("ASC 715"), which requires balance sheet recognition of the overfunded or underfunded status of pension plans. The determination of the amounts associated with these benefits is performed by actuaries and dependent on various actuarial assumptions including discount rates, expected return on plan assets, compensation increases, mortality and health care cost trends. Actual results may differ from the actuarial assumptions and are generally accumulated into *Accumulated other comprehensive income (loss)* and amortized into *Net income from operations* over future periods. We review our actuarial assumptions at each measurement date and make modifications to the assumptions based on current rates and trends, if appropriate.

A change in any of these assumptions would have an effect on net periodic pension and post-retirement benefit costs reported in the Consolidated Financial Statements. The following table summarizes the sensitivity of our pension plan liabilities and net periodic cost to a 25 basis point change in the discount rates for benefit obligations, interest cost and service cost as of December 31, 2021:

(IN MILLIONS)	Increase in Discount Rate of 25 bps	Decrease in Discount Rate of 25 bps
Projected benefit obligation	\$(32)	\$35
Net periodic pension (benefit) cost	\$ (2)	\$ 2

Net periodic pension (benefit) cost is also sensitive to changes in the expected return on plan assets. An increase or decrease of 25 basis points in the expected return on plan assets would have decreased or increased 2021 pension expense by approximately \$1 million. See Note 10 – Employee Benefit Plans in the accompanying Notes to the Consolidated Financial Statements in this Annual Report on Form 10-K for additional information.

### Contingent Liabilities

We are involved in various litigation, claims and administrative proceedings, including those related to environmental and legal matters (including asbestos). In accordance with ASC 450, *Contingencies* ("ASC 450"), we record accruals for loss contingencies when it is probable that a liability will be incurred and the amount of the loss can be reasonably estimated. These accruals are generally based upon a range of possible outcomes. If no amount within the range is a better estimate than any other, we accrue the minimum amount. In addition, these estimates are reviewed periodically and adjusted to reflect additional information when it becomes available. We are unable to predict the final outcome of these matters based on the information currently available. However, we do not believe that the resolution of any of these matters will have a material adverse effect upon our competitive position, results of operations, cash flows or financial condition.

As described in Note 23 – Commitments and Contingent Liabilities in the accompanying Notes to the Consolidated Financial Statements in this Annual Report on Form 10-K, contractual, regulatory and other matters, including asbestos claims, may arise in the ordinary course of business that subject us to claims or litigation. We have recorded reserves in the consolidated financial statements related to these matters, which are developed using input derived from actuarial estimates and historical and anticipated experience depending on the nature of the reserve, and in certain instances in consultation with legal counsel, internal and external consultants and engineers. Subject to the uncertainties inherent in estimating future costs for these types of liabilities, we believe our estimated reserves are reasonable and do not believe the final determination of the liabilities with respect to these matters would have a material adverse effect upon our competitive position, results of operations, cash flows or financial condition. See the "Risk Factors" section in this Annual Report on Form 10-K for additional information.

### Recent Accounting Pronouncements

See Note 3 – Summary of Significant Accounting Policies in the accompanying Notes to the Consolidated Financial Statements in this Annual Report on Form 10-K for a discussion of recent accounting pronouncements and their effect on our financial statements.

## Cautionary Note Concerning Factors That May Affect Future Results

This Annual Report on Form 10-K contains statements which, to the extent they are not statements of historical or present fact, constitute “forward-looking statements” under the securities laws. From time to time, oral or written forward-looking statements may also be included in other information released to the public. These forward-looking statements are intended to provide management’s current expectations or plans for our future operating and financial performance, based on assumptions currently believed to be valid. Forward-looking statements can be identified by the use of words such as “believe,” “expect,” “expectations,” “plans,” “strategy,” “prospects,” “estimate,” “project,” “target,” “anticipate,” “will,” “should,” “see,” “guidance,” “outlook,” “confident,” “scenario” and other words of similar meaning in connection with a discussion of future operating or financial performance or the Separation (as defined in PART I, ITEM I, BUSINESS, Separation from United Technologies Corporation). Forward-looking statements may include, among other things, statements relating to future sales, earnings, cash flows, results of operations, uses of cash, share repurchases, tax rates and other measures of financial performance or potential future plans, strategies or transactions of Carrier, the estimated costs associated with the Separation, Carrier’s plans with respect to our indebtedness and other statements that are not historical facts. All forward-looking statements involve risks, uncertainties and other factors that may cause actual results to differ materially from those expressed or implied in the forward-looking statements. For those statements, we claim the protection of the safe harbor for forward-looking statements contained in the U.S. Private Securities Litigation Reform Act of 1995. Such risks, uncertainties and other factors include, without limitation:

- the effect of economic conditions in the industries and markets in which Carrier and our businesses operate in the U.S. and globally and any changes therein, including financial market conditions, fluctuations in commodity prices, interest rates and foreign currency exchange rates, levels of end market demand in construction, the impact of weather conditions, pandemic health issues (including COVID-19, any variants and their effects, among other things, on production and on global supply, demand, and distribution as the outbreak continues and results in a prolonged period of travel, commercial and other restrictions and limitations), natural disasters and the financial condition of our customers and suppliers;
- challenges in the development, production, delivery, support, performance and realization of the anticipated benefits of advanced technologies and new products and services;
- future levels of indebtedness, capital spending and research and development spending;
- future availability of credit and factors that may affect such availability, including credit market conditions and Carrier’s capital structure and credit ratings;
- the timing and scope of future repurchases of Carrier’s common stock, including market conditions and the level of other investing activities and uses of cash;
- delays and disruption in the delivery of materials and services from suppliers;
- cost reduction efforts and restructuring costs and savings and other consequences thereof;
- new business and investment opportunities;
- risks resulting from being a smaller less diversified company than prior to the Separation;
- the outcome of legal proceedings, investigations and other contingencies;
- the impact of pension plan assumptions on future cash contributions and earnings;
- the impact of the negotiation of collective bargaining agreements and labor disputes;
- the effect of changes in political conditions in the U.S. and other countries in which Carrier and our businesses operate, including the effect of changes in U.S. trade policies, on general market conditions, global trade policies and currency exchange rates in the near term and beyond;
- the effect of changes in tax, environmental, regulatory (including among other things import/export) and other laws and regulations in the U.S. and other countries in which we and our businesses operate;
- the ability of Carrier to retain and hire key personnel;
- the scope, nature, impact or timing of acquisition and divestiture activity, including among other things integration of acquired businesses into existing businesses and realization of synergies and opportunities for growth and innovation and incurrence of related costs;
- the expected benefits of the Separation;
- a determination by the U.S. Internal Revenue Service (“IRS”) and other tax authorities that the Distribution or certain related transactions should be treated as taxable transactions;
- risks associated with indebtedness, including that incurred as a result of financing transactions undertaken in connection with the Separation, as well as our ability to reduce indebtedness and the timing thereof;
- the risk that dis-synergy costs, costs of restructuring transactions and other costs incurred in connection with the Separation will exceed Carrier’s estimates; and
- the impact of the Separation on Carrier’s business and Carrier’s resources, systems, procedures and controls, diversion of management’s attention and the impact on relationships with customers, suppliers, employees and other business counterparties.

This Annual Report on Form 10-K includes important information as to risks, uncertainties and other factors that may cause actual results to differ materially from those expressed or implied in the forward-looking statements. See the Notes to the Consolidated Financial Statements in this Annual Report on Form 10-K under the heading “Note 23 – Commitments and Contingent Liabilities,” the sections entitled “Management’s Discussion and Analysis of Financial Condition and Results of Operations” under the headings

"Business Overview," "Results of Operations," "Liquidity and Financial Condition," and "Critical Accounting Estimates," and the section entitled "Risk Factors." This Annual Report on Form 10-K also includes important information as to these factors in the "Business" section under the headings "General," "Other Matters Relating to Our Business as a Whole," and in the "Legal Proceedings" section. The forward-looking statements speak only as of the date of this report or, in the case of any document incorporated by reference, the date of that document. We undertake no obligation to publicly update or revise any forward-looking statements, whether as a result of new information, future events or otherwise, except as required by applicable law. Additional information as to factors that may cause actual results to differ materially from those expressed or implied in the forward-looking statements is disclosed from time to time in our other filings with the SEC.

This Annual Report on Form 10-K and our Quarterly Reports on Form 10-Q, Current Reports on Form 8-K and amendments to those reports are available free of charge through the Investors section of our Internet website (<http://www.corporate.carrier.com>) under the heading "SEC Filings" as soon as reasonably practicable after these reports are electronically filed with, or furnished to, the United States Securities and Exchange Commission ("SEC"). In addition, the SEC maintains an Internet website (<http://www.sec.gov>) containing reports, proxy and information statements, and other information regarding issuers that file electronically with the SEC.



# Report of Independent Registered Public Accounting Firm

## TO THE BOARD OF DIRECTORS AND SHAREOWNERS OF CARRIER GLOBAL CORPORATION

### Opinions on the Financial Statements and Internal Control over Financial Reporting

We have audited the accompanying consolidated balance sheet of Carrier Global Corporation and its subsidiaries (the "Company") as of December 31, 2021 and 2020, and the related consolidated statements of operations, of comprehensive income (loss), of changes in equity and of cash flows for each of the three years in the period ended December 31, 2021, including the related notes (collectively referred to as the "consolidated financial statements"). We also have audited the Company's internal control over financial reporting as of December 31, 2021, based on criteria established in *Internal Control - Integrated Framework* (2013) issued by the Committee of Sponsoring Organizations of the Treadway Commission (COSO).

In our opinion, the consolidated financial statements referred to above present fairly, in all material respects, the financial position of the Company as of December 31, 2021 and 2020, and the results of its operations and its cash flows for each of the three years in the period ended December 31, 2021 in conformity with accounting principles generally accepted in the United States of America. Also in our opinion, the Company maintained, in all material respects, effective internal control over financial reporting as of December 31, 2021, based on criteria established in *Internal Control - Integrated Framework* (2013) issued by the COSO.

### Basis for Opinions

The Company's management is responsible for these consolidated financial statements, for maintaining effective internal control over financial reporting, and for its assessment of the effectiveness of internal control over financial reporting, included in Management's Report on Internal Control Over Financial Reporting appearing under Item 9A. Our responsibility is to express opinions on the Company's consolidated financial statements and on the Company's internal control over financial reporting based on our audits. We are a public accounting firm registered with the Public Company Accounting Oversight Board (United States) (PCAOB) and are required to be independent with respect to the Company in accordance with the U.S. federal securities laws and the applicable rules and regulations of the Securities and Exchange Commission and the PCAOB.

We conducted our audits in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audits to obtain reasonable assurance about whether the consolidated financial statements are free of material misstatement, whether due to error or fraud, and whether effective internal control over financial reporting was maintained in all material respects.

Our audits of the consolidated financial statements included performing procedures to assess the risks of material misstatement of the consolidated financial statements, whether due to error or fraud, and performing procedures that respond to those risks.

Such procedures included examining, on a test basis, evidence regarding the amounts and disclosures in the consolidated financial statements. Our audits also included evaluating the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of the consolidated financial statements. Our audit of internal control over financial reporting included obtaining an understanding of internal control over financial reporting, assessing the risk that a material weakness exists, and testing and evaluating the design and operating effectiveness of internal control based on the assessed risk. Our audits also included performing such other procedures as we considered necessary in the circumstances. We believe that our audits provide a reasonable basis for our opinions.

### Definition and Limitations of Internal Control over Financial Reporting

A company's internal control over financial reporting is a process designed to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles. A company's internal control over financial reporting includes those policies and procedures that (i) pertain to the maintenance of records that, in reasonable detail, accurately and fairly reflect the transactions and dispositions of the assets of the company; (ii) provide reasonable assurance that transactions are recorded as necessary to permit preparation of financial statements in accordance with generally accepted accounting principles, and that receipts and expenditures of the company are being made only in accordance with authorizations of management and directors of the company; and (iii) provide reasonable assurance regarding prevention or timely detection of unauthorized acquisition, use, or disposition of the company's assets that could have a material effect on the financial statements.

Because of its inherent limitations, internal control over financial reporting may not prevent or detect misstatements. Also, projections of any evaluation of effectiveness to future periods are subject to the risk that controls may become inadequate because of changes in conditions, or that the degree of compliance with the policies or procedures may deteriorate.

### Critical Audit Matters

The critical audit matter communicated below is a matter arising from the current period audit of the consolidated financial statements that was communicated or required to be communicated to the audit committee and that (i) relates to accounts or disclosures that are material to the consolidated financial statements and (ii) involved our especially challenging, subjective, or complex judgments. The communication of critical audit matters does not alter in any way our opinion on the consolidated financial statements, taken as a whole, and we are not, by communicating the critical audit matter below, providing a separate opinion on the critical audit matter or on the accounts or disclosures to which it relates.

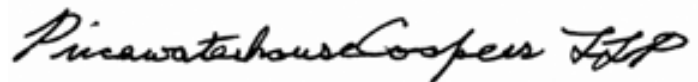
*Revenue Recognition from Contracts with Customers*

As described in Note 13 to the consolidated financial statements, the Company recognized \$20.6 billion of consolidated revenue for the year ended December 31, 2021. Some of the Company's contracts with customers contain a single performance obligation, while others contain multiple performance obligations most commonly when a contract spans multiple phases of a product life-cycle such as production, installation, maintenance and support. The Company recognizes revenue when control of a good or service promised in a contract (i.e., performance obligation) is transferred to a customer. Control is obtained when a customer has the ability to direct the use of and obtain substantially all of the remaining benefit from that good or service. A significant portion of the Company's performance obligations are recognized at a point-in-time when control of the product transfers to the customer, which is generally at the time of shipment. The remaining portion of the Company's performance obligations are recognized over time as the customer simultaneously obtains control as the Company performs work under a contract, or if the product being produced for the customer has no alternative use and the Company has a contractual right to payment. For over-time performance obligations requiring the installation of equipment, revenue is recognized using costs incurred to date relative to total estimated costs at completion to measure progress. The Company includes variable consideration in the estimated transaction price when there is a basis to reasonably estimate the amount and when it is probable that a significant reversal of revenue recognized would not occur when the uncertainty associated with variable consideration is subsequently resolved. In addition, the Company customarily offers customers incentives to purchase products to ensure an adequate supply of its products in distribution channels. The principal incentive programs provide reimbursements to distributors for offering promotional pricing for products. The Company accounts for estimated incentive payments as a reduction in sales at the time a sale is recognized.

The principal considerations for our determination that performing procedures relating to revenue recognition from contracts with customers is a critical audit matter are the high degree of audit

effort in performing procedures related to revenue recognized on the Company's point-in-time and over-time contracts with customers and in evaluating evidence related to management's determination of total estimated costs at completion for revenue recognized on an over-time basis.

Addressing the matter involved performing procedures and evaluating audit evidence in connection with forming our overall opinion on the consolidated financial statements. These procedures included testing the effectiveness of controls relating to the revenue recognition process on the Company's point-in-time and over-time contracts with customers, including controls over the determination of total estimated costs at completion for revenue recognized on an over-time basis. These procedures also included, among others (i) evaluating management's significant accounting policies related to revenue recognition; (ii) testing the appropriateness of the timing and amount of revenue recognized for a sample of point-in-time revenue transactions by obtaining and inspecting source documents, such as contracts with customers, purchase order information, shipping documents, cash receipts, and other documentation; and (iii) evaluating and testing management's process for determining the total estimated costs at completion for a sample of over-time revenue contracts, which included evaluating the estimated costs at completion used by management by considering factors that can affect the accuracy of those estimates. Evaluating the total costs at completion for revenue recognized on an over-time basis involved comparing the originally estimated costs and actual costs incurred, including identifying circumstances that may warrant a modification to the total estimated costs to complete.



/s/ PricewaterhouseCoopers LLP  
Hallandale Beach, Florida  
February 8, 2022

We have served as the Company's auditor since 2019.

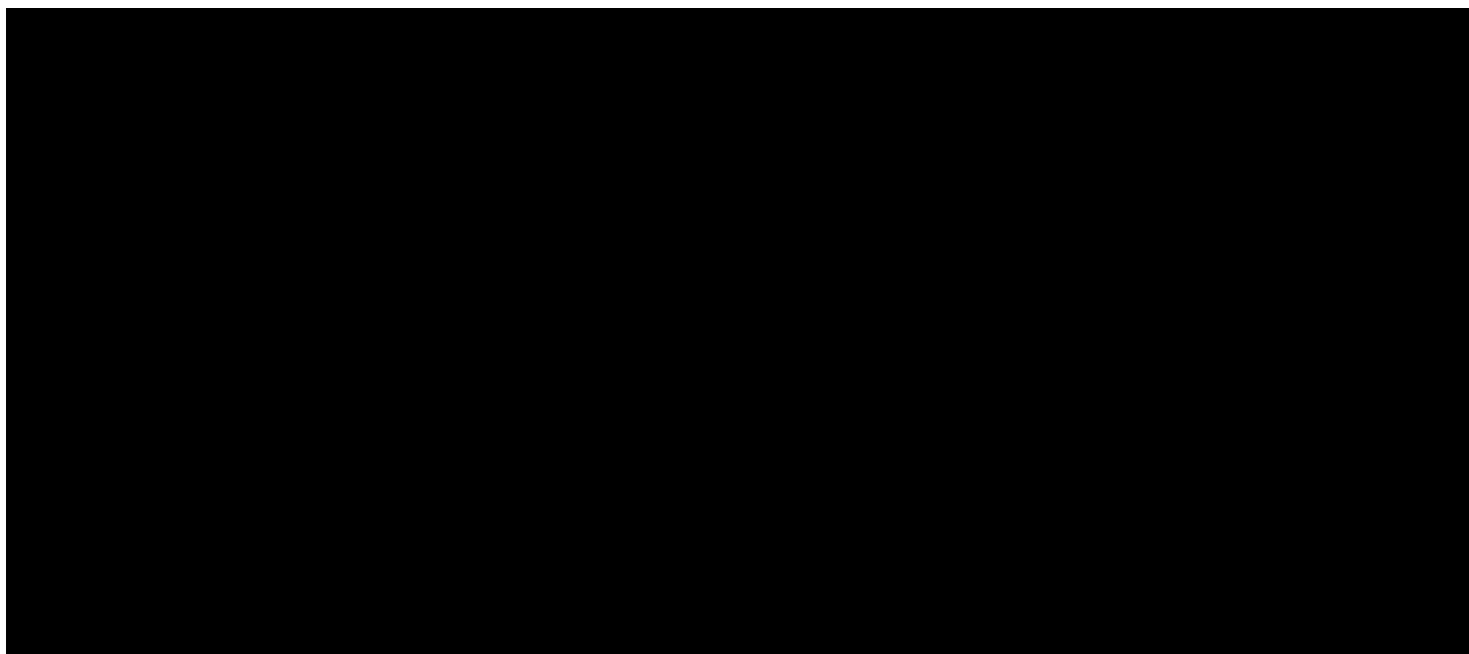


## Consolidated Statement of Operations

For the Year Ended December 31,

[illegible]

## Consolidated Statement of Comprehensive Income (Loss)

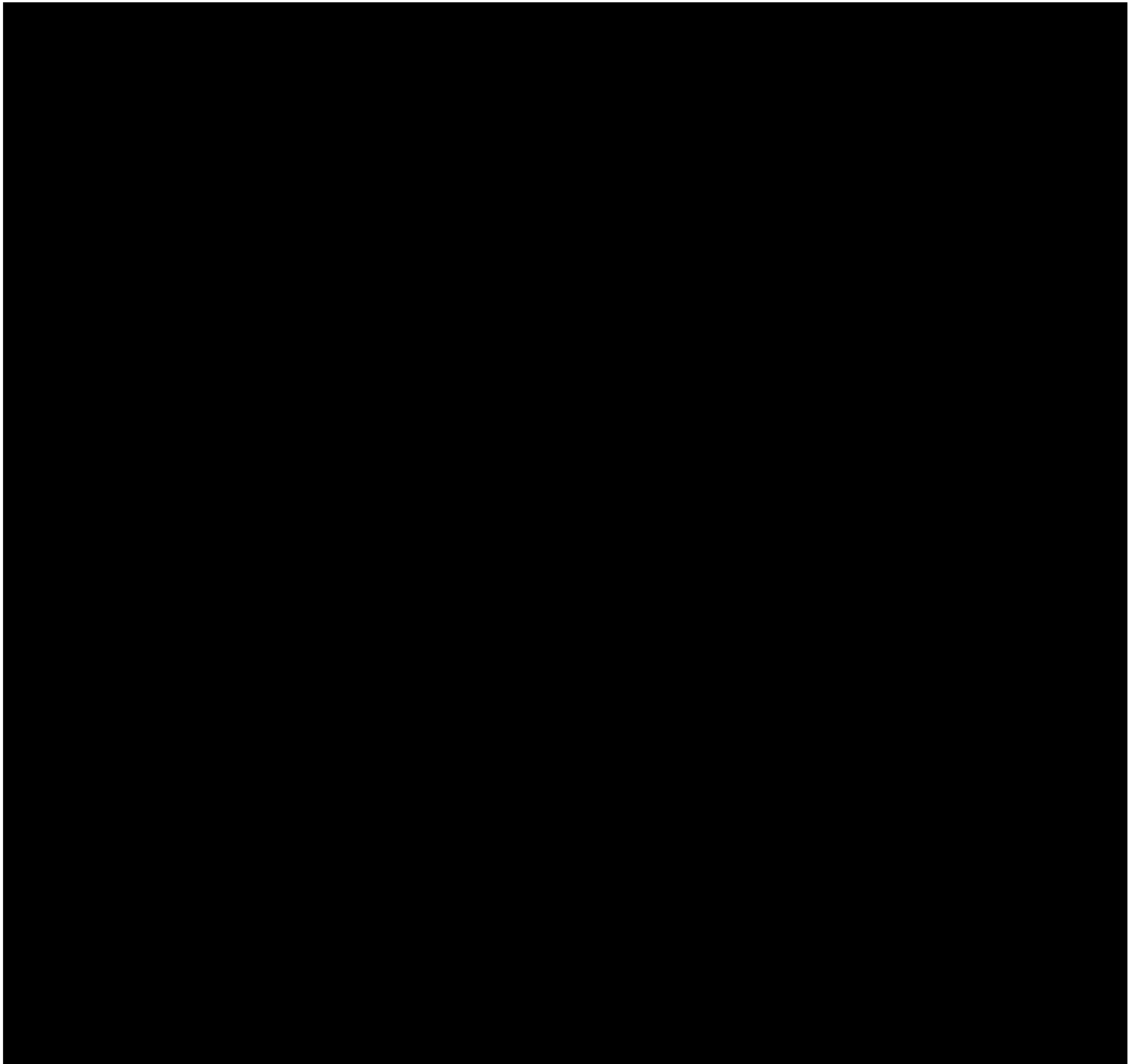
A large black rectangular box redacting the content of the Consolidated Statement of Comprehensive Income (Loss) table.

## Consolidated Balance Sheet

As of December 31

The accompanying notes are an integral part of the Consolidated Financial Statements.

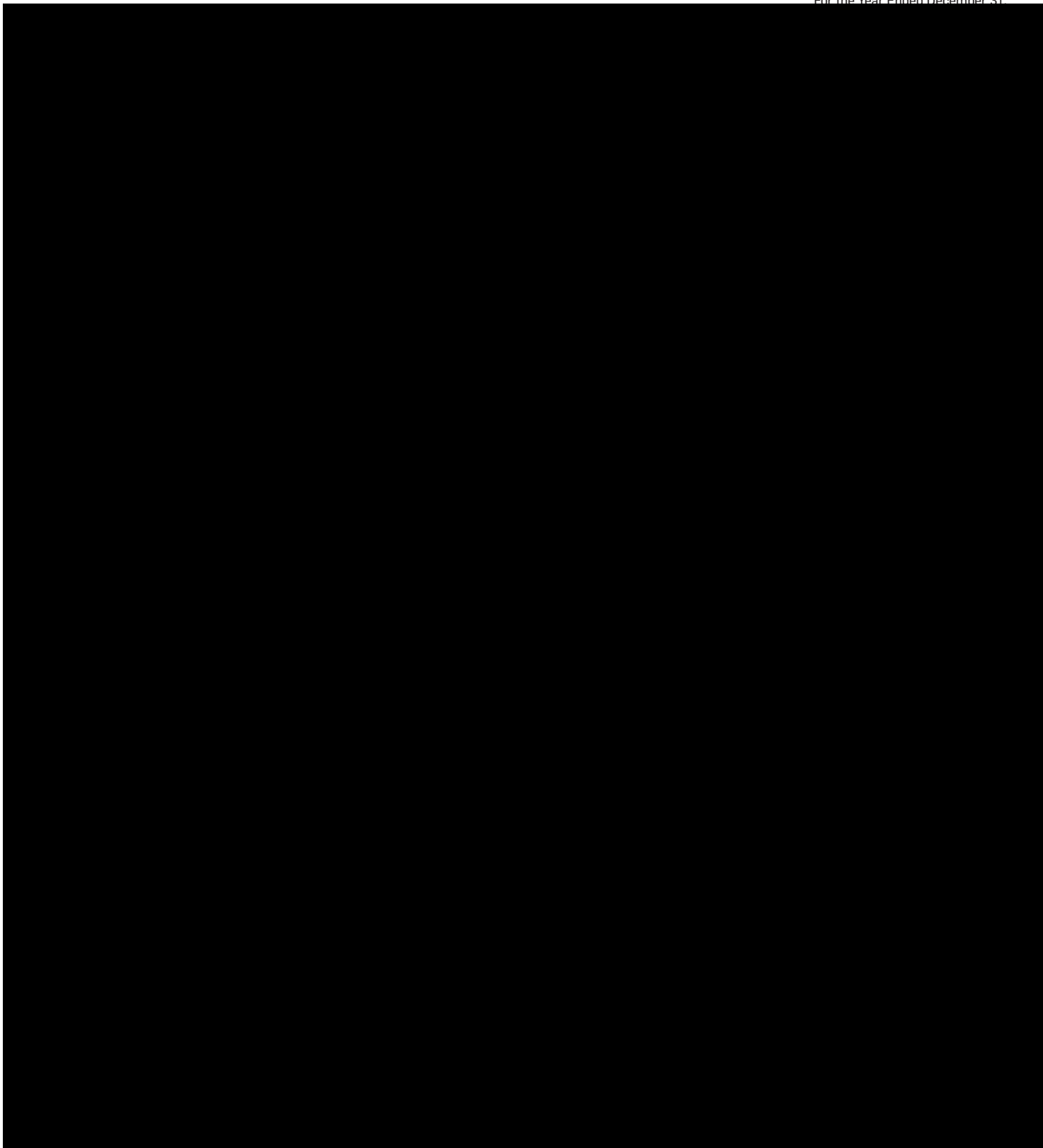
## Consolidated Statement of Changes In Equity



The accompanying notes are an integral part of the Consolidated Financial Statements.

## Consolidated Statement of Cash Flows

For the Year Ended December 31



The accompanying notes are an integral part of the Consolidated Financial Statements.

# Notes to the Consolidated Financial Statements

## Note 1: Description Of The Business

Carrier Global Corporation is a leading global provider of healthy, safe, sustainable and intelligent building and cold chain solutions. The Company's portfolio includes industry-leading brands such as Carrier, Kidde, Edwards, LenelS2, Carrier Transicold and Automated Logic that offer innovative HVAC, refrigeration, fire, security and building automation technologies to help make the world safer and more comfortable. The Company also provides a broad array of related building services, including audit, design, installation, system integration, repair, maintenance and monitoring. The Company's operations are classified into three segments: HVAC, Refrigeration and Fire & Security.

### The Separation

On April 3, 2020, United Technologies Corporation, since renamed Raytheon Technologies Corporation, completed the spin-off of the Company into an independent, publicly traded company through a pro rata distribution on a one-for-one basis of all of the outstanding shares of common stock of the Company to UTC shareowners who held shares of UTC common stock as of the close of business on March 19, 2020, the record date for the Distribution. In connection with the Separation, the Company issued an aggregate principal balance of \$11.0 billion of debt and transferred approximately \$10.9 billion of cash to UTC on February 27, 2020 and March 27, 2020. On April 1, 2020 and April 2, 2020, the Company received cash contributions totaling \$590 million from UTC related to the Separation.

In connection with the Separation, the Company entered into several agreements with UTC and Otis that govern various aspects of the relationship among the Company, UTC and Otis following the Separation and the Distribution, including a TSA that expired on March 31, 2021, a TMA, an employee matters agreement and an intellectual property agreement that cover services such as information technology, tax, finance and human resources. In addition, the Company incurred separation-related costs including employee-related costs, costs to establish certain stand-alone functions, information technology systems, professional service fees and other costs associated with becoming an independent, publicly traded company.

### Impact of the COVID-19 Pandemic

In early 2020, the World Health Organization declared the outbreak of a respiratory disease known as COVID-19 as a global pandemic. In response, many countries implemented containment and mitigation measures to combat the outbreak, which severely restricted the level of economic activity and caused a significant contraction in the global economy. As a result, the Company temporarily closed or reduced production at manufacturing facilities across the globe to ensure employee safety and instructed non-essential employees to work from home. In addition, the Company took several preemptive actions during 2020 to manage liquidity as demand for its products decreased. Despite the adverse impacts of the pandemic on the Company's results beginning in the first quarter of 2020, manufacturing operations resumed and several restorative actions

were completed during 2020, including the reinstatement of annual merit-based salary increases and continued investment to support the Company's strategic priorities.

The Company continues to focus its efforts on preserving the health and safety of its employees and customers as well as maintaining the continuity of its operations. In addition, the Company continues to actively monitor its liquidity position and working capital needs and believes that its overall capital resources and liquidity position are adequate. The preparation of financial statements requires management to use judgments in making estimates and assumptions based on the relevant information available at the end of each period, which can have a significant effect on reported amounts. However, due to significant uncertainty surrounding the pandemic, including a resurgence in cases and the spread of COVID-19 variants, management's judgments could change. While the Company's results of operations, cash flows and financial condition could be negatively impacted, the extent of any continuing impact cannot be estimated with certainty at this time.

## Note 2: Basis Of Presentation

The accompanying Consolidated Financial Statements reflect the consolidated operations of the Company and have been prepared in accordance with U.S. Generally Accepted Accounting Principles ("GAAP") as defined by the FASB within the FASB Accounting Standards Codification. Inter-company accounts and transactions have been eliminated. Related party transactions between the Company and its equity method investees have not been eliminated. Certain immaterial amounts presented in prior periods have been reclassified to conform to the current period presentation.

The Consolidated Financial Statements include all majority-owned subsidiaries of the Company. A non-controlling interest in a subsidiary is considered an ownership interest in a majority-owned subsidiary that is not attributable to the parent. The Company includes *Non-controlling interest* as a component of *Total equity* in the Consolidated Balance Sheet and the *Non-controlling interest in subsidiaries' earnings from operations* are presented as an adjustment to *Net income from operations* used to arrive at *Net income attributable to common shareowners* in the Consolidated Statement of Operations. Partially-owned equity affiliates represent 20-50% ownership interests in investments where the Company demonstrates significant influence, but does not have a controlling financial interest. Partially-owned equity affiliates are accounted for under the equity method.

### The Separation

The Company's financial statements for the periods prior to the Separation and the Distribution are prepared on a "carve-out" basis and include all amounts directly attributable to the Company. Net cash transfers and other property transferred between UTC and the Company, including related party receivables and payables between the Company and other UTC affiliates, are presented as Net transfers to UTC within *UTC Net Investment* on the Consolidated Financial Statements. In addition, the financial statements include allocations

of costs for administrative functions and services performed on behalf of the Company by centralized groups within UTC. All allocations and estimates in the Consolidated Financial Statements are based on assumptions that management believes are reasonable. The allocated centralized costs for the years ended December 31, 2020 and 2019, were \$43 million and \$245 million, respectively, and are primarily included in *Selling, general and administrative* in the Consolidated Statement of Operations.

The Company's financial statements for the periods subsequent to April 3, 2020 are consolidated financial statements based on the reported results of Carrier as a stand-alone company. In connection with the Separation, the Company incurred separation-related costs of approximately \$20 million, \$141 million and \$58 million for the years ended December 31, 2021, 2020 and 2019, respectively. These costs are primarily recorded in *Selling, general and administrative* in the Consolidated Statement of Operations and consist of employee-related costs, costs to establish certain stand-alone functions and information technology systems, professional service fees and other transaction-related costs resulting from Carrier's transition to becoming an independent, publicly traded company.

#### **Held for Sale**

On July 26, 2021, the Company entered into a stock purchase agreement to sell its Chubb business to API. As a result, the assets and liabilities of Chubb have been presented as held for sale on the accompanying Consolidated Balance Sheet as of December 31, 2021 and recorded at the lower of their carrying value or fair value less estimated cost to sell. See Note 20 - Divestitures for additional information.

#### **Note 3: Summary Of Significant Accounting Policies**

A summary of significant accounting policies used in the preparation of the accompanying Consolidated Financial Statements is as follows:

**Use of Estimates.** The preparation of the Consolidated Financial Statements in conformity with GAAP requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities and the disclosure of contingent assets and liabilities at the date of the financial statements as well as the reported amounts of revenues and expenses during the reporting period. Estimates are based on several factors including the facts and circumstances available at the time the estimates are made, historical experience and various other assumptions that are believed to be reasonable under the circumstances. Actual results could differ from those estimates.

**Currency Translation.** Assets and liabilities of non-U.S. subsidiaries, where the functional currency is not the U.S. dollar, have been translated at year-end exchange rates, and income and expense accounts have been translated using average exchange rates throughout the year. Adjustments resulting from the process of translating an entity's financial statements into the U.S. dollar have been recorded in the equity section of the Consolidated Balance Sheet within *Accumulated other comprehensive income (loss)*.

Transactions that are denominated in a currency other than an entity's functional currency are subject to changes in exchange rates with the resulting gains and losses recorded in *Net income from operations*.

**Cash and Cash Equivalents.** Cash and cash equivalents include cash on hand, demand deposits and short-term cash investments that are highly liquid in nature and have original maturities of three months or less. On occasion, the Company is required to maintain restricted cash deposits with certain banks due to contractual or other legal obligations. Restricted cash of \$39 million and \$4 million is included in *Other assets, current* as of December 31, 2021 and 2020, respectively.

**Accounts Receivable.** Accounts receivable consist of billed amounts owed for products shipped to or services performed for customers. Amounts are recorded net of an allowance for expected credit losses which represents the best estimate of probable loss inherent in the Company's accounts receivable portfolio. The allowance is determined using a combination of factors including a reserve based on the aging of the outstanding accounts receivable portfolio and the Company's historical credit loss experience with its end markets, customer base and products. In addition, the Company considers knowledge of specific customers, current market conditions as well as reasonable and supportable forecasts of future events and economic conditions. As of December 31, 2021 and 2020, the allowance for expected credit losses was \$88 million and \$89 million, respectively. These estimates and assumptions are reviewed periodically with the effects of changes, if any, reflected in the Consolidated Statement of Operations in the period that they are determined.

**Fixed Assets.** Property, plant and equipment are stated at cost less accumulated depreciation. Assets placed in service are recorded at cost and depreciated using the straight-line method over the estimated useful life of the asset. Assets acquired in a business combination are recorded at fair value at the date of acquisition. Major expenditures for replacements and significant improvements that increase asset values and extend useful lives are capitalized. Repairs and maintenance expenditures that do not extend the useful life of an asset are charged to expense as incurred.

Per ASC 360, the Company assesses the recoverability of the carrying value of its property, plant and equipment whenever events or changes in circumstances indicate that the carrying amount of an asset group may not be recoverable. Recoverability is measured by a comparison of the carrying amount of an asset group to the future net undiscounted cash flows expected to be generated by the asset group. If the undiscounted cash flows are less than the carrying amount of the asset group, an impairment loss is recognized for the amount by which the carrying amount of the asset group exceeds the fair value of the asset group.

**Equity Method Investments.** Investments in which the Company has the ability to exercise significant influence, but does not control, are accounted for under the equity method of accounting and are presented on the Consolidated Balance Sheet. Under this method of accounting, the Company's share of the net earnings or losses of the investee is presented within *Operating profit* on the Consolidated Statement of Operations since the activities of the investee are closely aligned with the operations of the Company. The Company evaluates its equity method investments whenever events or changes in circumstance indicate that the carrying amounts of such investments may be impaired. If a decline in the value of an equity method investment is determined to be other than temporary, a loss is recorded in earnings in the current period. Distributions received from equity method investees are presented in the Consolidated Statement of Cash Flows based on the cumulative earnings approach.

**Goodwill and Intangible Assets.** The Company records goodwill as the excess of the purchase price over the fair value of the net assets acquired in a business combination. In accordance with ASC 350, goodwill and other indefinite-lived intangibles are tested and reviewed annually for impairment on July 1 or whenever there is a material change in events or circumstances that indicate that the fair value of the asset is more likely than not less than the carrying amount of the asset.

Impairment of goodwill is assessed at the reporting unit level and begins with a qualitative assessment to determine if it is more likely than not that the fair value of each reporting unit is less than its carrying amount as a basis for determining whether it is necessary to perform the goodwill impairment test under ASC 350. For those reporting units that bypass or fail the qualitative assessment, the test compares the carrying amount of the reporting unit to its estimated fair value. If the estimated fair value of a reporting unit exceeds its carrying amount, goodwill of the reporting unit is not impaired. To the extent that the carrying amount of the reporting unit exceeds its estimated fair value, an impairment loss will be recognized for the amount by which the reporting unit's carrying amount exceeds its fair value, not to exceed the carrying amount of goodwill in that reporting unit.

Intangible assets such as patents, service contracts, monitoring lines and customer relationships with finite useful lives are amortized based on the pattern in which the economic benefits of the intangible assets are consumed. If a pattern of economic benefit cannot be reliably determined or if straight-line amortization approximates the pattern of economic benefit, a straight-line amortization may be used.

The weighted-average useful lives approximate the following (in years):

Customer relationships	1 to 30
Patents and trademarks	5 to 30
Monitoring lines	7 to 10
Service portfolio and other	1 to 23

The Company assesses the recoverability of the carrying amount of its intangible assets with finite useful lives whenever events or changes in circumstances indicate that the carrying amount of the asset group may not be recoverable. Recoverability is measured by a comparison of the carrying amount of an asset group to the future net undiscounted cash flows expected to be generated by the asset group. If the undiscounted cash flows are less than the carrying amount of the asset group, an impairment loss is recognized for the amount by which the carrying value of the asset group exceeds the fair value of the asset group.

**Leases.** The Company accounts for leases in accordance with ASC 842: *Leases*, which requires a lessee to record a right-of-use ("ROU") asset and a lease liability on the Consolidated Balance Sheet for all leases with terms longer than 12 months. ROU assets and liabilities are recognized at the commencement date based on the present value of lease payments over the lease term. The Company generally uses its incremental borrowing rate, which is based on information available at the lease commencement date, to determine the present value of lease payments except when an implicit interest rate is readily determinable. The lease term may include options to extend or terminate the lease when it is reasonably certain that the Company will exercise that option. The Company has elected not to recognize ROU assets and lease obligations for its short-term leases, which are defined as leases with an initial term of 12 months or less.

**Income Taxes.** The Company accounts for income taxes in accordance with ASC 740. Deferred tax assets and liabilities are determined based on temporary differences between financial reporting and tax bases of assets and liabilities, applying enacted tax rates expected to be in effect for the year in which the differences are expected to reverse. The Company recognizes future tax benefits to the extent that realizing these benefits is considered in its judgment to be more likely than not. For those jurisdictions where the expiration date of tax carryforwards or the projected operating results indicate that realization is not likely, a valuation allowance is provided. The Company reviews the realizability of its deferred tax asset valuation allowances on a quarterly basis, or whenever events or changes in circumstances indicate that a review is required and will adjust its estimate if significant events so dictate. To the extent that the ultimate results differ from the Company's original or adjusted estimates, the effect will be recorded in the provision for income taxes in the period that the matter is finally resolved.

In the ordinary course of business, there is inherent uncertainty in quantifying the Company's income tax positions. The Company assesses its income tax positions and records tax benefits for all years subject to examination based upon management's evaluation of the facts, circumstances and information available at the reporting date. For those tax positions where it is more likely than not that a tax benefit will be sustained, the Company has recorded the largest amount of tax benefit with a greater than 50% likelihood of being realized upon ultimate settlement with a taxing authority that has full knowledge of all relevant information. For those income tax positions where it is not more likely than not that a tax benefit will be sustained, no tax benefit has been recognized in the Consolidated Financial Statements.



Prior to the Separation, the Company's income tax provision was prepared following the separate return methodology. The separate return method applies ASC 740 to the financial statements of each member of a consolidated group as if the group members were separate taxpayers. As a result, certain operations of the Company were included in a consolidated return with other UTC entities. The calculation of the Company's income taxes on a separate return basis requires a considerable amount of judgment and use of both estimates and allocations. See Note 17 – Income Taxes for additional information.

**Pension and Post-retirement Obligations.** The Company provides a range of benefit plans to eligible current and former employees. The Company accounts for its benefit plans in accordance with ASC 715 which requires balance sheet recognition of the overfunded or underfunded status of pension and post-retirement benefit plans. Determining the amounts associated with these benefits are performed by actuaries and dependent on various actuarial assumptions including discount rates, expected return on plan assets, compensation increases, mortality and health care cost trends. Actual results may differ from the actuarial assumptions and are generally accumulated into *Accumulated other comprehensive income (loss)* and amortized into *Net income from operations* over future periods. The Company reviews its actuarial assumptions at each measurement date and makes modifications to the assumptions based on current rates and trends, if appropriate. See Note 10 – Employee Benefit Plans for additional information.

**Asset Retirement Obligations.** The Company records the fair value of legal obligations associated with the retirement of tangible long-lived assets in the period in which a liability is determined to exist, if a reasonable estimate of fair value can be made. Upon initial recognition of a liability, the Company capitalizes the cost of the asset retirement obligation by increasing the carrying amount of the related long-lived asset. Over time, the liability is increased for changes in its present value and the capitalized cost is depreciated over the useful life of the related asset.

**Research and Development.** The Company conducts research and development activities with a focus on new product development and technology innovation. These costs are charged to expense as incurred. For the years ended December 31, 2021, 2020 and 2019, these costs amounted to \$503 million, \$419 million and \$401 million, respectively.

### Recent Pronouncements

The FASB ASC is the sole source of authoritative GAAP other than SEC issued rules and regulations that apply only to SEC registrants. The FASB issues Accounting Standards Updates ("ASU") to communicate changes to the codification. The Company considers the applicability and impact of all ASUs. ASUs not referenced below were assessed and determined to be either not applicable or are not expected to have a material impact on the Consolidated Financial Statements.

### Recently Adopted Accounting Pronouncements and SEC Rules

In October 2021, the FASB issued ASU 2021-08, *Business Combinations (Topic 805): Accounting for Contract Assets and Contract Liabilities from Contracts with Customers*, which updates the current guidance to require that an entity recognize and measure contract asset and contract liabilities acquired in a business combination consistent with those recorded by the acquiree immediately before the acquisition. The guidance eliminates the complexity of determining the fair value of contract liabilities and will likely increase the balance of contract liabilities acquired in a business combination with a corresponding increase in post-combination revenue recognized by the acquirer. The update is effective for fiscal years beginning after December 15, 2022 and interim periods therein, with early adoption permitted. In October 2021, the Company early adopted ASU 2021-08 and the adoption did not have a material impact on the Company's Consolidated Financial Statements.

In December 2019, the FASB issued ASU 2019-12, *Income Taxes (Topic 740): Simplifying the Accounting for Income Taxes*. The amendments in this update remove certain exceptions allowed by Topic 740 including exceptions to the incremental approach for intra-period tax allocation when there is a loss from continuing operations and income or gain from other items, the requirement to recognize a deferred tax liability for equity method investments when a foreign subsidiary becomes an equity method investment, the ability not to recognize a deferred tax liability for a foreign subsidiary when a foreign equity method investment becomes a subsidiary and the general methodology for calculating income taxes in an interim period when a year-to-date loss exceeds the anticipated loss for the year. There are also additional areas of guidance in regards to franchise and other taxes partially based on income and the interim recognition of enactment of tax laws and rate changes. The provisions of this ASU were effective for years beginning after December 15, 2020, with early adoption permitted. The Company adopted ASU 2019-12 in the first quarter of 2021 and the adoption did not have a material impact on the Company's Consolidated Financial Statements.

In May 2020, the SEC issued Final Rule Release No. 33-10786, which amends the financial statement requirements for acquisitions and dispositions of businesses and related pro forma financial information required under SEC Regulation S-X, Rule 3-05. The final rule modifies the significance test required in SEC Regulation S-X, Rule 1-02(w) by raising the significance threshold for reporting dispositions of a business from 10% to 20% and by modifying the calculation of the investment and income tests. In accordance with Rules 3-09 or 4-08(g), the revised income test will apply to the evaluation of equity method investments for significance. The Company adopted these modifications, which were effective for fiscal years beginning after December 31, 2020. The adoption of these amendments did not have a material impact on the Consolidated Financial Statements.

In November 2020, the SEC issued Final Rule Release No. 33-10980, which amends the requirements for providing selected quarterly financial data, contractual obligations and management discussion and analysis. These modifications were required after August 9, 2021. The Company applied the requirements of this release for this Annual Report on Form 10-K.

**Note 4: Inventories, Net**

Inventories are stated at the lower of cost or estimated realizable value. Cost is primarily determined based on the first-in, first-out inventory method ("FIFO") or average cost methods, which approximates current replacement cost. However, certain Carrier entities use the last-in, first-out inventory method ("LIFO").

Inventories, net consisted of the following:

The Company performs periodic assessments utilizing customer demand, production requirements and historical usage rates to determine the existence of excess and obsolete inventory and records necessary provisions to reduce such inventories to estimated realizable value. Raw materials, work-in-process and finished goods are net of valuation reserves of \$154 million and \$183 million as of December 31, 2021 and 2020, respectively.

Certain entities use LIFO to determine the cost of inventory. If inventories that were valued using the LIFO method had been valued under the FIFO method, the net book value of the inventories would have been higher by \$141 million and \$118 million as of December 31, 2021 and 2020, respectively. As of December 31, 2021 and 2020, approximately 31% and 33%, respectively, of all inventory utilized the LIFO method.

**Note 5: Fixed Assets, Net**

Fixed assets, net consisted of the following:

Depreciation expense was \$238 million, \$234 million and \$219 million for the years ended December 31, 2021, 2020 and 2019, respectively.

**Note 6: Goodwill And Intangible Assets**

The Company records goodwill as the excess of the purchase price over the fair value of the net assets acquired in a business combination. Goodwill is tested and reviewed annually for impairment on July 1 or whenever there is a material change in events or circumstances that indicates that the fair value of the reporting unit may be less than its carrying amount.

The changes in the carrying amount of goodwill were as follows:

(1) See Note 19 - Acquisitions for additional information.

(2) See Note 20 - Divestitures for additional information.

Indefinite-lived intangible assets are tested and reviewed annually for impairment on July 1 or whenever there is a material change in events or circumstances that indicates that the fair value of the asset may be less than its carrying amount. All other intangible assets with finite useful lives are amortized over their estimated useful lives.

Identifiable intangible assets consisted of the following:

2021

2020

The estimated future amortization of intangible assets is as follows:

#### Annual Impairment Assessment

The Company tested its goodwill and indefinite-lived intangible assets for impairment as part of its annual assessment. For each test, the Company qualitatively assessed all relevant events or circumstances that could impact the estimate of fair value. Based upon this assessment, the Company determined that it was more likely than not that goodwill and indefinite-lived intangible assets were not impaired.

#### Note 7: Borrowings And Lines Of Credit

Long-term debt consisted of the following:

#### Revolving Credit Facility

On February 10, 2020, the Company entered into a revolving credit agreement with various banks permitting aggregate borrowings of up to \$2.0 billion pursuant to an unsecured, unsubordinated revolving credit facility that matures on April 3, 2025 (the "Revolving Credit Facility"). The Revolving Credit Facility supports the Company's commercial paper program and cash requirements of the Company. A commitment fee of 0.125% is charged on unused commitments. Borrowings under the Revolving Credit Facility are available in U.S. Dollars, Euros and Pounds Sterling. Pounds Sterling bears interest at a variable interest rate based on daily simple SONIA plus 0.0326%, Euros bears an interest rate using EURIBOR and U.S. Dollar bears an interest rate at LIBOR plus a ratings-based margin, which was 125 basis points as of December 31, 2021. As of December 31, 2021, there were no borrowings on the Revolving Credit Facility.

#### Commercial Paper Program

As of December 31, 2021, the Company had a \$2.0 billion unsecured, unsubordinated commercial paper program, which can be used for general corporate purposes, including the funding of working capital and potential acquisitions. As of December 31, 2021, there were no borrowings outstanding under the commercial paper program.

#### Project Financing Arrangements

The Company is involved in several long-term construction contracts in which it arranges project financing with certain customers. As a result, the Company issued \$124 million and \$135 million of debt during the year ended December 31, 2021 and 2020, respectively. Long-term debt repayments associated with these financing arrangements for the years ended December 31, 2021 and 2020 were \$181 million and \$161 million, respectively.

(1) In February 2021, the Company prepaid the 1.923% Notes due in February 2023 and incurred a \$17 million make-whole premium upon prepayment and wrote-off \$2 million of the remaining unamortized deferred financing costs.

### Debt Covenants

The Revolving Credit Facility and the indenture for the long-term notes contain affirmative and negative covenants customary for financings of this type which, among other things, limit the Company's ability to incur additional liens, to make certain fundamental changes and to enter into sale and leaseback transactions. On June 2, 2020, the Company entered into an amendment to the Revolving Credit Facility, under which certain terms of the facility were amended for a period beginning on June 2, 2020 and ending on December 30, 2021 (the "Covenant Modification"). The Company terminated the Covenant Modification effective as of August 27, 2021 in accordance with procedures for termination set forth in the revolving credit agreement, which returned the consolidated leverage ratio covenant to the limit in effect prior to the Covenant Modification. As of December 31, 2021, the Company was in compliance with the covenants under the agreements governing its outstanding indebtedness.

### Schedule of Long-term Debt Maturities

Scheduled maturities of long-term debt, excluding amortization of discount, are as follows:

As of December 31, 2021, the average maturity of the Company's long-term notes is approximately 12 years and the weighted-average interest rate on its total borrowings is approximately 2.8%.

Interest expense associated with long-term debt for the years ended December 31, 2021 and 2020 was \$319 million and \$298 million, respectively. Interest expense for the year ended December 31, 2021 includes amortization of debt issuance costs of \$10 million, a make

whole-premium related to the prepayment of the 1.923% Notes of \$17 million and a write-off of debt issuance costs of \$2 million. Interest expense for the year ended December 31, 2020 includes amortization of debt issuance costs of \$9 million and a write-off of debt issuance costs of \$5 million.

### Note 8: Fair Value Measurements

ASC 820, *Fair Value Measurement* ("ASC 820"), defines fair value as the price that would be received if an asset is sold or the price paid to transfer a liability in an orderly transaction between market participants at the measurement date. ASC 820 also establishes a three-level fair value hierarchy that prioritizes information used in developing assumptions when pricing an asset or liability as follows:

- Level 1: Observable inputs such as quoted prices in active markets;
- Level 2: Inputs, other than quoted prices in active markets, that are observable either directly or indirectly; and
- Level 3: Unobservable inputs where there is little or no market data, which requires the reporting entity to develop its own assumptions.

ASC 820 requires the use of observable market data, when available, in making fair value measurements. When inputs used to measure fair value fall within different levels of the hierarchy, the level within which the fair value measurement is categorized is based on the lowest level input that is significant to the fair value measurement.

In the normal course of business, the Company is exposed to certain risks arising from business operations and economic factors, including foreign currency and commodity price risk. These exposures are managed through operational strategies and the use of undesignated hedging contracts. The Company's derivative assets and liabilities are measured at fair value on a recurring basis using internal models based on observable market inputs, such as forward, interest, contract and discount rates with changes in fair value reported directly in earnings.

The following tables provide the valuation hierarchy classification of assets and liabilities that are recorded at fair value and measured on a recurring basis in the Company's Consolidated Balance Sheet:

(1) Included in *Other assets, current* on the accompanying Consolidated Balance Sheet.

(2) Included in *Accrued liabilities* on the accompanying Consolidated Balance Sheet.

The following table provides the carrying amounts and fair values of the Company's long-term notes that are not recorded at fair value in the Consolidated Balance Sheet:

	2021	2020

(1) Excludes debt discount and issuance costs.

The fair value of the Company's long-term debt is measured based on observable market inputs which are considered Level 1 within the fair value hierarchy. The carrying value of cash and cash equivalents, accounts receivable, accounts payable and short-term borrowings approximate fair value due to the short-term nature of these accounts and would be classified as Level 1 in the fair value hierarchy. The Company's financing leases and project financing obligations, included in *Long-term debt* approximate fair value and are classified as Level 3 in the fair value hierarchy. For the years ended December 31, 2021 and 2020 there were no transfers in or out of levels 1, 2 or 3.

**Note 9: Leases**

The Company enters into operating and finance leases for the use of real estate space, vehicles, information technology equipment and certain other equipment. At contract inception, the Company determines a lease exists if the arrangement conveys the right to control an identified asset for a period of time in exchange for consideration. Control is considered to exist when the lessee has the right to obtain substantially all of the economic benefits from the use of an identified asset as well as the right to direct the use of that asset. If a contract is considered to be a lease, the Company recognizes a lease liability based on the present value of the future lease payments with an offsetting entry to recognize a ROU asset.

Operating lease ROU assets and liabilities are reflected on the Consolidated Balance Sheet as follows:

The operating lease ROU assets include any lease payments related to initial direct costs and prepayments and excludes lease incentives. The Company's leases generally have remaining lease terms of 1 to 23 years, some of which include options to extend. For the majority of its leases with options to extend, those options are up to 5 years with the ability to terminate the lease within 1 to 5 years of inception. The exercise of lease renewal options is at the Company's sole discretion and its lease ROU assets and liabilities reflect only the options the Company is reasonably certain that it will exercise.

Supplemental cash flow and lease expense information related to operating leases were as follows:

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Operating lease expense is recognized on a straight-line basis over the lease term. Where applicable, the Company accounts for each separate lease component of a contract and its associated non-lease component as a single lease component.

Undiscounted maturities of operating lease liabilities, including options to extend lease terms that are reasonably certain of being exercised, as of December 31, 2021 are as follows:

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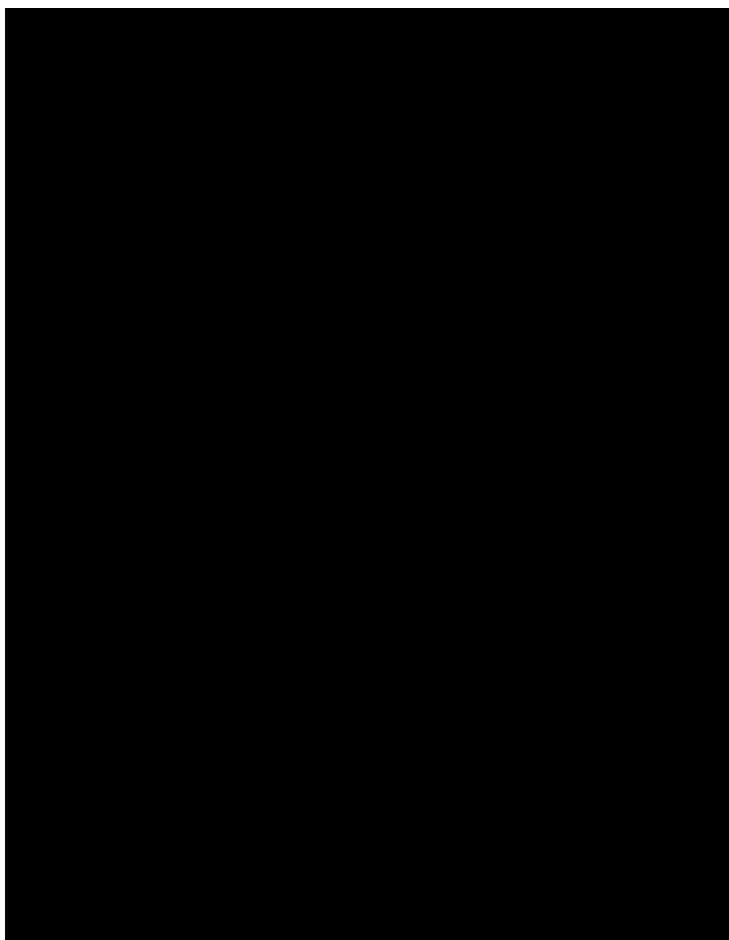
**NOTE 10: Employee Benefit Plans**

The Company sponsors both funded and unfunded domestic and international defined benefit pension and defined contribution plans. In addition, the Company contributes to various domestic and international multi-employer defined benefit pension plans.

**Pension Plans**

Qualified domestic pension plan benefits covering collectively bargained U.S. employees comprise approximately 34% of the projected benefit obligation. This noncontributory defined benefit plan provides benefits on a flat dollar formula based on location and is closed to new entrants. The non-U.S. plans comprise approximately 66% of the projected benefit obligation; certain of these plans provide participants with one-time payments upon separation of employment rather than a retirement annuity. These plans provide benefits based on a plan specific benefit formula. Non-qualified domestic pension plans provide supplementary retirement benefits to certain employees and are not a material component of the projected benefit obligation.

The following table details information regarding the Company's pension plans:

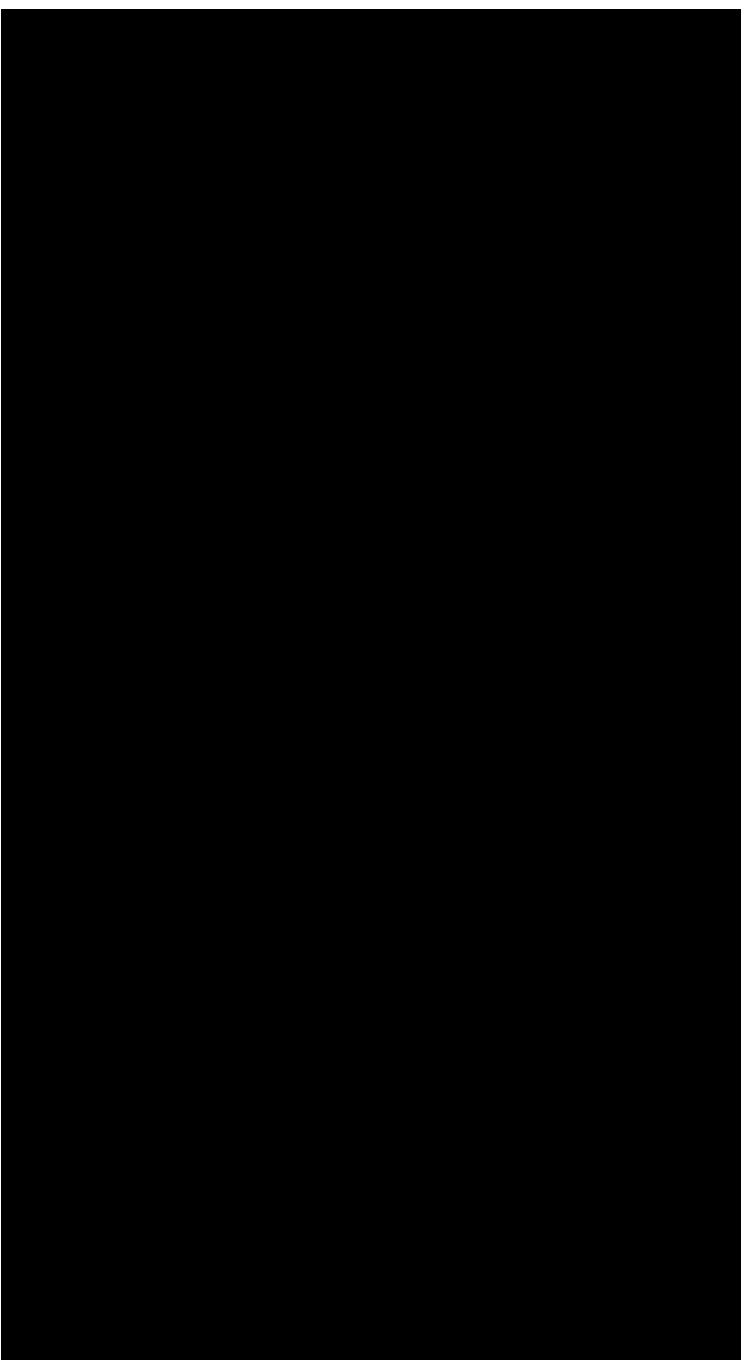


(1) Reflects the impact of foreign exchange translation, primarily for plans in the United Kingdom, Canada and Germany.

(2) See Note 20 - Divestitures for additional information.

The key contributor to the movement in the funded position was the reclassification of plans included in the sale of Chubb to held for sale. The plans to be retained by the Company experienced an improvement in the net deficit position due to better than expected asset performance globally, favorable exchange rate movements and an increase in the discount rate used to measure the benefit obligations of the plans. Discount rates in all applicable territories and countries increased over the measurement period as a result of increases in corporate bond yields.

The pretax amounts recognized in *Accumulated other comprehensive (income) loss* are:



The accumulated benefit obligation for all defined benefit plans was \$0.9 billion and \$3.2 billion as of December 31, 2021 and 2020, respectively.

Major assumptions used in determining the benefit obligation and net cost for pension plans are presented in the following table as weighted-averages:

Benefit Obligation	Net Costs
[REDACTED]	

(1) The 2021 and 2020 discount rates used to measure the service cost and interest cost applies to the significant plans of the Company. The projected benefit obligation discount rate is used for the service cost and interest cost measurements for non-significant plans.

(2) Assumptions prior to 2020 include assumptions used for the UTC plan which included Carrier employees.

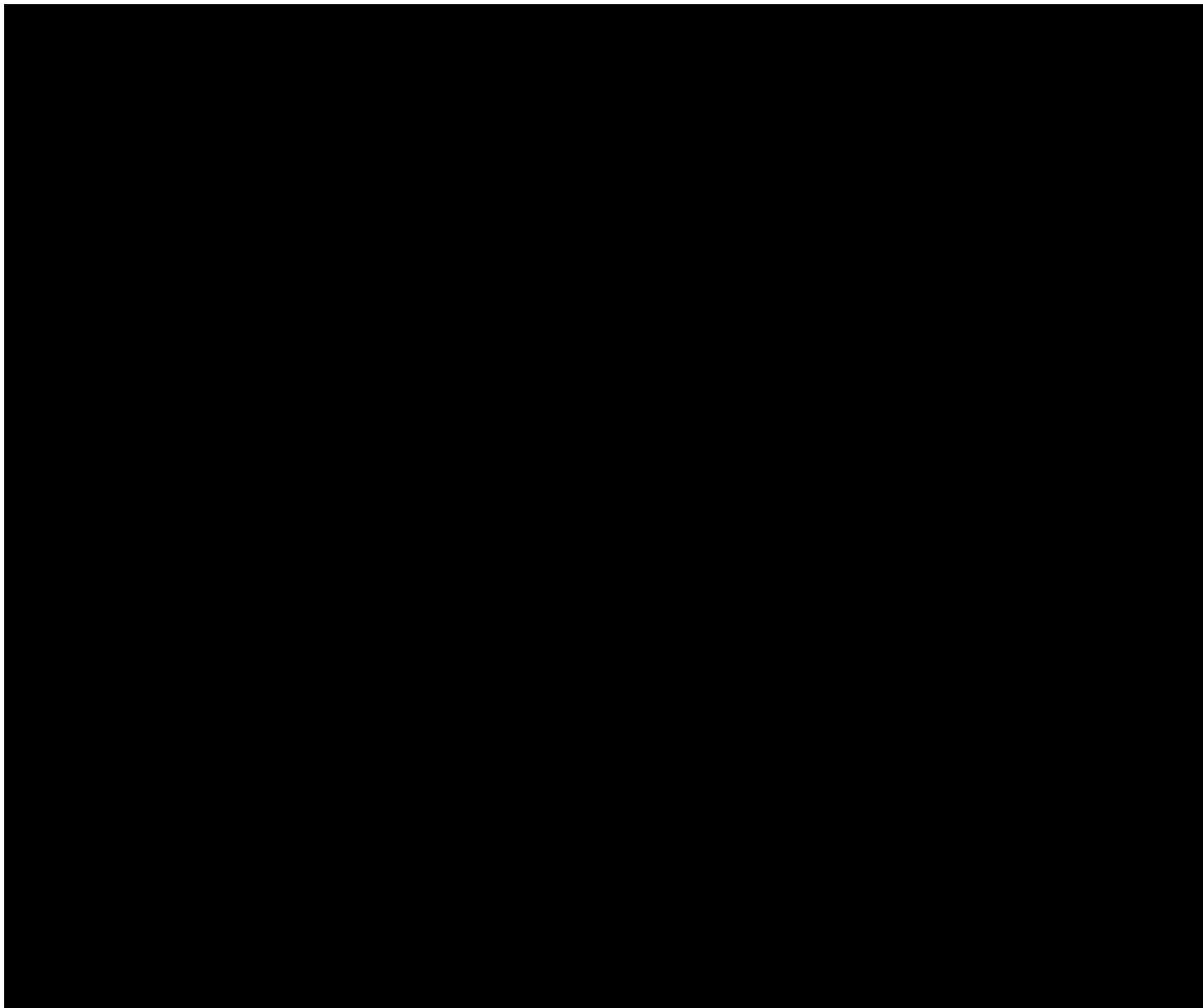
The weighted-average discount rates used to measure pension benefit obligations and net costs are set by reference to specific analyses using each plan's specific cash flows and high-quality bond indices to assess reasonableness. For those significant plans, the Company utilizes a full yield curve approach in the estimation of the service cost and interest cost components by applying the specific spot rates along the yield curve used in determination of the benefit obligation to the relevant projected cash flows.

In determining the expected return on plan assets, the Company considered the relative weighting of plan assets, the historical performance of total plan assets and individual asset classes and economic and other indicators of future performance. Return projections are assessed for reasonableness using a simulation model that incorporates yield curves, credit spreads and risk premiums to project long-term prospective returns.

The plans' investment management objectives include providing the liquidity and asset levels needed to meet current and future benefit payments, while maintaining a prudent degree of portfolio diversification considering interest rate risk and market volatility. Globally, investment strategies target a mix of approximately 50% of growth seeking assets and 50% of income generating and hedging assets using a wide diversification of asset types, fund strategies and investment managers. The growth seeking allocation consists of global public equities in developed and emerging countries and alternative-asset class strategies. Within the income generating assets, the fixed income portfolio primarily consists of government and broadly diversified high quality corporate bonds.

The plans seek to reduce interest rate risk and have incorporated liability hedging programs that include the adoption of a risk reduction objective as part of the long-term investment strategy. Under this objective, the income generating and hedging assets typically increase as funded status improves. The hedging programs incorporate a range of assets and investment tools, each with various interest rate sensitivities. As a result of the improved funded status of the plans, due to favorable asset returns and funding of the plans, the income generating and hedging assets increased in recent years.

The fair values of pension plan assets by asset category are as follows:



(1) Represents commingled funds that invest primarily in common stocks.

(2) In accordance with ASU 2015-07, *Fair Value Measurement (Topic 820)*, certain investments that are measured at fair value using the net asset value per share (or its equivalent) practical expedient have not been classified in the fair value hierarchy. The fair value amounts presented in this table are intended to permit reconciliation of the fair value hierarchy to the amounts presented for the total pension plan assets.

(3) Represents investments in real estate, including commingled funds and directly held properties.

(4) Represents insurance contracts and global balanced risk commingled funds consisting mainly of equity, bonds and some commodities.

(5) Includes fixed income repurchase agreements entered into for purposes of pension asset and liability matching.

(6) Represents short-term commercial paper, bonds and other cash or cash-like instruments.

(7) Represents trust receivables and payables that are not leveled.

(8) Chubb plan assets for 2021, totaling \$2.6 billion are not included within this table, as the business has been reclassified as held for sale.



Derivatives in the plan are primarily used to manage risk and gain asset class exposure while still maintaining liquidity. Derivative instruments mainly consist of fixed income repurchase agreements, interest rate swaps, total return swaps and currency forward contracts.

Quoted market prices are used to value investments when available. Investments in securities traded on exchanges, including listed futures and options, are valued at the last reported sale prices on the last business day of the year or, if not available, the last reported bid prices. Fixed income securities are primarily measured using a market approach pricing methodology, whereby observable prices are obtained by market transactions involving identical or comparable securities of issuers with similar credit ratings. Over-the-counter securities and government obligations are valued at the bid prices or the average of the bid and ask prices on the last business day of the year from published sources or, if not available, from other sources considered reliable, including broker quotes. Temporary cash investments are stated at cost, which approximates fair value.

For the years ended December 31, 2021, 2020 and 2019, the Company made \$47 million, \$41 million and \$36 million, respectively, of cash contributions to its defined benefit pension plans. The Company expects to make total contributions of approximately \$3 million to its defined benefit pension plans in 2022. Contributions do not reflect benefits to be paid directly from corporate assets. Benefit payments, including amounts to be paid from corporate assets, and reflecting expected future service, as appropriate, are expected to be paid as follows: \$25 million in 2022, \$28 million in 2023, \$29 million in 2024, \$32 million in 2025, \$34 million in 2026 and \$197 million from 2027 through 2030.

#### Multiemployer Benefit Plans

The Company contributes to various domestic and foreign multiemployer defined benefit pension plans. The risks of participating in these multiemployer plans are different from those of single-employer plans in that assets contributed are pooled and may be used to provide benefits to employees of other participating employers. If a participating employer stops contributing to the plan, the unfunded obligations of the plan may be borne by the remaining participating employers. The Company's contributions to these plans for the years ended December 31, 2021 and 2020 was \$14 million and \$15 million, respectively.

#### Employee Savings Plans

The Company sponsors various employee savings plans. Certain employees of Carrier participate in these plans. Carrier's contributions to employer sponsored defined contribution plans were \$115 million, \$103 million and \$88 million for the years ended December 31, 2021, 2020 and 2019, respectively.

#### Note 11: Product Warranties

In the ordinary course of business, the Company provides standard warranty coverage on its products. Provisions for these amounts are established at the time of sale and estimated primarily based on product warranty terms and historical claims experience. In addition, the Company incurs discretionary costs to service its products in connection with specific product performance issues. Provisions for these amounts are established when they are known and estimable. The Company assesses the adequacy of its initial provisions and will make adjustments as necessary based on known or anticipated claims or as new information becomes available that suggests it is probable that future costs will be different than estimated amounts. Amounts associated with these provisions are classified as *Accrued liabilities* or *Other long-term liabilities* based on their anticipated settlement date.

The changes is the carrying amount of warranty related provisions are as follows:

#### Note 12: Equity

##### Share Repurchase Program

In July 2021, the Company's Board of Directors authorized a \$1.75 billion increase to the Company's existing \$350 million stock repurchase program. The program allows the Company to repurchase its outstanding common stock from time to time subject to market conditions and at the Company's discretion in the open market or through one or more other public or private transactions and subject to compliance with the Company's obligations under the TMA. The Company records repurchases under the cost method whereby the entire cost of the acquired stock is recorded as *Treasury stock* as a reduction to equity. The reissuance of treasury stock uses the first-in, first-out method of accounting.

The Company repurchased 10.4 million shares of common stock for an aggregate purchase price of \$529 million for the year ended December 31, 2021, which are held in *Treasury stock* as of December 31, 2021 as reflected on its Consolidated Balance Sheet.

**Accumulated Other Comprehensive Income (Loss)**

A summary of the changes in each component of *Accumulated other comprehensive income (loss)* is as follows:

**Note 13: Revenue Recognition**

The Company accounts for revenue in accordance with ASC 606: *Revenue from Contracts with Customers*. Revenue is recognized when control of a good or service promised in a contract (i.e., performance obligation) is transferred to a customer. Control is obtained when a customer has the ability to direct the use of and obtain substantially all of the remaining benefits from that good or service. A significant portion of the Company's performance obligations are recognized at a point-in-time when control of the product transfers to the customer, which is generally the time of shipment. The remaining portion of the Company's performance obligations are recognized over time as the customer simultaneously obtains control as the Company performs work under a contract, or if the product being produced for the customer has no alternative use and the Company has a contractual right to payment.

**Performance Obligations**

A performance obligation is a distinct good, service or a bundle of goods and services promised in a contract. Some of the Company's contracts with customers contain a single performance obligation, while others contain multiple performance obligations most commonly when a contract spans multiple phases of a product life-cycle such as production, installation, maintenance and support. The Company identifies performance obligations at the inception of a contract and allocates the transaction price to each distinct performance obligation. Revenue is recognized when or as the performance obligation is satisfied. When there are multiple performance obligations within a contract, the Company allocates the transaction price to each performance obligation based on its relative stand-alone selling price.

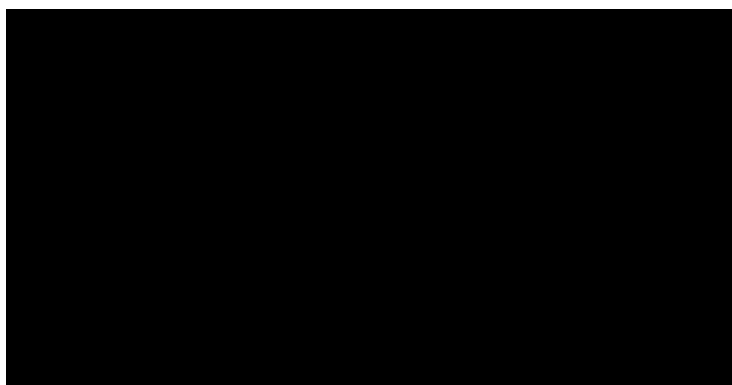
The Company primarily generates revenue from the sale of products to customers and recognizes revenue at a point in time when control transfers to the customer. Transfer of control is generally based on the shipping terms of the contract. In addition, the Company recognizes revenue on an over-time basis on installation and service contracts. For over-time performance obligations requiring the installation of equipment, revenue is recognized using costs incurred to date relative to total estimated costs at completion to measure progress. Incurred costs represent work performed, which correspond with and best depict transfer of control to the customer. Contract costs include direct costs such as labor, materials and subcontractors' costs and where applicable, indirect costs.

Segment sales disaggregated by product and service are as follows:

The transaction price allocated to performance obligations reflects the Company's expectations about the consideration it will be entitled to receive from a customer. The Company includes variable consideration in the estimated transaction price when there is a basis to reasonably estimate the amount and when it is probable that a significant reversal of revenue recognized would not occur when the uncertainty associated with variable consideration is subsequently resolved. In addition, the Company customarily offers its customers incentives to purchase products to ensure an adequate supply of its products in distribution channels. The principal incentive programs provide reimbursements to distributors for offering promotional pricing for products. The Company accounts for estimated incentive payments as a reduction in sales at the time a sale is recognized.

### Contract Balances

Total contract assets and liabilities consisted of the following:



The timing of revenue recognition, billings and cash collections results in contract assets and contract liabilities. Contract assets relate to the conditional right to consideration for any completed performance under a contract when costs are incurred in excess of billings under

the percentage-of-completion methodology. Contract liabilities relate to payments received in advance of performance under the contract or when the Company has a right to consideration that is conditioned upon transfer of a good or service to the customer. Contract liabilities are recognized as revenue as (or when) the Company performs under the contract.

The Company recognized revenue of \$408 million for the year ended December 31, 2021 that was related to contract liabilities as of January 1, 2021. The Company expects a majority of its contract liabilities at the end of the period to be recognized as revenue over the next 12 months. There were no individually significant customers with sales exceeding 10% of total sales for the years ended December 31, 2021, 2020 and 2019.

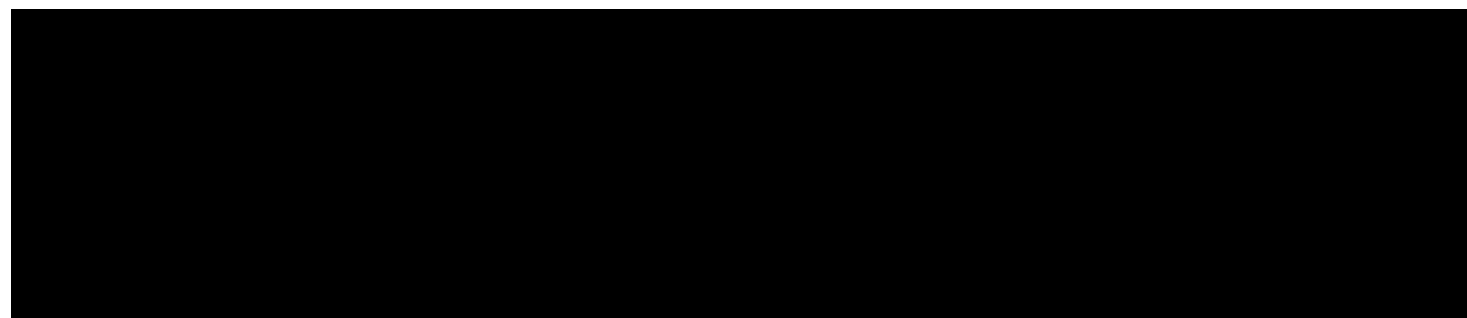
### Note 14: Stock-Based Compensation

The Company accounts for stock-based compensation plans in accordance with ASC 718, *Compensation - Stock Compensation*, which requires a fair-value based method for measuring the value of stock-based compensation. Fair value is measured at the date of grant and is generally not adjusted for subsequent changes. The Company's stock-based compensation plans include programs for stock appreciation rights, restricted stock and performance share units.

### Stock Options and Appreciation Rights

Eligible participants may receive stock options or stock appreciation rights as part of the Company's long-term incentive program. The fair value of each instrument is determined as of the date of grant using a binomial lattice model and expensed on a straight-line basis over the required service period, which is generally a three-year vesting period. However, in the event of retirement, awards held for at least one year may vest and become exercisable (if applicable), subject to certain terms and conditions.

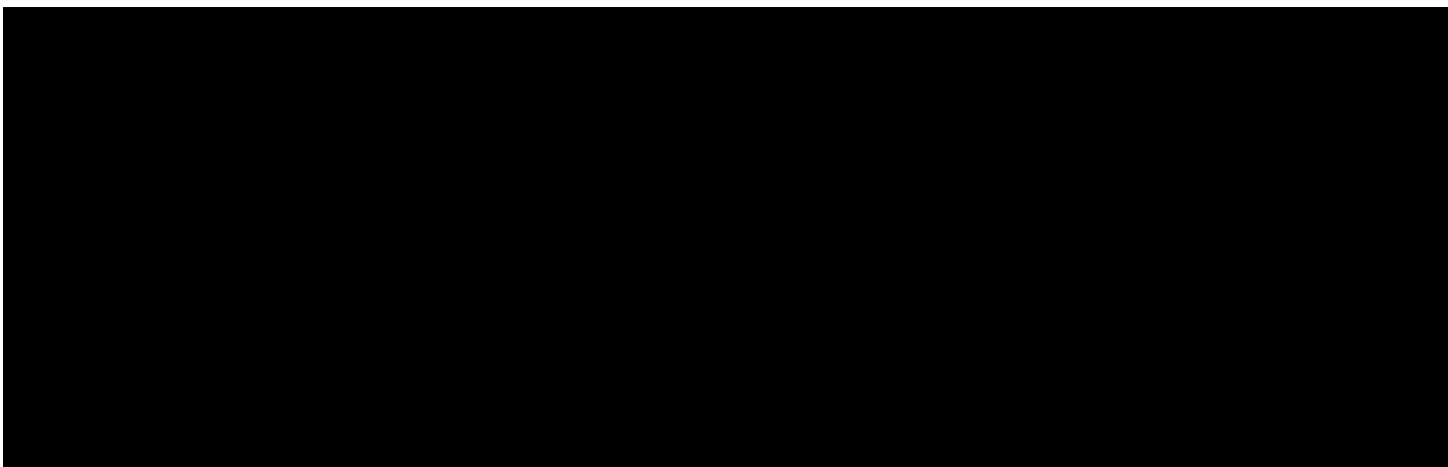
The following table summarizes fair value information for stock options and stock appreciation rights:



(2) The assumptions for 2019 were determined by UTC based on UTC's stock price performance.

The Company used historical employee data, including data prior to the Separation and the Distribution, to estimate expected term. The expected dividend yield is consistent with management's expectations. The risk-free rate is based on the term structure of interest rates at the time the awards were granted.

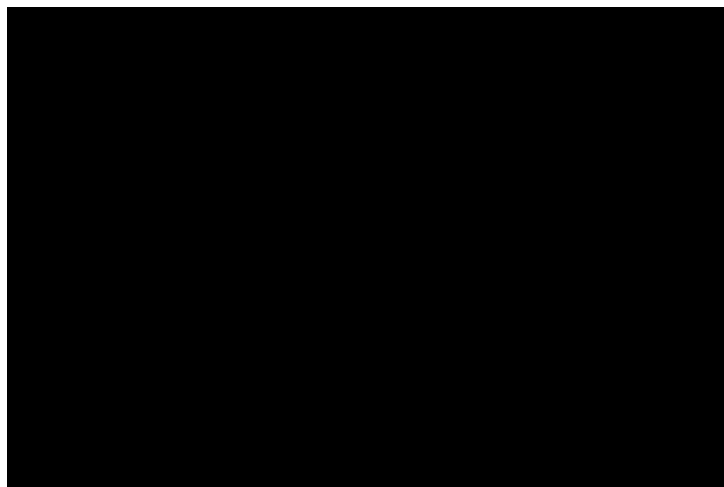
Changes in stock options and stock appreciation rights outstanding subsequent to the Separation and Distribution were as follows:



#### **Restricted Stock Units**

Eligible participants may receive restricted stock units ("RSU") as part of the Company's long-term incentive program. The fair value of restricted stock units are based on the closing market price of the Company's common stock on the date of grant and expensed on a straight-line basis over the required service period (which is generally the three-year vesting period). However, in the event of retirement, awards held for at least one year may vest and become exercisable (if applicable), subject to certain terms and conditions. Dividends accrue during the vesting period and are paid in shares of the Company's common stock.

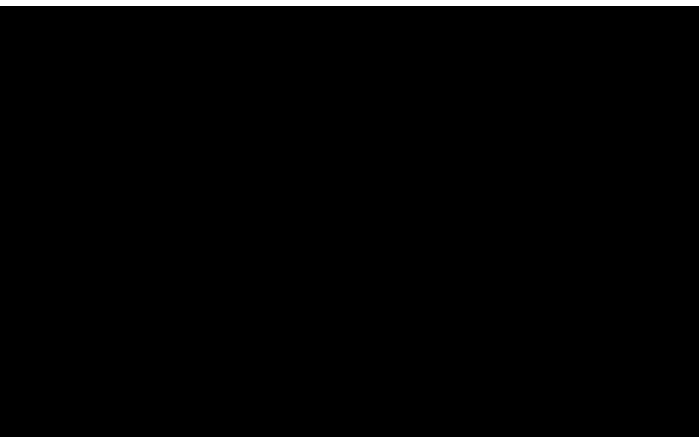
Changes in restricted stock units subsequent to the Separation and Distribution were as follows:



#### **Performance Share Units**

The Company has a performance share program for key employees whereby awards are provided in the form of performance share units ("PSU") based on performance against pre-established objectives. The annual target level is expressed as shares of the Company's common stock based on the fair value of its stock on the date of grant. Awards are earned over a three-year performance period based equally on a performance condition, measured by the compound annual growth rate of the Company's earnings per share and on a market condition, measured by the Company's relative total shareholder return compared to the total shareholder return of a subset of industrial companies in the S&P 500 Index. The fair value of the market condition is estimated using a Monte Carlo simulation approach. The fair value of the PSU awards are expensed over the required service period, which is generally a three-year vesting period. In the event of retirement, performance share units held for at least one year remain eligible to vest based on actual performance relative to pre-established metrics. Dividends do not accrue on the performance share units during the performance period.

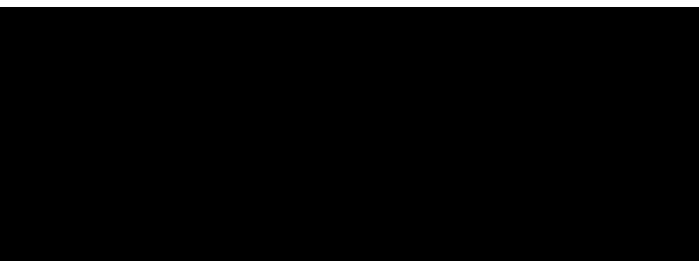
Changes in PSUs subsequent to the Separation and Distribution were as follows:



### Compensation Expense

Stock-based compensation expense, net of estimated forfeitures, is included in *Cost of products sold*, *Selling, general and administrative* and *Research and development*, in the accompanying Consolidated Statement of Operations.

Stock-based compensation cost by award type are as follows:



- (1) The stock-based compensation cost for 2020 and 2019 include amounts allocated to Carrier by UTC related to its direct employees.  
 (2) The cash settled awards are classified as liability awards and are measured at fair value at each balance sheet date.

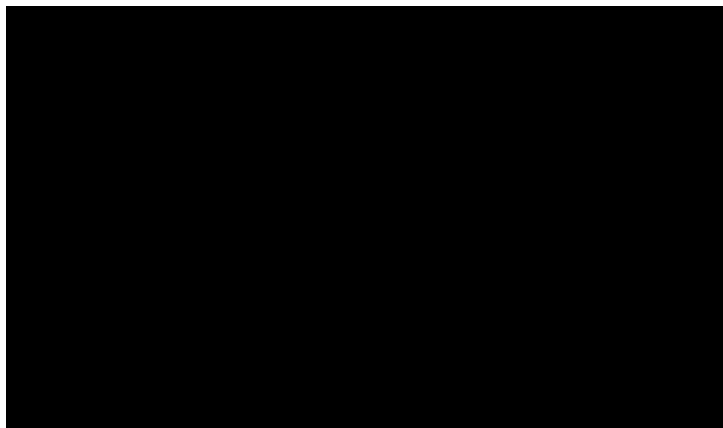
Prior to the Separation and the Distribution, the Company participated in UTC's long-term incentive plans, which authorized various types of market and performance-based incentive awards. Stock-based compensation expense was allocated to the Company from UTC based upon direct employee headcount. In connection with the Separation and the Distribution, all awards were converted to Carrier stock-based awards with unvested awards converted to preserve the aggregate intrinsic value immediately before and after the Separation.

As of December 31, 2021 and 2020, there were \$77 million and \$91 million of unrecognized stock-based compensation costs related to non-vested awards granted under the plan, respectively, which will be recognized ratably over the awards weighted-average vesting period of 2 years.

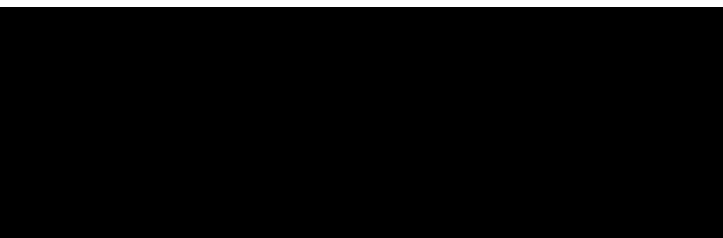
### Note 15: Restructuring Costs

The Company incurs costs associated with restructuring initiatives intended to improve operating performance, profitability and working capital levels. Actions associated with these initiatives may include improving productivity, workforce reductions and the consolidation of facilities.

The Company recorded net pre-tax restructuring costs for new and ongoing restructuring actions as follows:



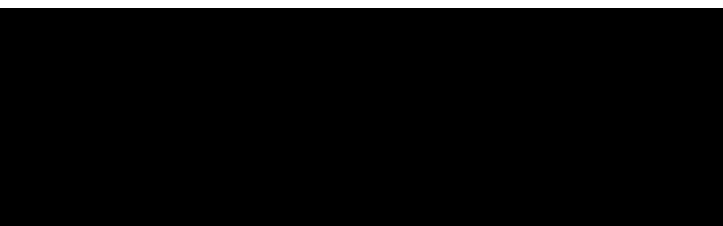
The following table summarizes the reserves and charges related to the restructuring reserve:



During the year ended December 31, 2021, charges associated with restructuring initiatives related to cost reduction efforts. Amounts recognized primarily related to severance due to workforce reductions and exit costs due to the consolidation of field operations. As of December 31, 2021, the Company had \$54 million accrued for costs associated with its announced restructuring initiatives, all of which is expected to be paid within one year.

### Note 16: Other Income (Expense), Net

Other income (expense), net consisted of the following:



- (1) See Note 22 - Related Parties for additional information.

*Other income (expense), net* primarily includes the impact of gains and losses related to the sale of interests in equity method investments, foreign currency gains and losses on transactions that are denominated in a currency other than the entity's functional currency and hedging-related activities.

**Note 17: Income Taxes****Income Before Income Taxes**

The sources of *Income from operations before income taxes* are as follows:

**Provision for Income Taxes**

The income tax expense (benefit) consisted of the following components:

**Reconciliation of Effective Income Tax Rate**

The differences between the effective income tax rate and the statutory U.S. federal income tax rate are as follows:

The effective tax rate for the year ended December 31, 2021 includes a net tax charge of \$157 million primarily relating to the re-organization and disentanglement of certain Chubb subsidiaries executed in advance of the planned divestiture of Chubb, a \$43 million deferred

tax charge as a result of the tax rate increase from 19% to 25% in the United Kingdom, partially offset by a favorable tax adjustment of \$70 million due to foreign tax credits generated and expected to be utilized in the current year and \$21 million resulting from the re-organization of a German subsidiary.

The effective tax rate for the year ended December 31, 2020 reflects a \$51 million charge related to a valuation allowance recorded against a United Kingdom tax loss and credit carryforward and a charge of \$46 million resulting from the Company's decision to no longer permanently reinvest certain pre-2018 unremitted non-U.S. earnings. These items were impacted by the Separation and are included in "Separation impact" in the previous table.

The effective tax rate for the year ended December 31, 2019 reflects a net tax benefit of \$149 million as a result of the filing by a subsidiary of the Company to participate in an amnesty program offered by the Italian Tax Authority and the conclusion of an audit by the IRS for UTC's 2014, 2015 and 2016 tax years.

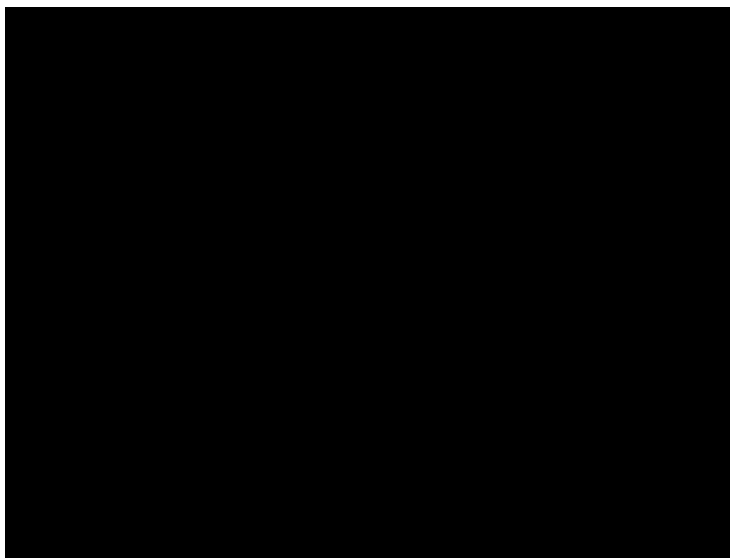
**Deferred Tax Assets and Liabilities**

Future income taxes represent the tax effects of transactions, which are reported in different periods for tax and GAAP purposes. These amounts consist of the tax effects of differences between tax and GAAP that are expected to be reversed in the future and tax carryforwards. Future income tax benefits and payables within the same tax paying component of a particular jurisdiction are offset for presentation in the Consolidated Balance Sheet.

The tax effects of temporary differences and tax carryforwards which give rise to future income tax benefits and payables as of December 31, 2021 and 2020 are as follows:

Valuation allowances have been established primarily for tax credit carryforwards, tax loss carryforwards and certain foreign temporary differences to reduce future income tax benefits to expected realizable amounts. As of December 31, 2021, future income tax benefits and future income tax payables exclude a net liability of \$266 million classified as held for sale. See Note 20 - Divestitures for additional information.

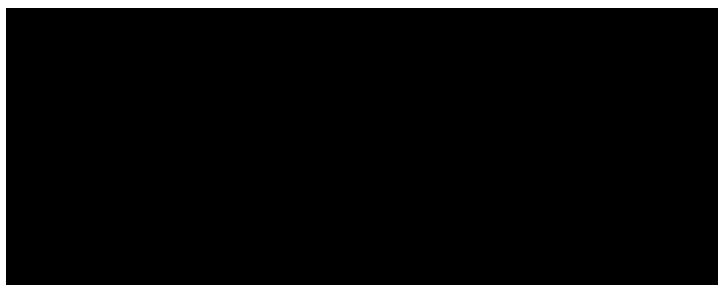
Changes to valuation allowances consisted of the following:



(1) Includes \$89 million relating to "Separation impact" discussed in section "Reconciliation of Effective Income Tax Rate."

### Tax Credit and Loss Carryforwards

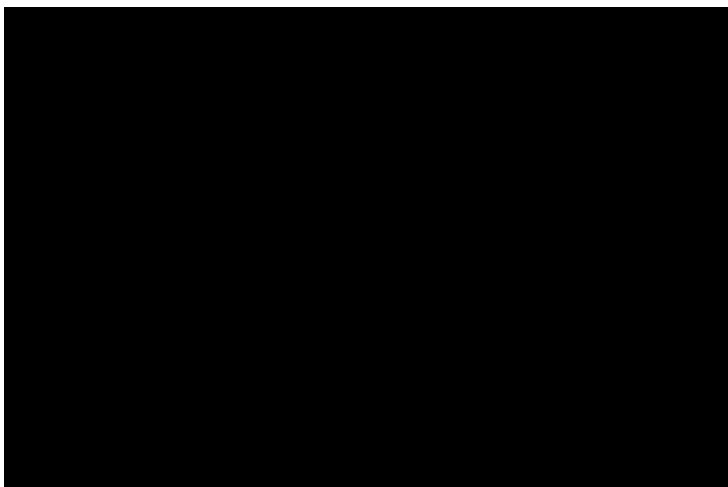
As of December 31, 2021, tax credit carryforwards and tax loss carryforwards, excluding amounts associated with Chubb entities, were as follows:



The Company assesses the realizability of its deferred tax assets on a quarterly basis through an analysis of potential sources of future taxable income, including prior year taxable income available to absorb a carryback of tax losses, reversals of existing taxable temporary differences, tax planning strategies and forecasts of taxable income. The Company considers all negative and positive evidence, including the weight of the evidence, to determine if valuation allowances against deferred tax assets are required. The Company maintains valuation allowances against certain deferred tax assets, primarily in non-U.S. jurisdictions.

### Unrecognized Tax Benefits

As of December 31, 2021, the Company had unrecognized tax benefits of \$251 million, all of which, if recognized, would impact its effective tax rate. A reconciliation of the beginning and ending amounts of unrecognized tax benefits and related interest expense is as follows:



(1) Includes \$14 million related to acquisitions during the year ended December 31, 2021.

(2) Includes an adjustment of \$37 million recorded in UTC Net investment for the year ended December 31, 2020 for tax positions of prior years.

The Company conducts business globally and, as a result, the Company and its subsidiaries file income tax returns in the U.S. federal, various state and foreign jurisdictions. In certain jurisdictions, the Company's operations were included in UTC's combined tax returns for the periods through the Separation and the Distribution. The IRS commenced an audit of UTC's tax years 2017 and 2018 in the second quarter of 2020. In the normal course of business, the Company is subject to examination by taxing authorities throughout the world, including the U.S., Australia, Belgium, Canada, China, Czech Republic, France, Germany, Hong Kong, India, Italy, Mexico, the Netherlands, Singapore and the United Kingdom. The Company is no longer subject to U.S. federal income tax examination for years prior to 2017 and, with few exceptions, is no longer subject to U.S. state and local and foreign income tax examinations for tax years before 2012.

During the second quarter of 2019, a subsidiary of the Company that was engaged in litigation before the Italian Supreme Court filed to participate in the Italian amnesty program. In addition, during the second quarter of 2019, the IRS completed its review of UTC's 2014, 2015 and 2016 tax years and certain U.S. state income tax exams concluded. As a result of the amnesty filing in Italy and the conclusion of the IRS and U.S. state audits, the Company recognized a non-cash gain of approximately \$166 million, including pre-tax interest of approximately \$16 million.

In the ordinary course of business, there is inherent uncertainty in quantifying the Company's income tax positions. The Company assesses its income tax positions and records tax benefits for all years subject to examination based upon management's evaluation of the facts, circumstances and information available at the reporting date. It is reasonably possible that a net decrease in unrecognized tax



benefits from \$10 million to \$65 million may occur within 12 months as a result of additional worldwide uncertain tax positions, the revaluation of uncertain tax positions arising from examinations, appeals, court decisions or the closure of tax statutes.

As a result of the Tax Cuts and Jobs Act ("TCJA"), the Company no longer intends to reinvest certain undistributed earnings of its international subsidiaries that have been previously taxed in the U.S. As such, the Company has recorded the taxes associated with the future remittance of these earnings. In addition, the Company no longer intends to permanently reinvest the book and tax basis difference including the undistributed earnings of the Company's Chubb business due to its divestiture. For the remainder of the Company's undistributed international earnings, unless tax effective to repatriate, the Company intends to continue to permanently reinvest these earnings. As of December 31, 2021 such undistributed earnings were approximately \$6.0 billion, excluding other comprehensive income amounts. It is not practicable to estimate the amount of tax that might be payable on the remaining amounts. In addition, the TCJA subjects the Company to a tax on global intangible low-taxed income ("GILTI"). GILTI is a tax on foreign income in excess of a deemed return on tangible assets of foreign corporations which the Company has elected to account for as a period cost.

#### Note 18: Earnings Per Share

Earnings per share is computed by dividing *Net income attributable to common shareowners* by the weighted-average number of shares of common stock outstanding during the period (excluding treasury stock). Diluted earnings per share is computed by giving effect to all potentially dilutive stock awards that are outstanding. The computation of diluted earnings per share excludes the effect of the potential exercise of stock-based awards, including stock appreciation rights and stock options, when the effect of the potential exercise would be anti-dilutive.

On the Distribution Date, 866,158,910 shares of the Company's common stock, par value \$0.01 per share, were distributed to UTC shareowners of record as of March 19, 2020. This share amount is utilized for the calculation of basic and diluted earnings per share for all periods presented prior to the Separation and the Distribution and such shares are treated as issued and outstanding for purposes of calculating historical earnings per share. It is assumed that there are no dilutive equity instruments for periods prior to the Separation and Distribution because there were no Carrier stock-based awards outstanding prior to the Separation and the Distribution.

#### Note 19: Acquisitions

During the year ended December 31, 2021, the Company acquired consolidated and minority-owned businesses. The aggregate cash paid, net of cash acquired, totaled \$366 million and was funded through cash on hand. Acquisitions are recorded using the acquisition method of accounting in accordance with ASC 805, *Business Combinations* ("ASC 805"). As a result, the aggregate purchase price has been allocated to assets acquired and liabilities assumed based on the estimate of fair market value of such assets and liabilities at the date of acquisition. Intangible assets associated with these transactions totaled \$146 million and primarily related to customer relationships, technology assets and a non-compete agreement. The excess purchase price over the estimated fair value of net assets acquired was recognized as goodwill and totaled \$320 million.

#### Acquisition of Guangdong Giwee Group Co.

On June 1, 2021, the Company acquired a 70% controlling stake in Guangdong Giwee Group Co. and its subsidiaries ("Giwee") and subsequently acquired the remaining 30% ownership in Giwee on September 7, 2021. Giwee is a China-based manufacturer offering a portfolio of HVAC products including variable refrigerant flow, modular chillers and light commercial air conditioners. The results of Giwee are reported within the HVAC segment as of the date of acquisition. The Company has not included pro forma financial information required under ASC 805 as the pro forma impact was not deemed significant.

The excess of the purchase price over the estimated fair value of the net assets acquired was recognized as goodwill and totaled \$182 million, which is not deductible for tax purposes. Accounts receivable and current liabilities were stated at their historical carrying value, which approximates fair value given the short-term nature of these assets and liabilities. The estimate of fair value for inventory and property, plant and equipment was based on an assessment of the acquired assets' condition as well as an evaluation of the current market value of such assets.

The Company recorded intangible assets which consisted of the following:

(1) The weighted-average number of common shares outstanding for basic and diluted earnings per share for the year ended December 31, 2020 was based on the weighted-average number of common shares outstanding for the period beginning after the Distribution Date.



The valuation of intangible assets was determined using an income approach methodology including the multi-period excess earnings method and the relief from royalty method. Key assumptions used in estimating future cash flows included projected revenue growth rates, customer attrition rates and royalty rates. The projected future cash flows are discounted to present value using an appropriate discount rate. As of December 31, 2021, the Company has finalized the process of allocating the purchase price and valuing the acquired assets and liabilities for the Giwee acquisition.

#### Note 20: Divestitures

On July 26, 2021, the Company entered into a stock purchase agreement to sell its Chubb business to APi. Chubb, reported within the Company's Fire & Security segment, delivers essential fire safety and security solutions from design and installation to monitoring, service and maintenance across more than 17 countries around the globe.

The assets and liabilities of Chubb have been reclassified as held for sale in the accompanying Consolidated Balance Sheet as of December 31, 2021 and recorded at the lower of their carrying value or fair value less estimated cost to sell. In addition, depreciation and amortization was ceased in accordance with ASC 360. Based on the carrying amount of Chubb's net assets, foreign currency translation rates and other assumptions as of December 31, 2021, the Company expects to recover the carrying value of the disposal group upon completion of the transaction.

The components of Chubb's assets and liabilities recorded as held for sale were as follows:

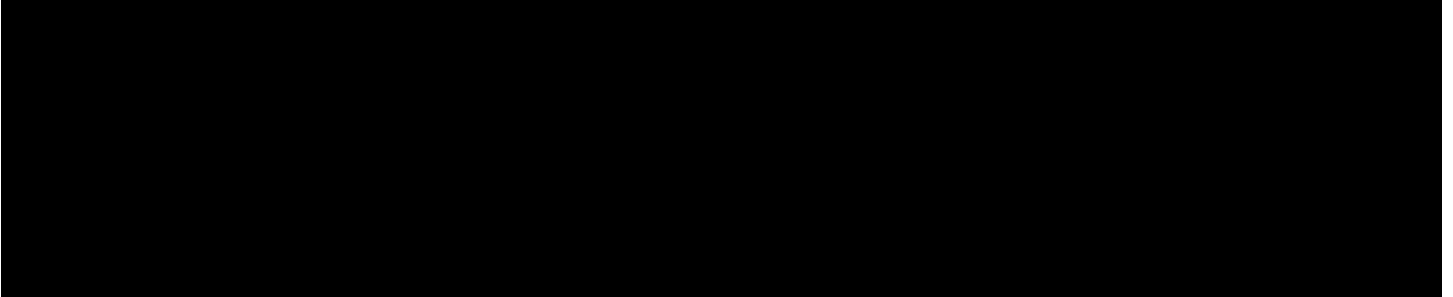
On January 3, 2022, the Company completed the sale of Chubb for an enterprise value of \$3.1 billion, subject to working capital and other adjustments as provided in the Chubb Sale Agreement. Consistent with the Company's capital allocation strategy, the net proceeds of approximately \$2.6 billion will be used to fund investments in organic and inorganic growth initiatives and capital returns to its shareowners as well as for general corporate purposes.

#### Note 21: Segment Financial Data

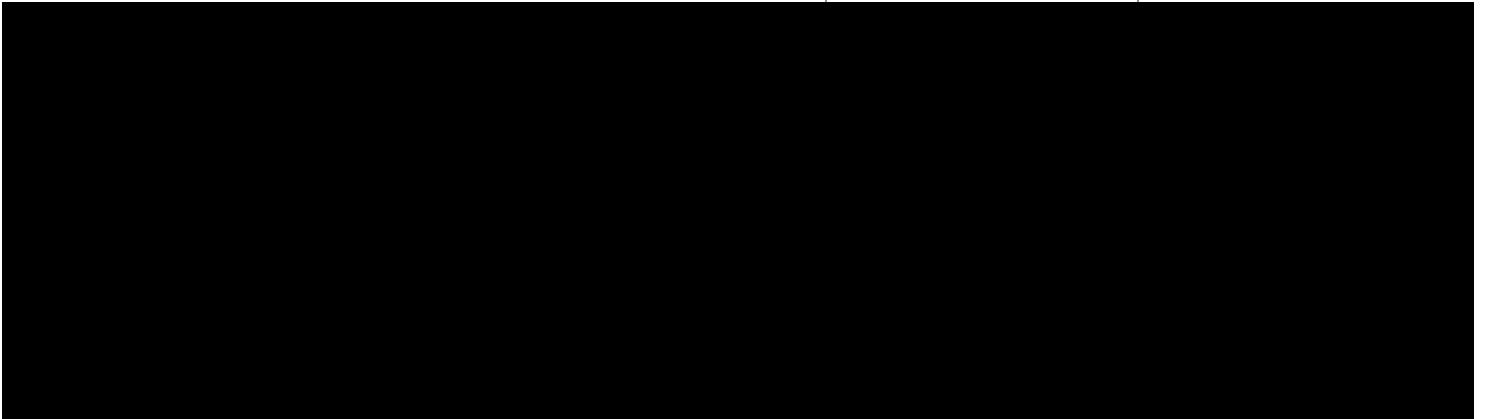
The Company conducts its operations through three reportable operating segments: HVAC, Refrigeration and Fire & Security. In accordance with ASC 280 - *Segment Reporting*, the Company's segments maintain separate financial information for which results of operations are evaluated on a regular basis by the Company's CODM in deciding how to allocate resources and in assessing performance. Inter-company sales between segments are immaterial.

- The HVAC segment provides products, controls, services and solutions to meet the heating, cooling and ventilation needs of residential and commercial customers while enhancing building performance, health, energy efficiency and sustainability. Products include air conditioners, heating systems, controls and aftermarket components as well as aftermarket repair and maintenance services and building automation solutions. Products and solutions are sold directly to building contractors and owners and indirectly through joint ventures, independent sales representatives, distributors, wholesalers, dealers and retail outlets.
- The Refrigeration segment provides a healthier, safer, more sustainable and more intelligent cold chain through the reliable transport and preservation of food, medicine and other perishable cargo. Refrigeration and monitoring products services and digital solutions strengthen the connected cold chain and are designed for trucks, trailers, shipping containers, intermodal applications, food retail and warehouse monitoring. Commercial refrigeration solutions include refrigerated cabinets, freezers, systems and controls incorporating next-generation technologies to preserve freshness, ensure safety and enhance the appearance of retail food and beverage. Products and services are sold directly to transportation companies and retail stores and indirectly through joint ventures, independent sales representatives, distributors, wholesalers and dealers.
- The Fire & Security segment provides a wide range of residential, commercial and industrial technologies designed to help protect people and property. Products include fire, flame, gas, smoke and carbon monoxide detection, portable fire extinguishers, fire suppression systems, intruder alarms, access control systems and video management systems and electronic controls. Other fire and security offerings include audit, design, installation and system integration as well as aftermarket maintenance and repair and monitoring services. Products and solutions are sold directly to end customers as well as through manufacturers' representatives, distributors, dealers, value-added resellers and retail distribution.

Segment information are as follows:

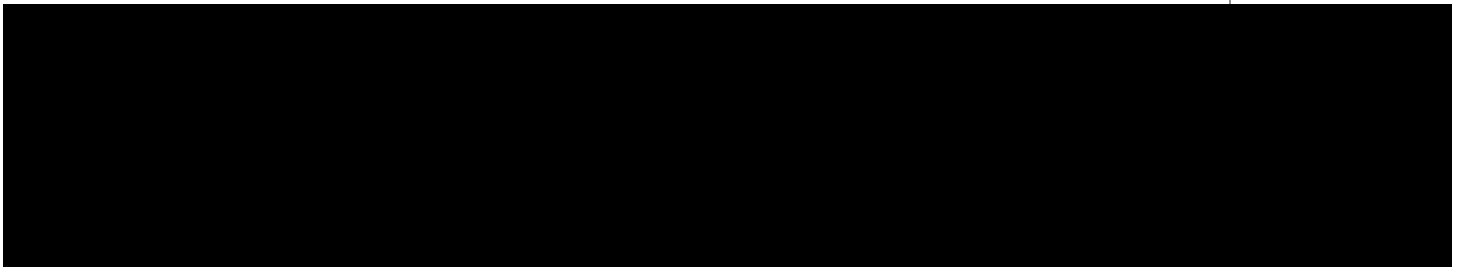
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Total assets are not presented for each segment as they are not presented to or reviewed by the CODM. Segment assets in the following table represent *Accounts receivable, net*, *Contract assets, current* and *Inventories, net*. These assets are regularly reviewed by management and are therefore reported in the following table as segment assets. All other remaining assets and liabilities for all periods presented are managed on a company-wide basis.

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#### **Geographic External Sales**

Geographic external sales and operating profits are attributed to the geographic regions based on their location of origin. With the exception of the U.S. as presented in the following table, there were no individually significant countries with sales exceeding 10% of total sales for the years ended December 31, 2021, 2020 and 2019.

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**Note 22: Related Parties**  
**Equity Method Investments**

The Company sells products to and purchases products from unconsolidated entities accounted for under the equity method, and therefore, these entities are considered to be related parties. The Company has 30 directly owned unconsolidated domestic and foreign affiliates as of December 31, 2021 and 2020, respectively, of which 99% of such investments are in its HVAC segment. Amounts attributable to equity method investees are as follows:

The Company had receivables from and payables to equity method investees as follows:

The Company periodically reviews the carrying value of its equity method investments to determine if there has been an other-than-temporary decline in fair value. In 2020, the Company determined that indicators of impairment existed for a minority owned joint venture investment and performed a valuation of this investment using a discounted cash flow method. The Company determined that the loss in value was other-than-temporary due to a reduction in sales and earnings that were primarily driven by a deterioration in the oil and gas industry (the joint venture's primary market) and by the impact of the COVID-19 pandemic. As a result, the Company recorded a non-cash, other-than-temporary impairment charge of \$71 million on this investment in 2020, which is included in *Other income (expense), net* on the accompanying Consolidated Statement of Operations. In 2019, the Company determined that indicators of impairment existed for a minority owned joint venture investment and performed a valuation of this investment using a discounted cash flow method. The Company determined that the loss in value was other-than-temporary. As a result, the Company recorded a non-cash, other-than-temporary impairment charge of \$108 million on this investment in 2019, which is included in *Other income (expense), net* on the accompanying Consolidated Statement of Operations.

In September 2020, the Company sold 9.25 million B shares of Beijer for SEK290 (\$32.38) per share equal to approximately 7.9% of the outstanding B shares in Beijer, through an accelerated equity offering. The Company received proceeds of approximately \$300 million and recognized a pre-tax gain on the sale of \$252 million, which is included in *Other income (expense), net* on the Consolidated Statement of Operations. Subsequently, in December 2020, the Company sold all of its remaining A and B shares of Beijer for SEK245 (\$29.03) per share. The Company received proceeds of approximately \$1.1 billion and recognized a pre-tax gain on the sale of \$871 million, which is included in *Other income (expense), net* on the Consolidated Statement of Operations. Prior to the sale of the Company's remaining shares, Beijer was reported as an equity method investment.

**Summarized Financial Information.** Pursuant to Rule 3-10 and Rule 4-08(g) of Regulation S-X under the Securities Act, the Company is required to present summarized financial information of the combined accounts of its non-consolidated joint ventures accounted for by the equity method. Summarized unaudited financial information for equity method investments is as follows:

**Note 23: Commitments and Contingent Liabilities**

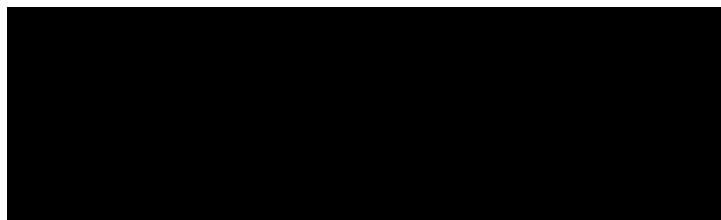
The Company is involved in various litigation, claims and administrative proceedings, including those related to environmental and legal matters (including asbestos). In accordance with ASC 450, the Company records accruals for loss contingencies when it is probable that a liability will be incurred and the amount of the loss can be reasonably estimated. These accruals are generally based upon a range of possible outcomes. If no amount within the range is a better estimate than any other, the Company accrues the minimum amount. In addition, these estimates are reviewed periodically and adjusted to reflect additional information when it becomes available. The Company is unable to predict the final

outcome of the following matters based on the information currently available, except as otherwise noted. However, the Company does not believe that the resolution of any of these matters will have a material adverse effect upon the Company's competitive position, results of operations, cash flows or financial condition.

### Environmental Matters

The Company's operations are subject to environmental regulation by various authorities. The Company has accrued for the costs of environmental remediation activities, including but not limited to, investigatory, remediation, operating and maintenance costs and performance guarantees. The most likely cost to be incurred is accrued based on an evaluation of currently available facts with respect to individual sites, including the technology required to remediate, current laws and regulations and prior remediation experience.

As of December 31, 2021 and 2020, the outstanding liability for environmental obligations are as follows:

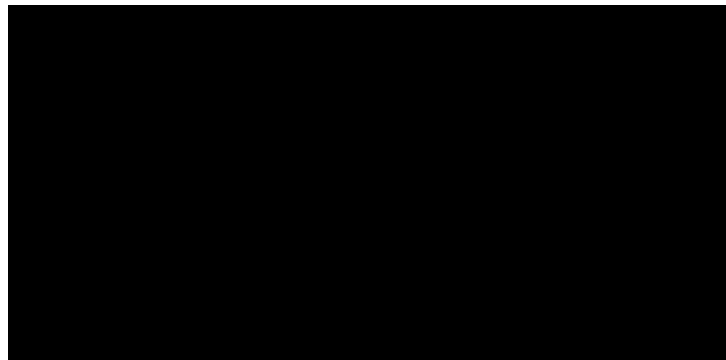


For sites with multiple responsible parties, the Company considers its likely proportionate share of the anticipated remediation costs and the ability of other parties to fulfill their obligations in establishing a provision for those costs. Accrued environmental liabilities are not reduced by potential insurance reimbursements and are undiscounted.

### Asbestos Matters

The Company has been named as a defendant in lawsuits alleging personal injury as a result of exposure to asbestos allegedly integrated into certain Carrier products or business premises. While the Company has never manufactured asbestos and no longer incorporates it into any currently-manufactured products, certain products that the Company no longer manufactures contained components incorporating asbestos. A substantial majority of these asbestos-related claims have been dismissed without payment or have been covered in full or in part by insurance or other forms of indemnity. Additional cases were litigated and settled without any insurance reimbursement. The amounts involved in asbestos-related claims were not material individually or in the aggregate in any period.

The Company had asbestos liabilities and related insurance recoveries as follows:



The amounts recorded for asbestos-related liabilities are based on currently available information and assumptions that the Company believes are reasonable and are made with input from outside actuarial experts. In connection with the recognition of liabilities for asbestos-related matters, the Company records asbestos-related insurance recoveries that are deemed probable. These amounts are undiscounted and exclude the Company's legal fees to defend the asbestos claims, which are expensed as incurred. As of December 31, 2021, the estimated range of liability to resolve all pending and unasserted potential future asbestos claims through 2059 is approximately \$237 million to \$258 million.

### UTC Equity Awards Conversion Litigation

On August 12, 2020, several former employees of UTC or its subsidiaries filed a putative class action complaint (the "Complaint") in the United States District Court for the District of Connecticut against RTX, Carrier, Otis, the former members of the UTC Board of Directors and the members of the Carrier and Otis Boards of Directors (*Geraud Darnis, et al. v. Raytheon Technologies Corporation, et al.*). The Complaint challenges the method by which UTC equity awards were converted to RTX, Carrier and Otis equity awards following the Separation and the Distribution. Defendants moved to dismiss the Complaint. Plaintiffs amended their Complaint on September 13, 2021 (the "Amended Complaint"). The Amended Complaint, now with RTX, Carrier and Otis as the only defendants, asserts that the defendants are liable for breach of certain equity compensation plans and for breach of the implied covenant of good faith and fair dealing. The Amended Complaint also seeks specific performance. Carrier believes that the claims against the Company are without merit. Defendants moved to dismiss the Amended Complaint on October 13, 2021.

### Aqueous Film Forming Foam Litigation

As of December 31, 2021, the Company has been named as a defendant in over 1,800 lawsuits filed by individuals in or removed to the federal courts of the United States alleging that the historic use of AFFF caused personal injuries and/or property damage. The Company has also been named as a defendant in over 160 lawsuits filed by several U.S. states, municipalities and water utilities in or removed to U.S. federal courts alleging that the historic use of AFFF caused contamination of property and water supplies. In December 2018,

the U.S. Judicial Panel on Multidistrict Litigation transferred and consolidated all AFFF cases pending in the U.S. federal courts against the Company and others to the MDL Court for MDL Proceedings. The individual plaintiffs in the MDL Proceedings generally seek damages for alleged personal injuries, medical monitoring and diminution in property value and injunctive relief to remediate alleged contamination of water supplies. The U.S. state, municipal and water utility plaintiffs in the MDL Proceedings generally seek damages and costs related to the remediation of public property and water supplies.

AFFF is a firefighting foam, developed beginning in the late 1960s pursuant to U.S. military specification, used to extinguish certain types of hydrocarbon-fueled fires primarily at military bases and airports. AFFF was manufactured by several companies, including National Foam and Angus Fire. UTC first entered the AFFF business with the acquisition of National Foam and Angus Fire in 2005 as part of the acquisition of Kidde. In 2013, Kidde divested the National Foam and Angus Fire businesses to a third party. The Company acquired Kidde as part of its separation from UTC in April 2020. During the eight year period of its operation by Kidde, National Foam manufactured AFFF for sale to government (including the U.S. federal government) and non-government customers in the U.S. at a single facility located in West Chester, Pennsylvania ("Pennsylvania Site"). During the same period, Angus Fire manufactured AFFF for sale outside the United States at a single facility located in Bentham, England.

The key components of AFFF that contribute to its fire-extinguishing capabilities are known as fluorosurfactants. National Foam and Angus Fire did not manufacture fluorosurfactants but instead purchased these substances from unrelated third parties. Plaintiffs in the MDL Proceedings allege that the fluorosurfactants used by various manufacturers in producing AFFF contained, or over time degraded into, compounds known as PFOS and/or PFOA. Plaintiffs further allege that, as a result of the use of AFFF, PFOS and PFOA were released into the environment and, in some instances, ultimately reached drinking water supplies.

Plaintiffs in the MDL Proceedings allege that PFOS and PFOA contamination has resulted from the use of AFFF containing fluorosurfactants manufactured using a process known as ECF. They also allege that PFOA contamination has resulted from the use of AFFF containing fluorosurfactants manufactured using a different process, known as telomerization. Plaintiffs further allege that 3M was the only AFFF manufacturer that used fluorosurfactants relying on the ECF process and that all other foam manufacturers (including National Foam and Angus Fire) relied solely on fluorosurfactants produced via telomerization. Compounds containing PFOS and PFOA (as well as many other per- and polyfluoroalkyl substances known collectively as "PFAS") have also been used for decades by many third parties in a number of different industries to manufacture carpets, clothing, fabrics, cookware, food packaging, personal care products, cleaning products, paints, varnishes and other consumer and industrial products.

Plaintiffs in the MDL Proceedings have named multiple defendants, including four suppliers of chemicals and raw materials used to

manufacture fluorosurfactants, four fluorosurfactant manufacturers, two toll manufacturers of fluorosurfactants and seven current (including National Foam and Angus Fire) and former (including the Company) AFFF manufacturers.

General liability discovery in the MDL Proceedings continues. Preliminary stage discovery in ten "bellwether" water provider cases was concluded and three of these cases were selected for tier two site-specific discovery. That discovery is ongoing. The MDL Court has established a briefing schedule with respect to certain aspects of the government contractor defense, potentially applicable to AFFF sold to or used by the U.S. government or other customers requiring product manufactured to meet military specification, such that all briefs were filed at the end of January 2022 with a hearing to follow.

Outside of the MDL Proceedings, the Company and other defendants are also party to six lawsuits in U.S. state courts brought by oil refining companies alleging product liability claims related to legacy sales of AFFF and seeking damages for the costs to replace the product and for property damage. In addition, the Company and other defendants are party to two actions related to the Pennsylvania Site in which the plaintiff water utility company seeks remediation costs related to the alleged contamination of the local water supply.

The Company believes that it has meritorious defenses to the claims in the MDL Proceedings and the other AFFF lawsuits. Based on the 2013 agreement for the sale of National Foam and Angus Fire, the Company is pursuing indemnification against these claims from the purchaser and current owner of National Foam and Angus Fire. The Company is also pursuing insurance coverage for these claims. At this time, however, given the numerous factual, scientific and legal issues to be resolved relating to these claims, the Company is unable to assess the probability of liability or to reasonably estimate the damages, if any, to be allocated to the Company, if one or more plaintiffs were to prevail in these cases, and there can be no assurance that any such future exposure will not be material in any period.

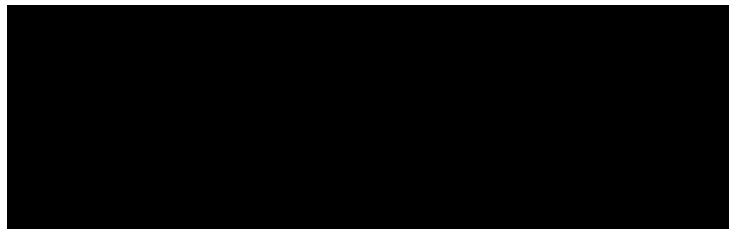
### Income Taxes

Under the TMA, the Company is responsible to UTC for its share of the TCJA transition tax associated with foreign undistributed earnings as of December 31, 2017. As a result, a liability of \$417 million is included within the accompanying Consolidated Balance Sheet within *Other Long-Term Liabilities* as of December 31, 2021. This obligation is expected to be settled in annual installments ending in April 2026 with the next installment of \$34 million due in 2023. The Company believes that the likelihood of incurring losses materially in excess of this amount is remote.

### Self-Insurance

The Company maintains self-insurance for a number of risks, including but not limited to, workers' compensation, general liability, automobile liability, property and employee-related healthcare benefits. It has obtained insurance coverage for amounts exceeding individual and aggregate loss limits. The Company accrues for known future claims and incurred but not reported losses.

The Company's self-insurance liabilities were as follows:



The Company incurred expenses related to self-insured risks of \$155 million, \$145 million and \$177 million for the years ended December 31, 2021, 2020 and 2019, respectively.

#### Other Matters

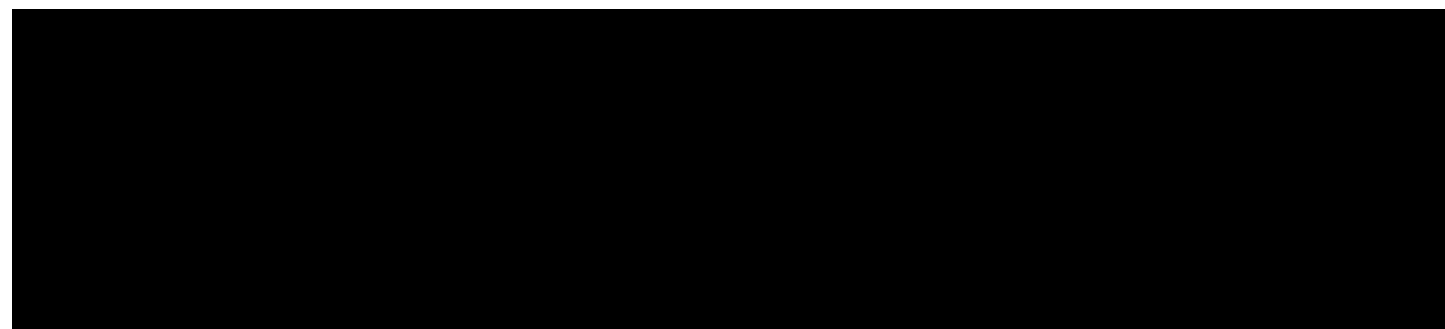
The Company has other commitments and contingent liabilities related to legal proceedings, self-insurance programs and matters arising in the ordinary course of business. The Company accrues for

contingencies generally based upon a range of possible outcomes. If no amount within the range is a better estimate than any other, the Company accrues the minimum amount.

In the ordinary course of business, the Company is also routinely a defendant in, party to or otherwise subject to many pending and threatened legal actions, claims, disputes and proceedings. These matters are often based on alleged violations of contract, product liability, warranty, regulatory, environmental, health and safety, employment, intellectual property, tax and other laws. In some of these proceedings, claims for substantial monetary damages are asserted against the Company and could result in fines, penalties, compensatory or treble damages or non-monetary relief. The Company does not believe that these matters will have a material adverse effect upon its competitive position, results of operations, cash flows or financial condition.

#### Note 24: Supplemental Cash Flow Information

Supplemental cash flow information was as follows:



#### Note 25: Subsequent Events

##### Share Repurchase Program

On January 4, 2022, the Company announced that it has entered into an accelerated share repurchase agreement to repurchase \$500 million of the Company's common stock pursuant to the Company's existing share repurchase program. The final settlement of the accelerated share repurchase is expected to be completed in the first quarter of 2022.

##### Toshiba Carrier Corporation Acquisition Agreement

On February 6, 2022, the Company entered into a binding agreement to acquire a majority ownership stake in Toshiba Carrier Corporation ("TCC") for approximately \$900 million. TCC, a variable refrigerant

flow ("VRF") and light commercial HVAC joint venture between Carrier and Toshiba Corporation, designs and manufactures flexible, energy-efficient and high-performance VRF and light commercial HVAC systems as well as commercial products, compressors and heat pumps. The acquisition will include all of TCC's advanced research and development centers and global manufacturing operations, product pipeline and the long-term use of Toshiba's iconic brand. The transaction is expected to close before the end of the third quarter of 2022, subject to customary closing conditions, including regulatory approvals. Upon closing, Toshiba Corporation will retain a 5% ownership in TCC.

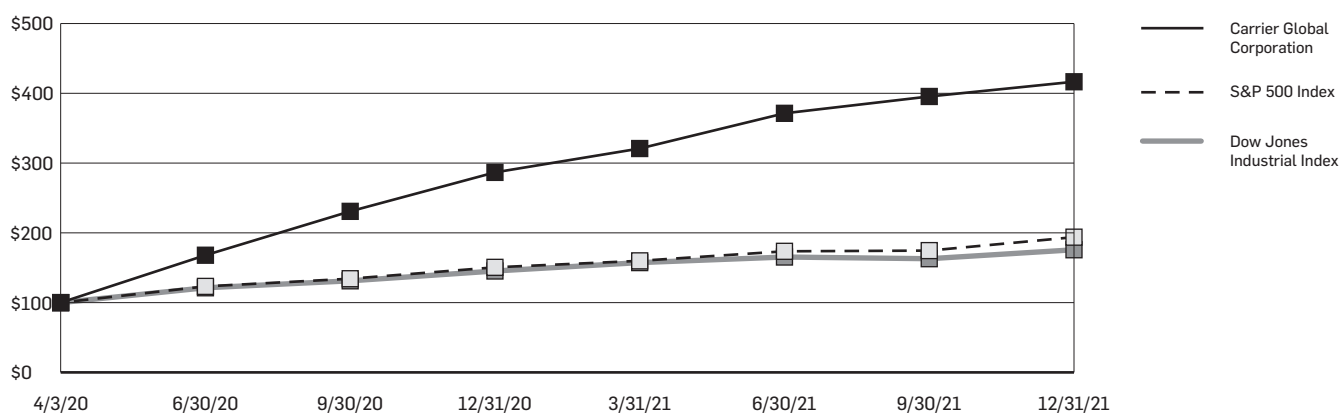
## Comparison of Cumulative Total Return

### PERFORMANCE GRAPH

The following information is not deemed to be “soliciting material” or to be “filed” with the SEC or subject to Regulation 14A or 14C under the Exchange Act or to the liabilities of Section 18 of the Exchange Act, and will not be deemed to be incorporated by reference into any filing of the Company under the Securities Act or the Exchange Act, except to the extent the Company specifically incorporates it by reference into such a filing.

On April 3, 2020, UTC completed the Separation of Carrier into a stand-alone company. As a result of the Separation and the Distribution, Carrier became an independent public company. The following graph presents the cumulative total shareowner return from the Distribution Date through December 31, 2021 for our common stock, as compared with the S&P 500 Index and the Dow Jones Industrial Average.

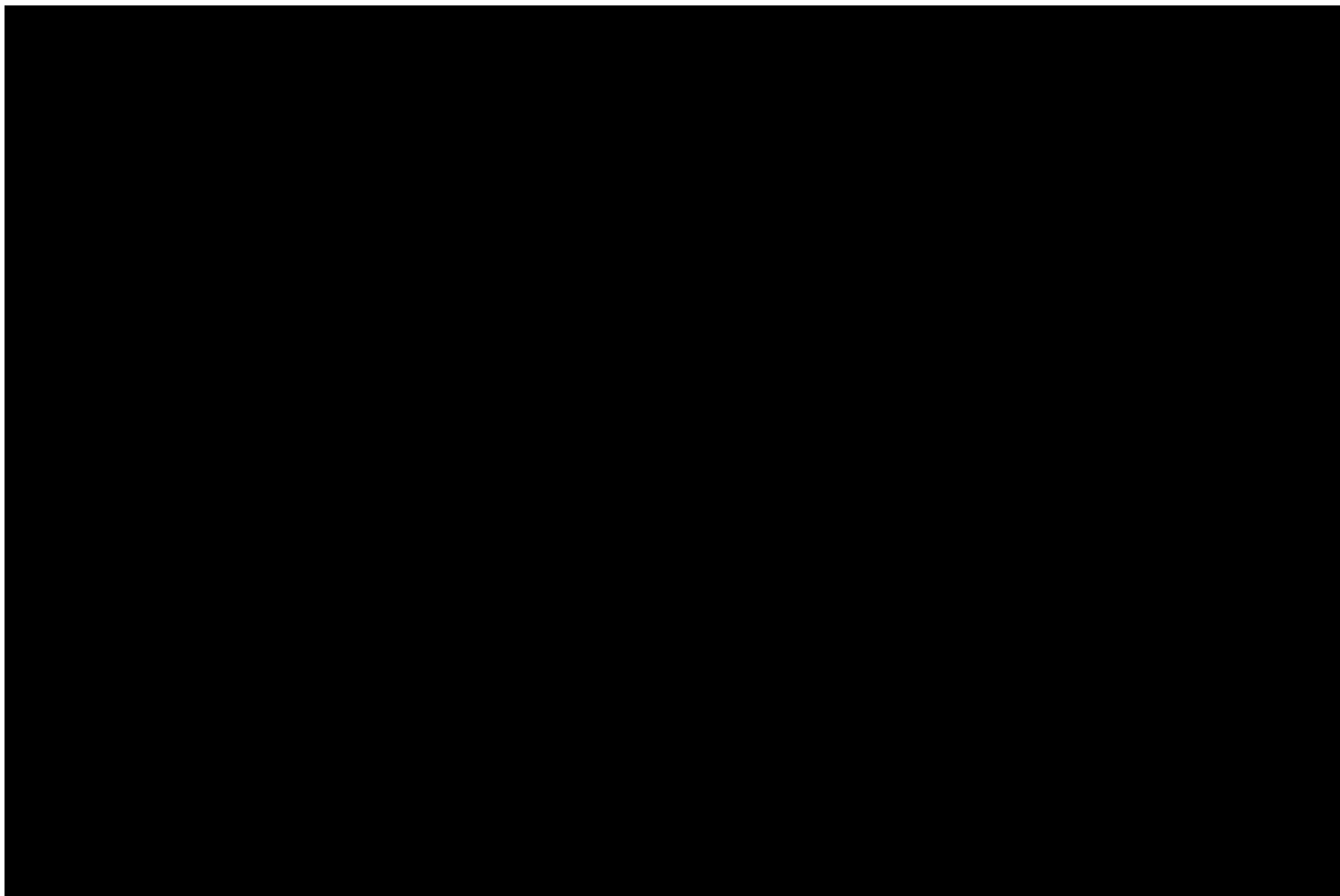
Our common stock is a component of the S&P 500 Index. These figures assume that all dividends paid over the period were reinvested and that the starting value of each index and the investment in Carrier common stock was \$100 on April 3, 2020.



The cumulative total returns on Carrier common stock and each index as of each April 3, 2020 through December 31, 2021 plotted in the above graph are as follows:

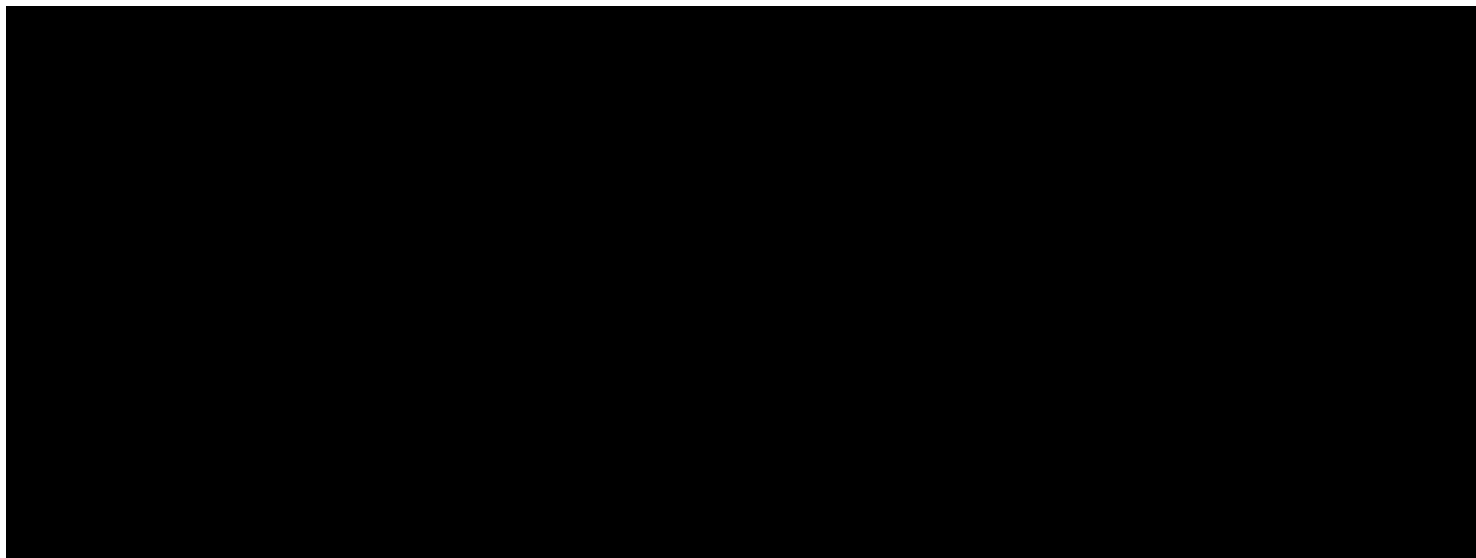
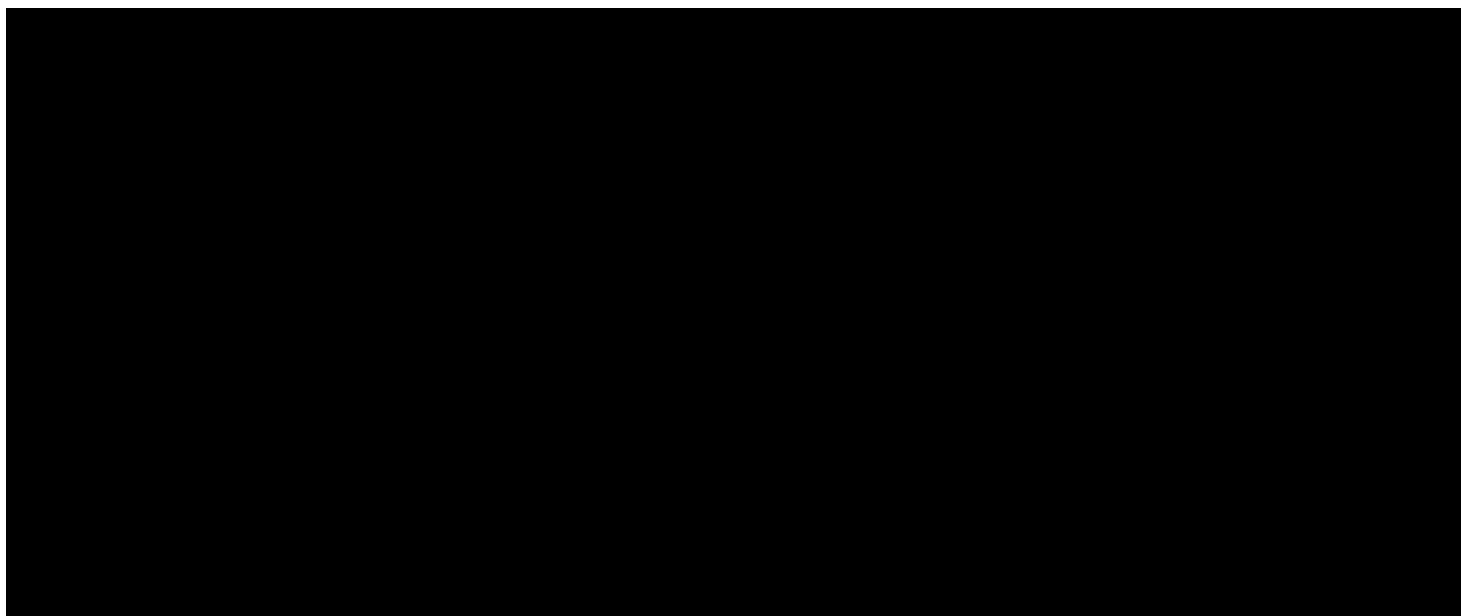
## Reconciliation of Non-GAAP Measures to Corresponding GAAP Measures

### Net Income, Earnings Per Share, and Effective Tax Rate

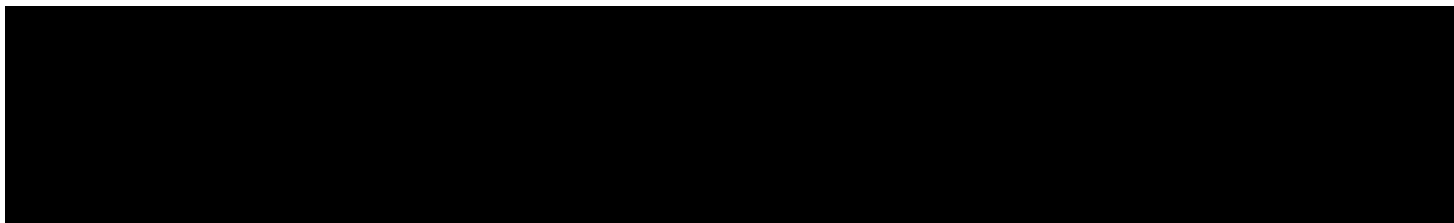




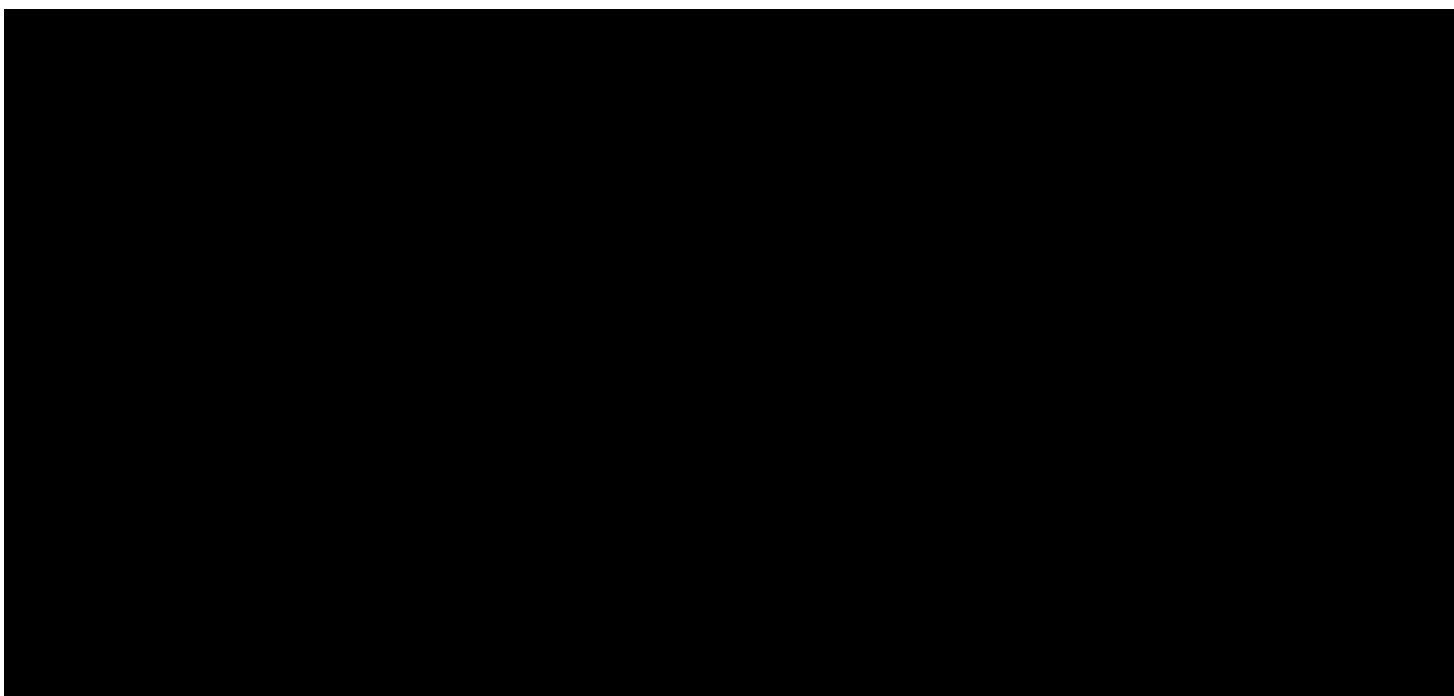
**Reconciliation of Segment Results to Adjusted Segment Results**

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**Reconciliation of Net Cash Flows From Operating Activities to Free Cash Flow**

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**Reconciliation of Net Debt to Adjusted Earnings Before Interest, Taxes, Depreciation and Amortization ("EBITDA")**

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- (1) On January 3, 2022, Carrier received net proceeds of \$2.6 billion from the Chubb divestiture, reducing out net debt to approximately \$4.1 billion upon the close of the transaction.  
(2) On April 1, 2020, Carrier received cash contributions totaling \$590 million from UTC related to the Separation, resulting in net debt of approximately \$9.9 billion as of April 3, 2020.

# Board of Directors

**David Gitlin**

Chairman & Chief Executive Officer  
Carrier Global Corporation

**John V. Faraci**

Former Executive Chairman  
Carrier Global Corporation

**Jean-Pierre Garnier, Ph.D.**

Lead Independent Director  
Former Chief Executive Officer  
GlaxoSmithKline plc

**John J. Greisch**

Former President & Chief Executive Officer  
Hill-Rom Holdings, Inc.

**Charles M. Holley, Jr.**

Former Executive Vice President &  
Chief Financial Officer  
Wal-Mart Stores, Inc.

**Michael M. McNamara**

Chairman  
PCH International Holdings  
Former Chief Executive Officer  
Flex Ltd.

**Michael A. Todman**

Former Vice Chairman  
Whirlpool Corporation

**Virginia M. Wilson**

Former Senior Executive Vice President &  
Chief Financial Officer  
Teachers Insurance and Annuity Association of America

**Beth A. Wozniak**

Chief Executive Officer  
nVent Electric plc

## COMMITTEES

**Audit Committee**

Charles M. Holley, Jr., Chair  
Michael M. McNamara  
Michael A. Todman  
Virginia M. Wilson

**Compensation Committee**

John J. Greisch, Chair  
Jean-Pierre Garnier  
Charles M. Holley, Jr.  
Michael A. Todman

**Governance Committee**

Jean-Pierre Garnier, Chair  
John J. Greisch  
Michael M. McNamara  
Virginia M. Wilson  
Beth A. Wozniak

# Leadership

**David Gitlin\***

Chairman & Chief Executive Officer

**Ajay Agrawal\***

Senior Vice President,  
Global Services, Healthy Buildings & Chief Strategy Officer

**Jennifer Anderson**

Senior Vice President,  
Strategy, Business Development & Chief Sustainability Officer

**Eva Azoulay**

Senior Vice President, Global Business Services

**Kyle Crockett\***

Vice President, Controller

**Bobby George**

Senior Vice President & Chief Digital Officer

**Patrick Goris\***

Senior Vice President & Chief Financial Officer

**Rishi Grover**

Senior Vice President, Operations

**Christopher Kmetz**

Senior Vice President, Engineering

**Mary Milmoe**

Vice President, Communications & Marketing

**Christopher Nelson\***

President, HVAC

**Kevin O'Connor\***

Senior Vice President & Chief Legal Officer

**Jurgen Timperman\***

President, Fire & Security

**Nadia Villeneuve\***

Senior Vice President & Chief Human Resources Officer

**Timothy White\***

President, Refrigeration

\*Executive Officer

# Shareowner Information

## Corporate Office

Carrier Global Corporation  
13995 Pasteur Boulevard  
Palm Beach Gardens, FL 33418  
561.365.2000  
[www.corporate.carrier.com](http://www.corporate.carrier.com)

This report is made available to shareowners in advance of the annual meeting of shareowners scheduled to be held at 8 a.m. Eastern Time on April 14, 2022, in a virtual-only format to protect the health of our shareowners, directors and employees during the COVID-19 pandemic. The proxy statement will be made available to shareowners on or about March 1, 2022, and will provide additional information about voting and participating in the meeting.

## Stock Listing

New York Stock Exchange (ticker symbol "CARR")

## Transfer Agent and Registrar

Computershare Trust Company, N.A., is the transfer agent, registrar and dividend disbursing agent for Carrier's common stock. Questions and communications from registered shareowners should be directed to:

Computershare Trust Company, N.A.  
462 South 4th Street  
Suite 1600  
Louisville, KY 40202  
866.507.8028  
781.575.3345 (outside U.S.)  
[www.computershare.com/investor](http://www.computershare.com/investor)

## Electronic Access or Delivery of Shareowner Communications

Registered shareowners can help conserve natural resources and reduce printing and mailing costs incurred by Carrier by signing up for electronic communications, including annual meeting materials, stock plan statements and tax documents, at:  
[www.computershare-na.com/green](http://www.computershare-na.com/green).

Beneficial shareowners may be able to request electronic access or delivery by contacting their broker or bank, or Broadridge Financial Solutions at: [www.investordelivery.com](http://www.investordelivery.com).

## 2021 Annual Report on Form 10-K

Copies of the Carrier Annual Report on Form 10-K as filed with the U.S. Securities and Exchange Commission can be accessed and downloaded via our website at:  
<https://ir.carrier.com/financials/sec-filings>.

Copies also can be obtained, without charge, from:

Carrier Corporate Secretary  
Carrier Global Corporation  
13995 Pasteur Boulevard  
Palm Beach Gardens, FL 33418  
[corpsec@carrier.com](mailto:corpsec@carrier.com)

## Investor Relations

Investor Relations  
Carrier Global Corporation  
13995 Pasteur Boulevard  
Palm Beach Gardens, FL 33418  
[investorrelations@carrier.com](mailto:investorrelations@carrier.com)

# Recognition & Industry Leadership

Named to  
**Change the World List**

*Fortune, 2021*

Founding member of  
**U.S. Green Building Council**

Among the  
**Best Places to Work for  
LGBTQ Equality**

*Human Rights Campaign Foundation  
Corporate Equality Index, 2021*

Founding member of  
**International  
WELL Building Institute**

Among  
**America's Most Responsible  
Companies**

*Newsweek, 2021*

Founding member of  
**Global Food Cold Chain Council**

Named an  
**ESG Industry Top-Rated Company**

*Sustainalytics, 2021*



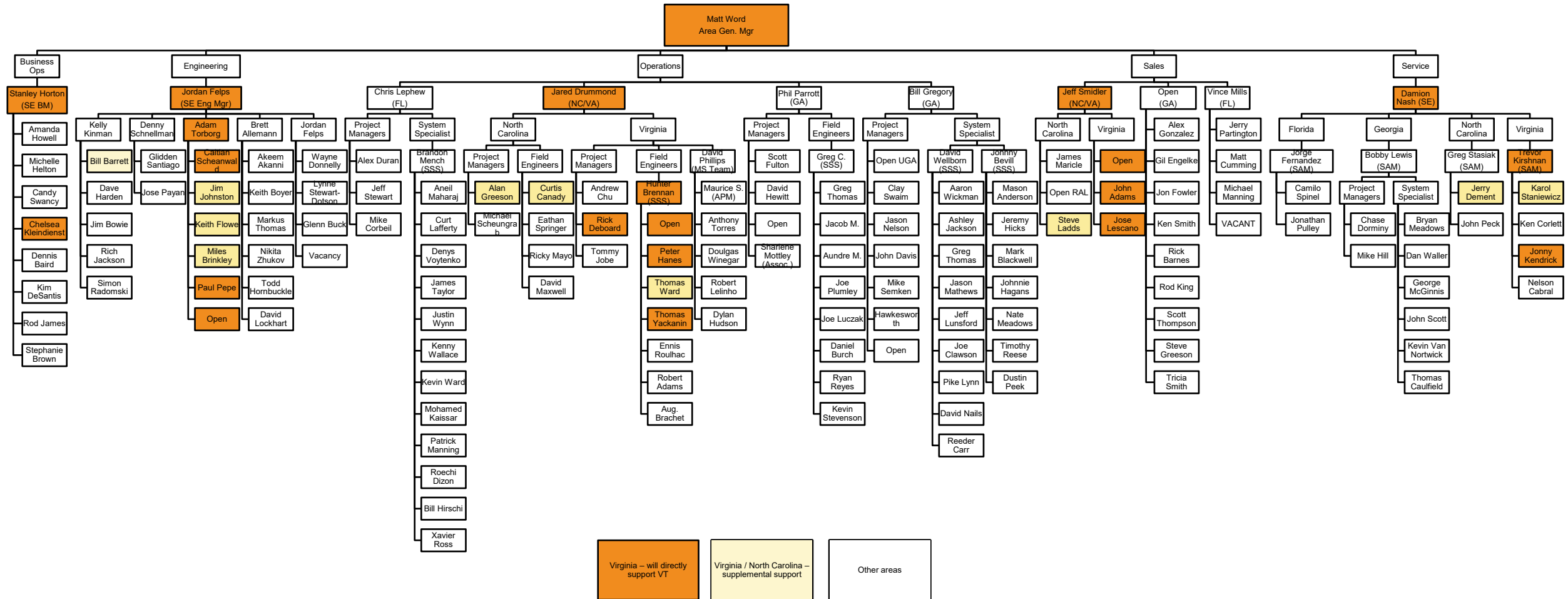
This report is printed with soy-based inks in a facility powered by 100% renewable wind energy. All paper used in this report is certified to Forest Stewardship Council® (FSC®) standards. The paper for the cover and narrative sections is produced using 80% renewable electricity and is manufactured with a minimum of 10% recycled fiber. The paper for the financial section is manufactured in facilities where more than 70% of the energy in their pulp and paper mills comes from renewable biomass fuels.

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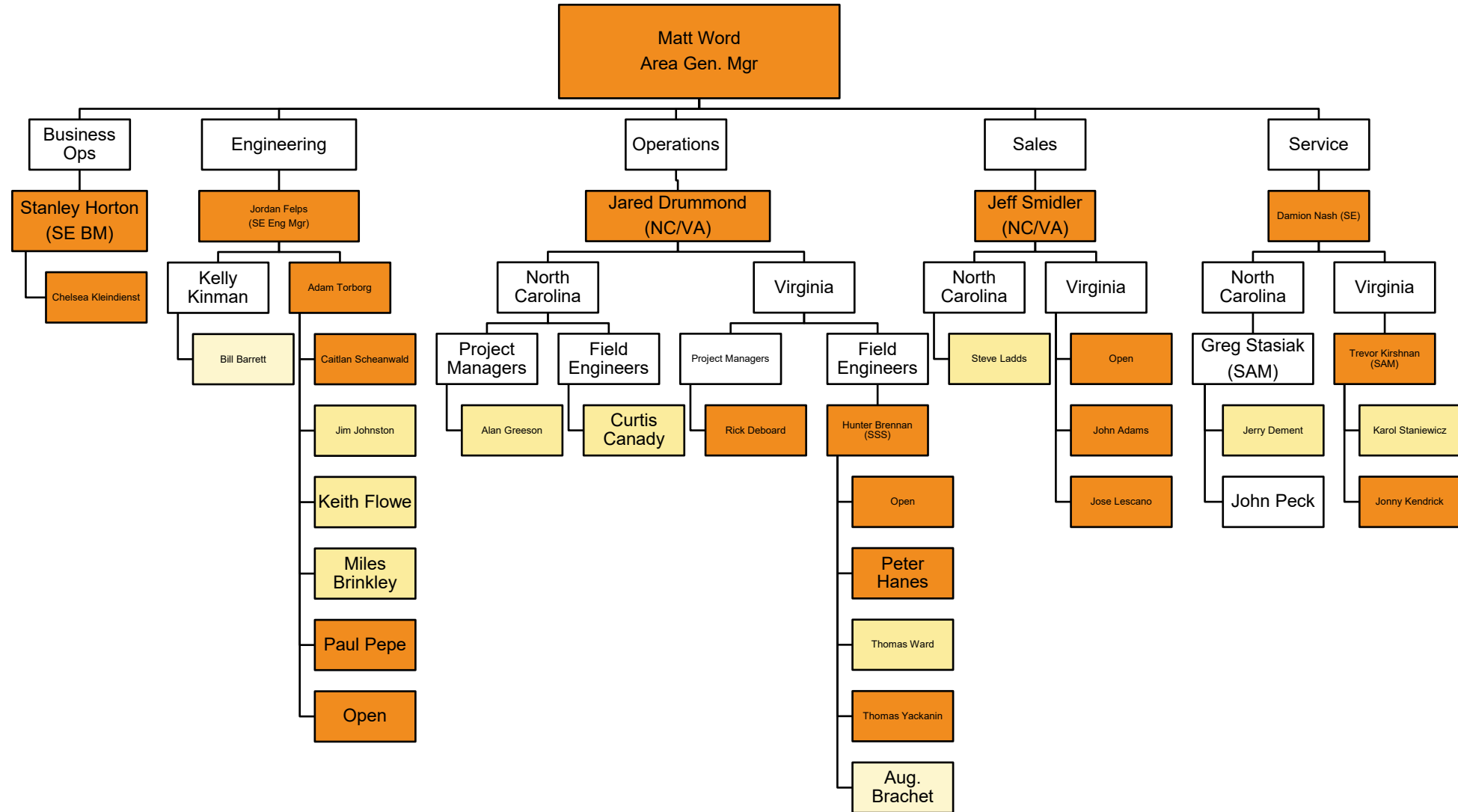
13995 Pasteur Boulevard  
Palm Beach Gardens, FL 33418  
[www.corporate.carrier.com](http://www.corporate.carrier.com)

# ALFO Southeast Organization Chart





# ALC / VT Organization Chart



Virginia – will  
directly support  
VT

Virginia / North Carolina –  
supplemental support

Other areas

# Automated Logic

Building automation, energy  
and environmental control

**ASSURANCE FROM DAY ONE**

A Carrier Company



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**For over 40 years,** Automated Logic Corporation (ALC) has delivered innovative, intelligent building automation systems that advance energy conservation, flexibility, and ease of use. All ALC products contribute to an intelligent building ecosystem — buildings that are designed to maximize occupant comfort, and ensure energy savings.

As part of ALC's building management services, our **Suite of Services** are designed to reduce your energy spend and keep your buildings efficient and comfortable.

The logo for Automated Logic, featuring the word "Automated" in white and "Logic" in red, with a stylized red swoosh above the "L" in "Logic".

Automated  
Logic

A Carrier Company



## Health Monitoring

Gain insights and health data for your systems

Get a complete picture of your system health in real-time from **WebCTRL® Health Monitoring Application**, part of the Analytics Suite by Automated Logic

**Add-on to your assurance plan for continued monitoring**



## Assurance Plan

Choose the right-fit plan for your business

Deploy preemptive strategies and choose optimal coverage with the ALC Assurance Plan:



CORE



ENHANCE



ELITE

Optional services and add-ons



## Sustainability

Complete ownership of efficiency and savings

Improve performance and extend system life:

- ✓ Tenant comfort
- ✓ Efficiency & optimization
- ✓ Energy savings

# WebCTRL® Health Monitoring

- Observe and track the health of your WebCTRL® building automation system and its associated controllers
- Access to data from your facilities, systems, and equipment into the ALC cloud for data analytics and optimization
- The web portal delivers key performance indicators:
  - Online dashboards
  - Complete picture of system health in real-time
- Proactive maintenance strategies can then be deployed to improve performance and extend system life





# WebCTRL® Health Monitoring Features & Benefits



## **BAS maintenance**

Utilize an authorized ALC representative as your trusted advisor for BAS maintenance



## **Proactive maintenance**

Maintain peace of mind that your system is being proactively maintained



## **Health advisories**

Receive health advisories for a single WebCTRL system or your entire portfolio of WebCTRL systems



## **Actionable insights**

Gain actionable insights from your ALC representative directly, or access them yourself via an online portal



## **Improve performance**

Help improve system performance, increase reliability, and prevent unplanned downtime



## **Eliminate risk**

Help eliminate risk and data loss



## **Stay secure**

Receive notifications when upgrades and patches are available to stay current and secure

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## Our cloud-based Analytics Suite

utilizes a robust platform that combines artificial intelligence and IoT connectivity with the knowledge of domain experts in all types of buildings, facilities and energy-consuming infrastructure



### Cloud-Based

Reducing the need for on-site equipment



### Industry Contextualized

Contextualize data based on industry/ building type



### Flexible

Work list management, weather feed integration, automated demand response and more



### Platform-Neutral

Process data from multiple IoT-enabled sources

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## Get Connected – Gain Insights

ALC modular platform uses the latest open cloud technologies and is able to learn from the past to inform the future via predictive and actionable Insights.

### **The WebCTRL® Health Monitoring enables you to:**

- ✓ View your entire portfolio of WebCTRL connected buildings and equipment in the palm of your hand
- ✓ Monitor connected equipment health with predictive health monitoring and actionable insights
- ✓ Dive deeper into identified problem areas and identify root causes as well as understand the next course of action
- ✓ View the effectiveness of the teams involved in interventions.





# Offering Targeted Solutions For Your Business Strategy

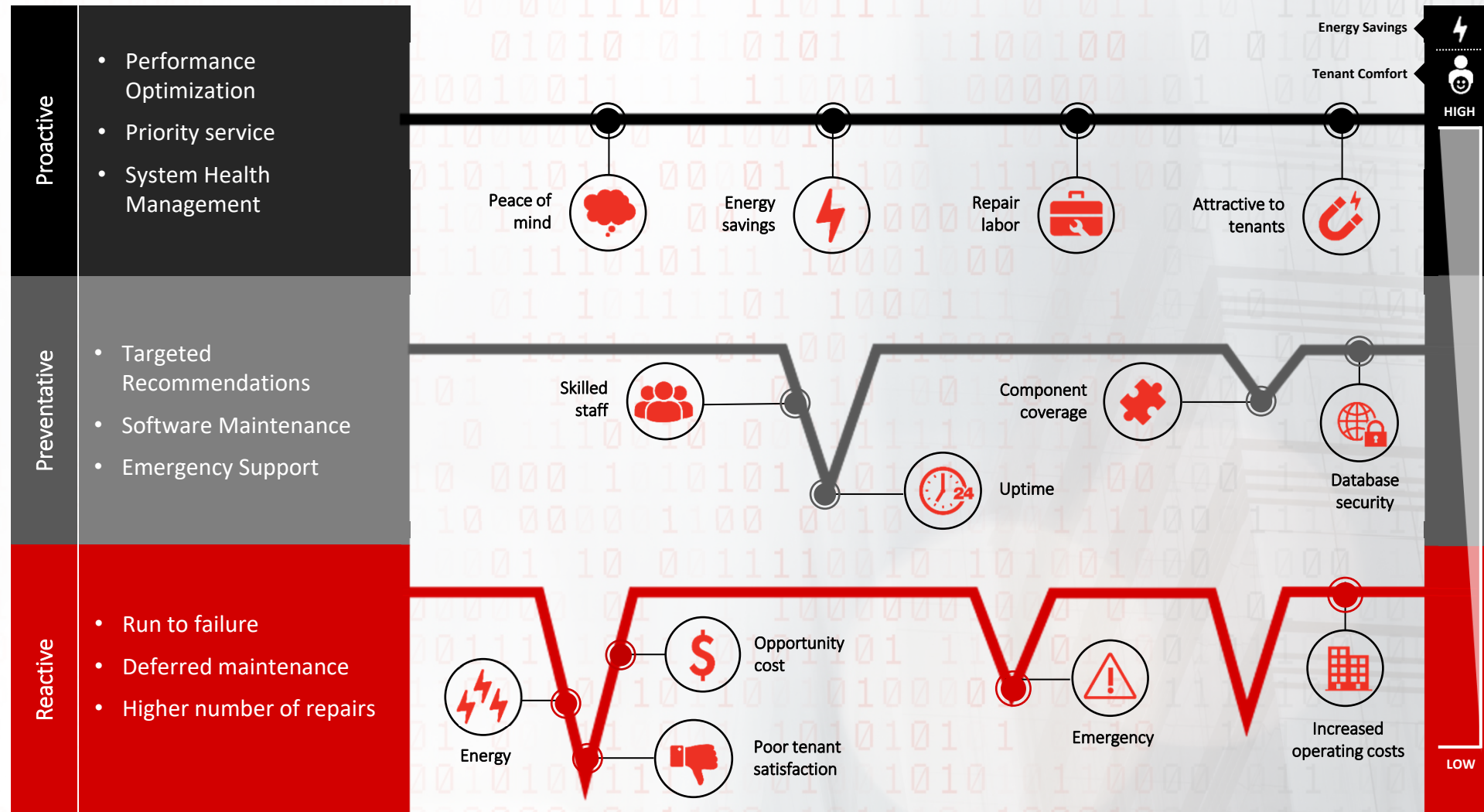


- Occupancy comfort
- Building optimization
- Overall systems performance
- Increased staff productivity



- Tune your facility to exceed all industry benchmarks
- Hands-on guidance to help you achieve the most out of your building management system

# Strategies — Lifespan Support



# Plans – Assuring smart building management from day one



## CORE

**Stay confident.  
Stay connected.**

Core is an economical solution for customers with IoT-enabled equipment that collects real-time data to improve staff efficiency and reduce unplanned downtime.



## ENHANCE

**Take uncertainty  
out of the equation.**

Enhance is complete preventive maintenance and technical expertise including proactive monitoring of health, efficiency and performance with actionable insights to identify opportunities for reducing operating costs and avoiding failures.






## ELITE

**Reach new heights in  
building operations.**

The ultimate worry-free, peace of mind program for clients. Realizing building comfort, efficiency and operational goals with ALC turn-key solutions powered by predictive analytics and OEM expertise.



# From 24/7 call-center support to onsite response in less than a day— Count on ALC experts to keep your building running efficiently

	 <b>CORE</b>	 <b>ENHANCE</b>	 <b>ELITE</b>
24/7 Emergency Call Center Support	✓	✓	✓
ALC Digital Core	✓	✓	✓
Remote Technical Support	✓	✓	✓
Planned Preventative Maintenance		✓	✓
Facility Management Consulting (SAM)		✓	✓
Application Optimization		✓	✓
System Operator Skills Training		✓	✓
Comprehensive Repair – ALC Hardware and Labor			✓
IntelliSuite Application Services			✓
Fault Detection Management			✓
VAV Diagnostics			✓



# Optional Services – Customer Focused Customization

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CORE, ENHANCE or ELITE– regardless of the service you choose, ALC is ready to guide you towards a more efficient building. Automated Logic also offers these optional and add-on services to cater to your unique needs and specific building and setting type:

- ✓ Non-ALC component repair/replacement Software subscription
- ✓ Energy audit
- ✓ Retro-commissioning
- ✓ Continual commissioning
- ✓ Utility expense analysis and reporting
- ✓ Energy management planning
- ✓ LEED® certification



# Automated Logic Sustainability Services

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Energy savings through retro-commissioning to drive controls enhancements  
(part of the ELITE Assurance Plan)

## **WHAT IS RETRO-COMMISSIONING?**

A process of evaluating, testing, adjusting and correcting existing building systems to optimize energy usage

## **RCx GOALS:**

- ✓ Identify energy savings projects
- ✓ Low cost/no-cost (fast simple payback)
- ✓ Operations & maintenance process improvements
- ✓ Indoor air quality improvements.

# Energy Consulting Services

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- Sample objectives
  - Benchmark each building's energy use and costs
  - Identify energy conservations measures (ECMs) that can be implemented
- Energy Conservation Measures Summary
  - ECMs are actions or projects that can be implemented to achieve energy and/or maintenance savings
  - These measures represent opportunities for improvements to the facility
  - ECMs may include:
    - Equipment upgrades
    - Modifications or installations of new equipment including new controls
    - Optimization of existing systems and existing controls
    - Opportunities to return equipment to original design intent.



# CASE STUDIES – Our Experience



ENERGY AUDITS &  
RETRO-COMMISSIONING

Advised on  
more than  
1500 facilities

Retro-  
commissioned  
more than  
150M SF

\$200M+ in  
annual energy  
reductions  
discovered





# Service In Action

**Client:** Financial high rise in Chicago

**Objective:** Reduce energy use & operational costs

**Assurance plan:** ELITE

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## Challenge:

- Multiple controls solutions installed – Management headache
- Inconsistent alarm/reporting system – High maintenance calls
- Lack of trending or data capture – No actionable intelligence
- Manual building adjustments – Higher energy costs

## Solution:

- Custom dashboards – Building management made easy
- Accurate alarm/issue identification – Reduced maintenance calls
- Effective data capture – Operational efficiency
- Continuous building optimization – Peak energy performance & tenant satisfaction



8000 points managed



Labor reduced by 60%



\$160,000 annual energy savings

# Complete Ownership of Comfort, Efficiency & Savings

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**ALC Assurance Plans** can enable us to keep your occupants comfortable, optimize the energy usage in your buildings, and make it easy for your staff to make changes to the building schedules and programs



Gain insights and health data for your systems through WebCTRL® Health Monitoring Application



Choose the right-fit ALC Assurance Plan based on your business



Improve performance and extend system life through sustainable measures

Automated  
Logic

## Detailed Description of Work

### Air Handling Unit

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

#### System Verification

- Verify that AHU is being controlled at the appropriate values, while the fan is operating.
- Change one set point value; verify smooth transition and stable control at the new set point.
- Return set point to original value. Repeat for each additional control loop, if any.
- Verify that controlled valves and dampers will stroke fully in both directions, sealing tightly where appropriate.
- Verify the proper operation of critical control processes and points associated with this unit. Make adjustments if necessary.
- Verify the setting/operation of the low temperature safety device, if applicable.
- Verify the operation of the cooling, pre-heat, reheat, & humidity control device, if applicable.
- Field test any alarm device or sensor and verify alarm condition is reported properly.
- Verify sensors are within acceptable range, calibrate if applicable.
- Check associated controller(s) and expansion modules for proper 24 Volt power and communication.
- Inspect wiring for signs of corrosion, fraying and discoloration, defective shielding or shield grounding.
- Clean enclosure exterior surfaces & Remove excessive dust from internal surfaces.
- Document any issues and discuss "Corrective Maintenance" options with customer

### Cabinet Heater

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

#### System Verification

- Verify that the unit is controlled at the specified setpoints and within acceptable tolerances.
- Verify valve close-off.
- Verify heating valve response to control commands.
- Verify that the sequence of operation is executed as designed.
- Backup controller databases, programs and settings

### Chilled Beam

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement



## Detailed Description of Work

and will be installed as they are made available and scheduled with your staff

### System Verification

- Verify that Chilled Beam is being controlled at the appropriate values
- Change temperature set point value; verify smooth transition and stable control at the new set point
- Return set point to original value.
- Verify the proper operation of critical control processes and points associated with this unit. Make adjustments if necessary.
- Field test any alarm device or sensor and verify alarm condition is reported properly
- Verify sensors are within acceptable range, calibrate if applicable.
- Check associated controller for proper 24 Volt power and communication.
- Return parameters to original values once complete.
- Inspect wiring for signs of corrosion, fraying and discoloration, defective shielding or shield grounding.
- Note any deficiencies of all of the above tests in detail on service report.
- Make any recommendations on findings to Facility Manager

## Chilled Water System

### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

### System Verification

- Verify system is enabled and system components are in the automatic position.
- Verify reasonable readings are received into the system from the Outside Air Temperature/Relative Humidity sensor.
- Ensure enable/disable or lockout setpoints are reasonable for the application and equipment i.e. air cooled, liquid cooled etc.
- Confirm setpoints or optimized setpoints are in the proper range for equipment
- Confirm chilled water supply and return temperature readings are reasonable for the condition of the system (prior to startup).
- Confirm with the operator the system water levels are full i.e. chilled water, condenser water etc.
- Start system and confirm the lead equipment i.e. pumps; chillers, towers etc. started as expected note any deficiencies.
- Confirm chilled water supply and return temperature readings are reasonable for the condition of the system (post startup).
- Note any deficiencies.
- Confirm flow readings are reasonable for the amount of pumps running.
- Enable Pump rotation sequence to confirm failure recovery. This process should be initiated

## Detailed Description of Work

- once for the amount of pumps present. Note any deficiencies.
- If equipped with VFD's adjust setpoint of process variable i.e. flow or differential pressure and confirm the control loop responds appropriately. Restore setpoint to original setting and note any deficiencies.
- Enable chiller rotation as applicable and be sure to allow for adequate runtime in between rotation in order to avoid the short-cycle of the cooling equipment. Note any deficiencies.
- Adjust parameters to allow for staging of equipment as applicable. Return parameters to original values once complete.
- Verify critical alarm reporting & Trend Configuration
- Test Chiller Manager roll-over sequence of recovery if equipped.
- Return parameters to original values once complete.
- Note any deficiencies of all of the above tests in detail on service report.
- Make any recommendations on findings to Facility Manager

## Condenser Water System

### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

### System Verification

- Verify system is enabled and system components are in the automatic position.
- Verify reasonable readings are received into the system from the Outside Air Temperature/Relative Humidity sensor.
- Ensure enable/disable or lockout setpoints are reasonable for the application and equipment i.e. air cooled, liquid cooled etc.
- Confirm setpoints or optimized setpoints are in the proper range for equipment
- Confirm chilled water supply and return temperature readings are reasonable for the condition of the system (prior to startup).
- Confirm with the operator the system water levels are full i.e. chilled water, condenser water etc.
- Start system and confirm the lead equipment i.e. pumps; chillers, towers etc. started as expected note any deficiencies.
- Confirm chilled water supply and return temperature readings are reasonable for the condition of the system (post startup). Note any deficiencies.
- Confirm flow readings are reasonable for the amount of pumps running.
- Enable Pump rotation sequence to confirm failure recovery. This process should be initiated once for the amount of pumps present. Note any deficiencies.
- If equipped with VFD's adjust setpoint of process variable i.e. flow or differential pressure and confirm the control loop responds appropriately. Restore setpoint to original setting and note any deficiencies.
- Enable chiller rotation as applicable and be sure to allow for adequate runtime in between

## Detailed Description of Work

- rotation in order to avoid the short-cycle of the cooling equipment. Note any deficiencies.
- Adjust parameters to allow for staging of equipment as applicable. Return parameters to original values once complete.
- Verify critical alarm reporting & Trend Configuration
- Test Chiller Manager roll-over sequence of recovery if equipped.
- Return parameters to original values once complete.
- Note any deficiencies of all of the above tests in detail on service report.
- Make any recommendations on findings to Facility Manager

## Domestic Hot Water

### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

### System Verification

- Verify pump controls operating as designed.
- Verify temperatures are maintained within tolerances.
- Check trend for peak loads being satisfied
- Backup controller databases, programs and settings

## Energy Recovery Unit

### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

### System Verification

- Run locked value report, log report and discuss locked values with customer representative.
- Create performance historical trends and analyze the operation of equipment and document any abnormalities
- Verify unit is operating per the As-built ATC drawings and document any abnormalities.
- Change critical set point value; verify smooth transition and stable control at the new set point.
- Return set point to original value. Repeat for each additional control loop, if any.
- Verify that controlled dampers will stroke fully in both directions, sealing tightly where appropriate.
- Verify the proper operation of critical control processes and points associated with this unit. Make adjustments if necessary.
- Verify the setting/operation of the low temperature safety device, if applicable.
- Field test any critical alarm device or sensor and verify alarm condition is reported properly.
- Verify sensors are within acceptable range, calibrate if applicable.

## Detailed Description of Work

- Check associated controller(s) and expansion modules for proper 24 Volt power and communication.
- Document any issues and discuss "Corrective Maintenance" options with customer

### Exhaust Fan - General

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

#### System Verification

- Verify that the sequence of operation is executed as designed.
- Verify proper operation of fan Start-Stop and or Speed Control.
- Ensure fan status corresponds to command signal.
- Verify damper actuator connections.
- Verify damper full stroke and observe smooth operation.
- Damper Actuator connections tightened and verified (if applicable).
- Backup controller databases, programs and settings

### Exhaust Fan - Lab

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

#### System Verification

- Verify proper operation of fan Start-Stop and Speed Control to customer specification.
- Ensure fan status corresponds to Laboratory System status.
- Verify damper / air valve actuator connections.
- Verify damper/air valve full stroke and observe smooth operation.
- Verify flow sensor signal.
- Record findings every visit.
- Backup controller databases, programs and settings

### Exhaust Fan - Stair Pressurization

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

#### System Verification



## Detailed Description of Work

- Damper operation verified (if applicable).
- Damper Actuator connections tightened and verified (if applicable).
- Examine trend data to verify control loop stability.
- Verify control logic and stairwell pressurization is controlled at the specified setpoints and within PID tolerance.
- Verify interlock operation with smoke system.
- Check timer settings (if applicable).
- Record findings every visit

### Fan Coil Unit

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

#### System Verification

- Verify that FCU is being controlled at the appropriate values.
- Change temperature set point value; verify smooth transition and stable control at the new set point.
- Return set point to original value.
- Verify that controlled valve(s) will stroke fully in both directions, sealing tightly where appropriate.
- Verify the proper operation of critical control processes and points associated with this unit. Make adjustments if necessary.
- Field test any alarm device or sensor and verify alarm condition is reported properly.
- Verify sensors are within acceptable range, calibrate if applicable.
- Check associated controller for proper 24 Volt power and communication.
- Return parameters to original values once complete.
- Note any deficiencies of all of the above tests in detail on service report.
- Make any recommendations on findings to Facility Manager.

### Fan Powered Box

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

#### System Verification

- Verify that FPB is being controlled at the appropriate values.
- Change temperature set point value; verify smooth transition and stable control at the new set point.



## Detailed Description of Work

- Verify the operation of reheat device, if applicable.
- Return set point to original value.
- Verify that controlled valves and dampers will stroke fully in both directions, sealing tightly where appropriate.
- Verify the proper operation of critical control processes and points associated with this unit. Make adjustments if necessary.
- Field test any alarm device or sensor and verify alarm condition is reported properly.
- Verify sensors are within acceptable range, calibrate if applicable.
- Check associated controller for proper communication.
- Document any issues and discuss "Corrective Maintenance" options with customer

## Heat Pump

### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

### System Verification

- Start-Stop will be verified.
- Verify that the unit is controlled at the specified setpoints.
- Observe control stability.
- Verify that the sequence of operation is executed as designed.
- Verify response and reasonableness of key values and control points.
- Backup controller databases, programs and settings (optional)

## Hot Water System

### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

### System Verification

- Verify system is enabled and system components are in the automatic position.
- Verify reasonable readings are received into the system from the Outside Air Temperature/Relative Humidity sensor.
- Ensure enable/disable or lockout setpoints are reasonable for the application and equipment.
- Confirm setpoints, reset schedules or optimized setpoints are in the proper range for equipment.
- Confirm hot water supply and return temperature readings are reasonable for the condition of the system (prior to startup).
- Confirm with the operator the system water levels are full to appropriate levels.

## Detailed Description of Work

- Start system and confirm the lead equipment i.e. pumps, boilers, etc. started as expected note any deficiencies.
- Confirm hot water supply and return temperature readings are reasonable for the condition of the system (post startup). Note any deficiencies.
- Confirm flow readings (if applicable) are reasonable for the amount of pumps running.
- Enable Pump rotation sequence to confirm proper failure recovery. This process should be initiated once for the amount of pumps present. Note any deficiencies.
- If equipped with VFD's adjust setpoint of process variable i.e. flow or differential pressure and confirm the control loop responds appropriately. Restore setpoint to original setting and note any deficiencies.
- If equipped with a mixing valve, adjust setpoint or reset schedule to force a response from valve. Verify the system responded appropriately and achieved setpoint. Restore setpoint to original and note any deficiencies.
- If equipped with a heat exchanger, adjust setpoint or reset schedule to force a response from valve. Verify the system responded appropriately and achieved setpoint. Restore setpoint to original and note any deficiencies.
- Enable boiler rotation as applicable and be sure to allow for adequate runtime in between rotation in order to avoid the short-cycle of the heating equipment. Note any deficiencies.
- Adjust parameters to allow for staging of equipment as applicable. Return parameters to original values once complete.
- Note any deficiencies of all of the above tests in detail on service report. & Make any recommendations on findings to Facility Manager.

## Lab Fume Hood w Air Valve

### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

### System Verification

- Verify the operation of supply and exhaust dampers, if applicable. a) Drive dampers fully open and fully closed. Check pressure input for response. b) Return system to automatic control.
- Verify sensors are within acceptable range, calibrate if applicable.
- Note any deficiencies from the above tests in detail on service report

## Make-up Air Unit

### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

### System Verification

## Detailed Description of Work

- Run locked value report, log report and discuss locked values with customer representative.
- Create performance historical trends, analyze the operation of equipment and document any abnormalities
- Verify unit is operating per the As-built ATC drawings and document any abnormalities.
- Change critical set point value; verify smooth transition and stable control at the new set point.
- Return set point to original value. Repeat for each additional control loop, if any.
- Verify that controlled dampers will stroke fully in both directions, sealing tightly where appropriate.
- Verify the proper operation of critical control processes and points associated with this unit. Make adjustments if necessary.
- Verify the setting/operation of the low temperature safety device, if applicable.
- Verify the operation of the cooling, pre-heat, reheat, & humidity control device, if applicable.
- Field test any critical alarm device or sensor and verify alarm condition is reported properly.
- Verify sensors are within acceptable range, calibrate if applicable.
- Check associated controller(s) and expansion modules for proper 24 Volt power and communication.
- Document any issues and discuss "Corrective Maintenance" options with customer

### Meter BTU

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

#### System Verification

- Verify indications from meter through controllers to Operator Workstation.
- Check local measured gas/electric/water indications through controllers to Operator Workstation.
- Verify metering program is configured to specified settings.
- Observe control stability using trending data.
- Verify response and reasonableness of key values and control points.
- Check indications to verify proper communication, appropriate Transmit and Receive activity on the communication trunks, and to check for possible Error Code indications.
- Consult with client personnel about meter readings and any concerns.
- Backup controller databases, programs and settings

### Meter Pulse

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

## Detailed Description of Work

### System Verification

- Verify indications from meter through controllers to Operator Workstation.
- Check local measured gas/electric/water indications through controllers to Operator Workstation.
- Verify metering program is configured to specified settings.
- Observe control stability using trending data.
- Verify response and reasonableness of key values and control points.
- Check indications to verify proper communication, appropriate Transmit and Receive activity on the communication trunks, and to check for possible Error Code indications.
- Consult with client personnel about meter readings and any concerns.
- Backup controller databases, programs and settings

### Misc Monitoring

#### System Verification

- Verify system is enabled and system components are in the automatic position.
- Where applicable confirm reasonable reading on monitoring temperature / humidity devices. Note deficiencies greater than 3% of full scale.
- Verify status points match actual conditions.
- Review integration points for valid communication with EMS.
- Compare readings at local display match those monitored through interface provided through EMS.
- Ensure enable/disable or lockout setpoints are reasonable for the application and equipment.
- Confirm setpoints are in the proper range for equipment.
- Adjust parameters to allow for staging of equipment as applicable.
- Return parameters to original values once complete.
- Note any deficiencies of the above tests in detail on service report.
- Make any recommendations on findings to Facility Manager

### Reheat Coil

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

#### System Verification

- Verify unit is controlled at the specified setpoints.
- Observe control stability.
- Verify sequence of operation is executed as designed.
- Verify heating valve response to controller commands.
- Backup controller databases, programs and settings



## Detailed Description of Work

### Rooftop Unit

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

#### System Verification

- Verify that RTU is being controlled at the appropriate values, while the fan is operating.
- Change one set point value; verify smooth transition and stable control at the new set point.
- Return set point to original value. Repeat for each additional control loop.
- Verify that heating stages & cooling stages enable & disable.
- Verify the proper operation of critical control processes and points associated with this unit. Make adjustments if necessary.
- Field test any alarm device or sensor and verify alarm condition is reported properly.
- Verify sensors are within acceptable range, calibrate if applicable.
- Check associated controller(s) and expansion modules for proper 24 Volt power and communication.
- Inspect wiring for signs of corrosion, fraying and discoloration, defective shielding or shield grounding.
- Clean enclosure exterior surfaces & Remove excessive dust from internal surfaces.
- Document any issues and discuss "Corrective Maintenance" options with customer

### System Integrator

#### System Verification

- Verify values at operator workstation.
- Inquire if any changes to the system i.e. maintenance of equipment or upgrades have been performed since the initial startup or the last visit.
- Create a trendlog to record analog and digital values at a one minute interval.
- Synchronize time on laptop with the time on server.
- At the device check indications to verify proper communication, appropriate Transmit and Receive activity on the communication trunks, and to check for possible Error Code indications.
- Remove excessive dust from internal surfaces.
- Record analog and digital values from device display and log start and stop timestamps.
- Clean device faceplate and input pad, and enclosure exterior surfaces.
- List recorded values; timestamps alongside trended values and compare to determine system accuracy.
- Verify that alarm notification is setup correctly for all critical points.
- Confirm equipment is properly located on floor plan graphics.
- Compare data collected through interface to that of the equipment shown on local display if equipped; otherwise verify the readings are reasonable to the status and/or condition of the

## Detailed Description of Work

- equipment.
- In the case of a controlling interface verify any points written to controlled equipment are being responded to properly.
- Note any deficiencies of all of the above tests in detail on service report & make any recommendations on findings to Facility Manager.
- Stop and remove all trends created and used during scheduled service

## Third Party Interface

### System Verification

- Verify values at operator workstation.
- Inquire if any changes to the system i.e. maintenance of equipment or upgrades have been performed since the initial startup or the last visit.
- Create a trendlog to record analog and digital values at a one minute interval.
- Synchronize time on laptop with the time on server.
- At the device check indications to verify proper communication, appropriate Transmit and Receive activity on the communication trunks, and to check for possible Error Code indications.
- Remove excessive dust from internal surfaces.
- Record analog and digital values from device display and log start and stop timestamps.
- Clean device faceplate and input pad, and enclosure exterior surfaces.
- List recorded values; timestamps alongside trended values and compare to determine system accuracy.
- Verify that alarm notification is setup correctly for all critical points.
- Confirm equipment is properly located on floor plan graphics.
- Compare data collected through interface to that of the equipment shown on local display if equipped; otherwise verify the readings are reasonable to the status and/or condition of the equipment.
- In the case of a controlling interface verify any points written to controlled equipment are being responded to properly.
- Note any deficiencies of all of the above tests in detail on service report & make any recommendations on findings to Facility Manager.
- Stop and remove all trends created and used during scheduled service

## Uninterruptable Power Supply - UPS

### System Verification

- Check plugs and cables for secure connection.
- Inspect connectors and cables for wear, cuts, abrasion, and breaks.
- Verify charging voltage is in tolerance.
- Check output level and quality.
- Ensure UPS charge is full and available for use.
- Check fans and filters for free flow and dust free.

## Detailed Description of Work

- Coordinate with customer to verify proper UPS operation by disconnecting power and monitoring continued load operation.
- Check years in service for replacement indication from manufacturer

### Unit Heater

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

#### System Verification

- Verify that the unit is controlled at the specified setpoints and within acceptable tolerances.
- Verify valve close-off.
- Verify heating valve response to control commands.
- Verify that the sequence of operation is executed as designed.
- Backup controller databases, programs and settings

### VAV Box

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

#### System Verification

- Verify that VAV is being controlled at the appropriate values.
- Change temperature set point value; verify smooth transition and stable control at the new set point.
- Return set point to original value.
- Verify that dampers will stroke fully in both directions, sealing tightly where appropriate.
- Verify the proper operation of critical control processes and points associated with this unit. Make adjustments if necessary.
- Field test any alarm device or sensor and verify alarm condition is reported properly.
- Verify sensors are within acceptable range, calibrate if applicable.
- Check associated controller for proper 24 Volt power and communication.
- Document any issues and discuss "Corrective Maintenance" options with customer

### VAV Box w Reheat

#### Software Maintenance

- Revisions and updates to purchased software drivers (firmware) are included in this agreement and will be installed as they are made available and scheduled with your staff

## Detailed Description of Work

### System Verification

- Verify that VAV is being controlled at the appropriate values.
- Change temperature set point value; verify smooth transition and stable control at the new set point.
- Verify the operation of reheat device, if applicable
- Return set point to original value.
- Verify that controlled valves and dampers will stroke fully in both directions, sealing tightly where appropriate.
- Verify the proper operation of critical control processes and points associated with this unit. Make adjustments if necessary.
- Field test any alarm device or sensor and verify alarm condition is reported properly.
- Verify sensors are within acceptable range, calibrate if applicable.
- Check associated controller for proper 24 Volt power and communication.
- Document any issues and discuss "Corrective Maintenance" options with customer



## VAV Air Handling Unit Functional Testing

Unit #:

Area Served:

\*Before beginning commissioning ensure that equipment is clear for automatic operation.

\*Notify anyone who may be working in the area that mechanical equipment will be starting.

### General:



All points **UNLOCKED**



All trends **ENABLED**



Critical alarms configured and enabled

Outgoing requests received at HWS/CHWS

### Occupancy Tests

Set unit occupancy to **UNOCCUPIED**. Verify that:

Supply fan is **OFF**

Return fan is **OFF**

Return Damper and Bypass Dampers are **OPEN**

Outside Air Damper and Exhaust Damper are **CLOSED**

Heat wheel is **OFF**

Set unit occupancy to **OCCUPIED**. Verify that:

Minimum Outside Air Damper **OPENS** Fully

End switch on Min OAD signals Supply Fan to **START**

After starting at MINIMUM VFD Speed, the Supply Fan VFD shall **INCREASE** as required to maintain Supply Duct Static Pressure Setpoint

Simultaneously, the Return Fan VFD shall **START** at **MINIMUM** speed and the speed shall **INCREASE** as required to maintain the Airflow Differential Setpoint

The Differential **CFM REMAINS CONSTANT** as the VFDs increase in speed

### Setpoint Reset Tests

Override the Outside Air Temp. to **50°F**. Verify that:

Heating is **ENABLED**

Cooling is **DISABLED**

Override the Outside Air Temp. to **80°F**. Verify that:

Heating is **DISABLED**

Cooling is **ENABLED**

**RELEASE** the Overrides on the Space Temp and the Outside Air temp. Verify that:

The system resumes normal **OCCUPIED** operation

### Minimum OA Ventilation Test

Override minimum OA flow setpoint to **1000** cfm. Verify that:

Minimum Outside Air Damper is **OPEN**

Main Outside Air Damper, Return Damper and Exhaust Damper are **MODULATING** to maintain the minimum outside air flow at setpoint

Damper Loop shows a properly tuned response

## Heating Test

Override the Outside Air Temp. to **50°F** and simulate a **HEATING** demand. Verify that:

System enters **HEATING** mode

Minimum Outside Air Damper is **OPEN**

Main Outside Air Damper, Return Damper and Exhaust Damper are **MODULATING** to maintain the mixed air temperature at setpoint

Cooling Valve is **CLOSED**

Heating Valve is **MODULATING** to maintain the discharge temperature at setpoint

Heating Valve Loop shows a properly tuned response

## Economizer Cooling Test

Override Outside Air Temp. to **55°F** and simulate a **COOLING** demand. Verify that:

System enters **ECONOMIZER COOLING** mode

Mixed Air Setpoint is **EQUAL** to discharge air setpoint

Minimum Outside Air Damper is **OPEN**

Main Outside Air Damper, Return Damper and Exhaust Damper are **MODULATING** to maintain the mixed air temperature at setpoint

Damper Loop shows a properly tuned response

## Cooling Test

Override Outside Air Temp. to **70°F** and simulate a **COOLING** demand. Verify that:

System enters **COOLING** mode

Minimum Outside Air Damper is **OPEN**

Main Outside Air Damper, Return Damper and Exhaust Damper are **MODULATING** to maintain the mixed air temperature at setpoint

Damper Loop shows a properly tuned response

Heating Valve is **CLOSED**

Cooling Valve is **MODULATING** to maintain the discharge temperature at setpoint

Cooling Valve Loop shows a properly tuned response

## Mechanical Cooling Test

Override Outside Air Temp. to **70°F** and simulate a **COOLING** demand. Verify that:

System enters **COOLING** mode

Minimum Outside Air Damper is **OPEN**

Main Outside Air Damper, Return Damper and Exhaust Damper are **MODULATING** to maintain the mixed air temperature at setpoint

Damper Loop shows a properly tuned response

Heating Valve is **CLOSED**

First stage of mechanical cooling is **STAGING** to maintain the discharge temperature at setpoint

Override Outside Air Temp. to **76°F** and simulate a **COOLING** demand. Verify that:

Second stage of mechanical cooling is **STAGING** to maintain discharge temperature at setpoint

## Energy Recovery Wheel Test

**INCREASE** the mixed air temp setpoint by **5°F**. Verify that:

Bypass Dampers are **CLOSED**

Energy recovery wheel is **MODULATING** to maintain mixed air temp setpoint

Energy recovery control loop shows a properly tuned response

**OVERRIDE** the exhaust air temp setpoint to **30°F** and the exhaust air humidity to **100%**. Verify that:  
Energy recovery control loop is **LIMITING** to prevent frost buildup  
Energy recovery control loop shows a properly tuned response

**RELEASE** the Overrides on the Space Temp and the Outside Air temp. Verify that:  
The system resumes normal **OCCUPIED** operation

## Fan VFD Control Test (Airflow Tracking)

**INCREASE** the supply air flow setpoint by 1000 cfm. Verify that:  
The Supply fan VFD Speed **INCREASES** to the new setpoint  
Air flow control loop shows a properly tuned response  
Return fan VFD speed properly **TRACKS** to maintain the differential CFM setpoint through the speed.  
Building Air flow control loop shows a properly tuned response

**DECREASE** the supply air flow setpoint by 1000 cfm. (to original setpoint) Verify that:  
The Supply fan VFD Speed **DECREASES** to the new setpoint  
Air flow control loop shows a properly tuned response  
Return fan VFD speed properly **TRACKS** to maintain the differential CFM setpoint through the speed.  
Building Air flow control loop shows a properly tuned response

## Fan VFD Control Test (Static Pressure)

**INCREASE** the duct static setpoint by **0.5" WC**. Verify that:  
The Supply fan VFD Speed **INCREASES** to the new setpoint  
Duct Static control loop shows a properly tuned response  
Return fan VFD speed properly **TRACKS** to maintain building static pressure at its setpoint.  
Building Static control loop shows a properly tuned response

**DECREASE** the duct static setpoint by **0.5" WC**. (to original setpoint) Verify that:  
The Supply fan VFD Speed **DECREASES** to the new setpoint  
Duct Static control loop shows a properly tuned response  
Return fan VFD speed properly **TRACKS** to maintain building static pressure at its setpoint  
Building Static control loop shows a properly tuned response

## Dehumidification Test

Override Outside Air Humidity to **45%rh** and return humidity to **70%rh**. Verify that:  
System enters **DEHUMIDIFICATION** mode.  
Supply air temperature is **RESET** to dehumidification setpoint.  
Minimum Outside Air Damper is **OPEN**  
Main Outside Air Damper, Return Damper and Exhaust Damper are **MODULATING** to maintain the mixed air temperature at setpoint  
Damper Loop shows a properly tuned response  
Heating Valve is **MODULATING** to maintain the discharge temperature at setpoint  
Cooling Valve is **MODULATING** to maintain the return air humidity at setpoint  
Dehumidification Loop shows a properly tuned response

## Humidification Test

Override Outside Air Humidity to **45%rh** and return humidity to **25%rh**. Verify that:  
System enters **HUMIDIFICATION** mode.  
Humidifier Valve is **MODULATING** to maintain the discharge humidity at setpoint  
Humidification Loop shows a properly tuned response

## Safety Shutdown Test

Freeze/Static Shutdown, verify that:

- Supply Fan/Exhaust Fan **SHUTDOWN**
- Minimum Outside Air Damper is **CLOSED**
- Outside Air Damper and Exhaust Damper are **CLOSED**
- Return Air Damper is **OPEN**
- Hot Water Valve **OPENS** Fully
- Chilled Water Valve **CLOSES** Fully

Smoke Detector Shutdown, verify that:

- Supply Fan/Exhaust Fan **SHUTDOWN**
- Minimum Outside Air Damper is **CLOSED**
- Outside Air Damper and Exhaust Damper are **CLOSED**
- Return Air Damper is **OPEN**
- Hot Water Valve **OPENS** Fully
- Chilled Water Valve **CLOSES** Fully

High Static Pressure Shutdown, verify that:

- Supply Fan/Exhaust Fan **SHUTDOWN**
- Minimum Outside Air Damper is **CLOSED**
- Outside Air Damper and Exhaust Damper are **CLOSED**
- Return Air Damper is **OPEN**
- Hot Water Valve **OPENS** Fully
- Chilled Water Valve **CLOSES** Fully

## Smoke Purge Test

Set in Smoke Purge Mode, verify that:

- Exhaust Damper and Outside Air Damper **OPENS** Fully
- Return Damper **CLOSES** Fully
- End Switch on Exhaust Damper signals Exhaust Fan to **START**
- End Switch on Outside Damper signals Supply Fan to **START**

## Air Quality Test

Override Return CO2 Setpoint to 1200 ppm, verify that:

- Outside Air Damper is **MODULATING** to maintain Return Air Quality
- Air Quality loop shows a properly tuned response

## Remote Exhaust Fan Test

- Exhaust Damper **OPENS** Fully
- Exhaust Fan Turns **ON**

## Final Checkout:

- Verify that all point overrides have been released to their natural conditions
- Ensure that nothing is in alarm
- Verify the unit time of day schedule

Note any unit deficiencies or incomplete work:

---

## Terminal Unit Functional Testing

Unit #: \_\_\_\_\_ Area Served: \_\_\_\_\_

\*Before beginning commissioning ensure that equipment is clear for automatic operation.

\*Notify anyone who may be working in the area that mechanical equipment will be starting.

### General:



All points **UNLOCKED**



All trends **ENABLED**



Critical alarms configured and enabled

Outgoing requests received at HWS/CHWS

### Occupied Heating Sequence

Override the Zone Temp. to **65°F** and set unit occupancy to **OCCUPIED**. Verify that:

Primary Air Damper **MODULATING** maintain **MINIMUM OCCUPIED** airflow

First Stage Heating: Induced air damper **MODULATING** open to maintain zone temperature

Second Stage Heating: HW Valve **MODULATING** open to coil to maintain zone temperature

Heating loop shows a properly tuned response

### Occupied Cooling Sequence

Override the Zone Temp. to **80°F** and set unit occupancy to **OCCUPIED**. Verify that:

HW Valve **CLOSED** to coil

Induced air damper is **CLOSED**

Primary air damper **MODULATING** between minimum and maximum occupied airflows to maintain zone temperature

Cooling loop shows a properly tuned response

### Unoccupied Heating/Cooling

Set unit occupancy to **UNOCCUPIED**. Verify that

Zone setpoint deadband widened to reduce demand

Primary air damper **MODULATING** between minimum and maximum unoccupied airflows to maintain zone temperature

### Heating Test

Override the Outside Air Temp. to **50°F** and simulate a **HEATING** demand. Verify that:

System enters **HEATING** mode

Minimum Outside Air Damper is **OPEN**

Main Outside Air Damper, Return Damper and Exhaust Damper are **MODULATING** to maintain the mixed air temperature at setpoint

Cooling Valve is **CLOSED**

### Auxiliary Zone Sensors

High zone humidity **DECREASES** SAT from serving AHU

High zone CO2 **INCREASES** OA from serving AHU

Motion detector **ENABLES** occupied mode of operation

Lights are **OFF** in unoccupied mode of operation

## Final Checkout:

- Verify that all point overrides have been released to their natural conditions
- Ensure that nothing is in alarm
- Verify the unit time of day schedule

Note any unit deficiencies or incomplete work:

## Fan Coil Unit Functional Testing

Unit #: \_\_\_\_\_ Area Served: \_\_\_\_\_

\*Before beginning commissioning ensure that equipment is clear for automatic operation.

\*Notify anyone who may be working in the area that mechanical equipment will be starting.

### General:



All points **UNLOCKED**



All trends **ENABLED**



Critical alarms configured and enabled

Outgoing requests received at HWS/CHWS

### Occupied Heating Sequence

Override the Zone Temp. to **65°F** and set unit occupancy to **OCCUPIED**. Verify that:

Supply Fan **ENERGIZES** upon demand

Heating: HW Valve **MODULATING** open to coil to maintain zone temperature

Heating loop shows a properly tuned response

### Occupied Cooling Sequence

Override the Zone Temp. to **80°F** and set unit occupancy to **OCCUPIED**. Verify that:

Supply Fan **ENERGIZES** upon demand

HW Valve **CLOSED** to coil

Cooling: CHWV Valve **MODULATING** open to coil to maintain zone temperature

Cooling loop shows a properly tuned response

### Unoccupied Heating/Cooling

Set unit occupancy to **UNOCCUPIED**. Verify that

Zone setpoint deadband widened to reduce demand

### Heating Test

Override the Outside Air Temp. to **50°F** and simulate a **HEATING** demand. Verify that:

System enters **HEATING** mode

Supply Fan **ENERGIZED**

Cooling Valve is **CLOSED**

### Cooling Test

Override the Outside Air Temp. to **65°F** and simulate a **Cooling** demand. Verify that:

System enters **COOLING** mode

Supply Fan **ENERGIZED**

Heating Valve is **CLOSED**

### Auxiliary Zone Sensors

High zone humidity **DECREASES** SAT from serving AHU

High zone CO2 **INCREASES** OA from serving AHU

Motion detector **ENABLES** occupied mode of operation

Lights are **OFF** in unoccupied mode of operation



## Final Checkout:

- Verify that all point overrides have been released to their natural conditions
- Ensure that nothing is in alarm
- Verify the unit time of day schedule

Note any unit deficiencies or incomplete work:

--

## Chilled Water System Functional Testing

Unit #:

Area Served:

\*Before beginning commissioning ensure that equipment is clear for automatic operation.

\*Notify anyone who may be working in the area that mechanical equipment will be starting.

### General:



All points **UNLOCKED**



All trends **ENABLED**



Critical alarms configured and enabled

All requests received from other equipment

### Occupancy Tests

Set unit occupancy to **UNOCCUPIED**. Verify that:

Primary pump is **OFF**

Chiller is **OFF**

Set unit occupancy to **OCCUPIED** and simulate a **RUN** command. Verify that:

Lead primary pump is **ON**

### Setpoint Reset Tests

Simulate a **Cooling** Demand and Override the Outside Air Temp. to **70°F**. Verify that:

Cooling is enabled

Simulate a **Cooling** Demand and Override the Outside Air Temp. to **40°F**. Verify that:

Cooling is disabled

**RELEASE** the overrides on the Outside Air temp. Verify that:

The system resumes normal **OCCUPIED** operation

### Cooling Test

Simulate a **Cooling** Demand and Override the Outside Air Temp. to **70°F**. Verify that:

System enters **COOLING** mode

Chiller is **ENABLED**

Lead primary pump is **ON**

**RELEASE** the overrides. Verify that:

The system resumes normal **OCCUPIED** operation

### Safety Shutdown Test

Chiller Shutdown, verify that:

System shutdown process executes

### Final Checkout:

Verify that all point overrides have been released to their natural conditions

Ensure that nothing is in alarm  
Verify the unit time of day schedule

Note any unit deficiencies or incomplete work:

---

## WebCTRL® System Third Party Integration

In today's buildings, the power of an innovative, easy-to-use building automation system is a **big** deal.



The Automated Logic® WebCTRL® open architecture and support for industry standards makes integration with third party mechanical and electrical building sub-systems easy. The WebCTRL system is capable of supporting multiple protocols over a TCP/IP network allowing many equipment items to be connected directly to the main WebCTRL backbone.

Equipment using BACnet can be connected to an IP, ARCNET, MS/TP, or Point to Point (PTP) network segment. Our Open Systems Integration allows for seamless interconnection to equipment using BACnet, Modbus®, N2®, JBUS, or LonWorks®, as well as an extensive list of proprietary protocols.

Automated Logic continually develops innovative third party integration solutions to add to our Integration resume. **Contact your local Automated Logic dealer** for a current listing of integration applications or to discuss your custom integration requirements.

**Electric Meters:** Cutler-Hammer®, Electro Industries, GE® PQM, Power Measurement, United Power®, Veris Industries®, ASCO®, APC®, MGE®, Siemens®, Square D®, Setra® Systems, Schneider® ION, Leviton® Series

**Static Transfer Switches and Switchgear:** ASCO®, Cyberex®, GE® Fanuc®, Power Paragon, Zenith®, Russelectric®, Cummins®, LayerZero®, MGE, United Power

**Computer Room Air Conditioning Units:** Air Technology Systems®, Inc. (ATS), APC Network Air, Liebert®, Stulz®, Data Aire®

**Variable Speed Drives:** ABB®, Allen-Bradley®, Cutler-Hammer, Danfoss®, Graham, Square D, Toshiba®, Yaskawa®, Eaton®, ACH

**Lighting:** GE, Square D, Philips®, Cooper Controls, PCI®, Watt Stopper®, Blue Ridge Technologies®

**Boilers:** Cleaver Brooks®, Fireye®, Lochinvar®, Weil-McLain®, Grundfos®, Laars®, Reimers® Electra Steam

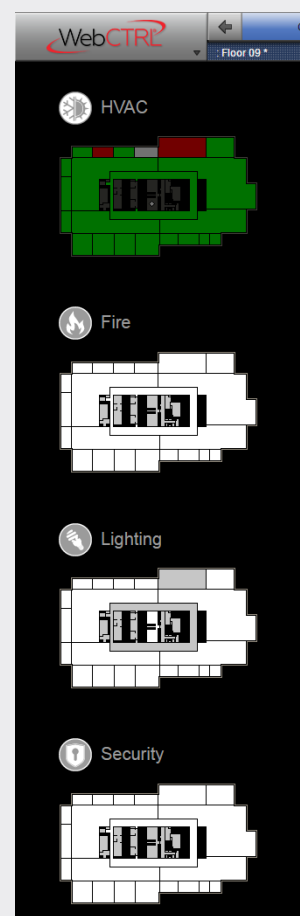
**Chillers:** Carrier®, Dunham-Bush®, Mammoth®, McQuay®, Trane®, York®, Multistack®, ClimaCool®

**Fire Systems:** Edwards® EST3, Siemens® Fire Finder, Simplex®, Kidde®, Honeywell® Notifier

**Fume Hood Control:** Phoenix, Laboratory Control Systems, Tek-Air, TSI®, Triatek®

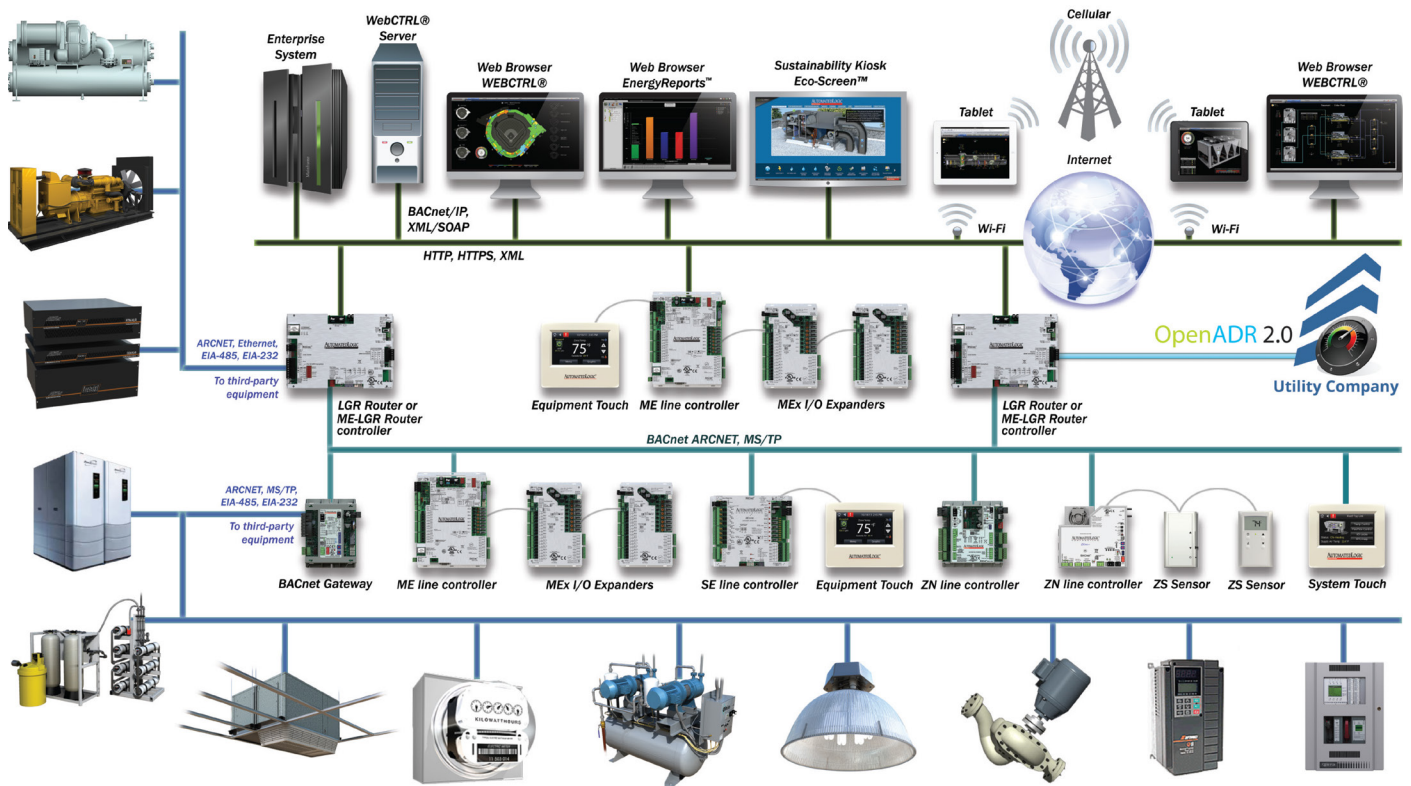
**Generators:** Caterpillar®, Cummins®/Onan, Mammoth, Detroit Diesel®, Kohler®

**UPS Monitoring:** MGE, Powerware®, APC®, Liebert, Piller®





## WebCTRL® System Third Party Integration Architecture



The WebCTRL® building automation system gives you the ability to understand your building operations and analyze the results. The WebCTRL system integrates environmental, energy, security and safety systems into one powerful management tool that allows you to reduce energy consumption, increase occupant comfort, and achieve sustainable building operations. Our web-based platform allows building managers to control and access information about their HVAC, lighting, central plant and critical processes on premises or remotely at any time of day.

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**AUTOMATEDLOGIC**  
United Technologies



# OptiFlex™ Virtual Integrator

Flexible, Scalable, Award Winning Integration Platform

Automated  
Logic



The Automated Logic® OptiFlex™ virtual integrator platform connects and monitors large volumes of data across various building systems, sub-systems, and devices - regardless of manufacturer. That data is then seamlessly integrated into the WebCTRL® building automation system, allowing operators to monitor all of their building systems through a single, web-based user interface.

The virtual integrator platform runs on a single computer server (sold separately), and monitors up to 50,000 BACnet™ / IP, SNMP and/or Modbus® TCP/IP points.

## Key Features and Benefits

### Flexible & Scalable

- Supports simultaneous BACnet, Modbus and SNMP data integration (direct IP connected or routed to IP).
- Scalable licensing architecture allows points to be added and purchased as project needs change - up to 50k points total.
- "Pluggable" protocol technology allows new protocols to be supported as third party devices or systems are added.

### Seamless Integration with the WebCTRL System

- Integrate thousands of third party data points from multiple, diverse systems and monitor all of them through a single, web-based user interface.
- Enhance third party data using WebCTRL graphics, dashboards, reports, and trends, giving operators real-time visibility into building operations and helping them gain insights for improvements.

### Efficient to Install

- Eliminates the need for physical gateways, saving wall space.
- Installs on a single computer server, making installation simple and cost-effective.

### Simple to Commission with New Technician Tools

New web-accessible, table-based user interface

- Connect, configure, and commission third party devices
- Sort, categorize, and scale data points
- Import/export third party point lists from Excel
- Duplicate devices
- Search and replace
- Enable alarms and trends for diagnostics/troubleshooting



The WebCTRL® system gives you the ability to understand your building operations and analyze the results. Integrate environmental, energy, security and safety systems into one powerful management tool that allows you to reduce energy consumption, increase occupant comfort, and achieve sustainable building operations.



**AUTOMATED LOGIC**

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**WE MAKE BUILDINGS BETTER.**

Next level building automation engineered  
to help you make smart decisions.

# OptiFlex™ Virtual Integrator

Flexible, Scalable, Award Winning Integration Platform

06042020

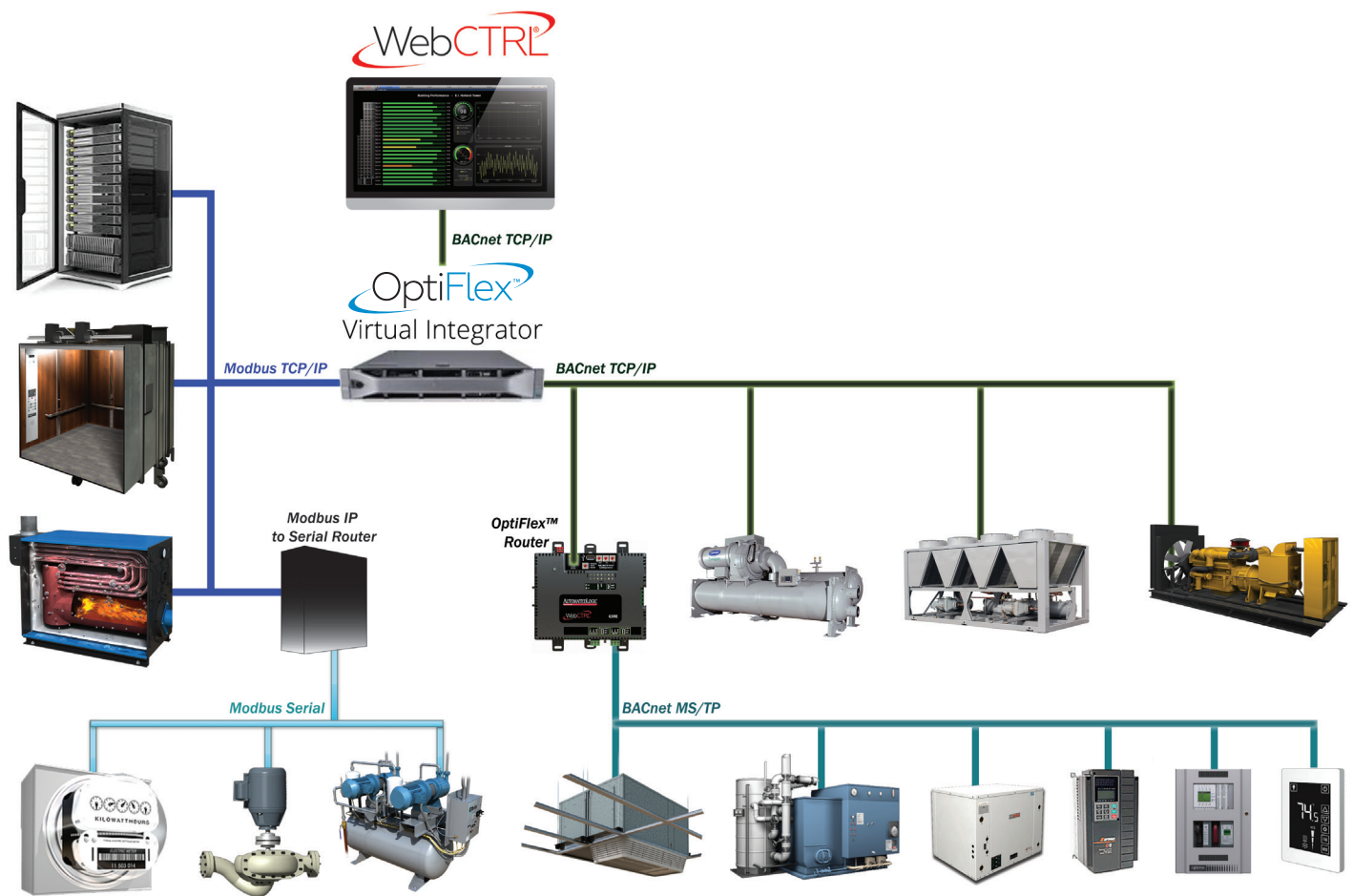
## Server Requirements (server sold separately)

The virtual integrator platform requires a 64-bit Microsoft® Windows or Linux® operating system with a minimum of 6 GB of RAM.

The memory requirements for the virtual integrator computer server will vary based on the:

- number of integration devices and points
- frequency of polling and/or change of value occurrences
- number of simultaneous users logged in to the virtual integrator commissioning tool

## System Architecture



Automated  
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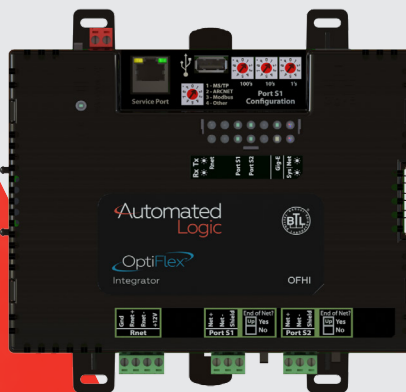
**WE MAKE BUILDINGS BETTER.**

Next level building automation engineered  
to help you make smart decisions.



# OPTIFLEX™ INTEGRATOR

HIGH SPEED ROUTING AND INTEGRATION



Automated  
Logic

## INTEGRATOR FOR THE WEBCTRL® BUILDING AUTOMATION SYSTEM

The OptiFlex Integrator supports routing between multiple BACnet networks. It also supports custom control programs to easily integrate with third party BACnet or Modbus equipment such as variable speed drives, boilers, and lighting.



## KEY FEATURES AND BENEFITS

### Application Features

- Supports routing between BACnet/IP, BACnet/Ethernet, BACnet ARCnet, and BACnet MS/TP networks
- Supports up to: 12,000 network visible BACnet objects; 1,000 Modbus points; 1,500 third party BACnet points
- Includes two additional BACnet ports for supporting either two simultaneous BACnet MS/TP networks (with up to 60 controllers each), or one ARCnet network (with up to 99 ARCnet controllers) and one BACnet MS/TP network (with up to 60 controllers)
- Can serve as a BACnet Broadcast Management Device (BBMD), routing any BACnet broadcast messages directly to other BBMD devices on the BACnet network
- Supports BACnet Foreign Device Registration (FDR)

### Hardware Features

- Supports and executes control programs
- Supports up to two BACnet/IP networks on the Gig-E port
- Supports Gig-E, 1,000Mbps BACnet IP and DHCP IP addressing
- Ethernet port provides local access for system start-up and troubleshooting
- Supports network captures for advanced diagnostic
- Provides network statistics numerically or as trend graphs inside the WebCTRL building automation system
- Supports DIN rail and screw mounting
- Capacitor-backed real-time clock keeps time in the event of power failure or network interruption for up to three days
- Connects seamlessly to the [WebCTRL building automation system](#)



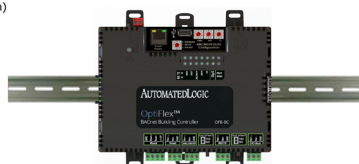
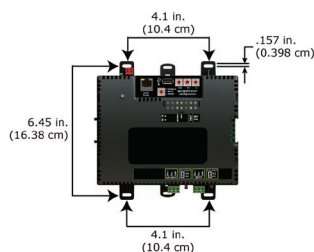
The WebCTRL building automation system gives you the ability to understand your building operations and analyze the results. Integrate environmental, energy, security and safety systems into one powerful management tool that helps you reduce energy consumption, increase occupant comfort, and achieve sustainable building operations.

# SPECIFICATIONS



Part #	OFHI OptiFlex Integrator																
BACnet Conformance	Conforms to the Advanced Application Controller (B-AAC) Standard Device Profile as defined in ANSI-ASHRAE Standard 135-2004 (BACnet) Annex L. Tested to Protocol Revision 12.																
Power	24Vac +/- 10%, 50 - 60Hz, 50VA   26Vdc +/- 10%, 15 W																
Communication																	
Gig-E Port	10/100/1000 BaseT Ethernet port for BACnet/IP and/or BACnet/Ethernet and/or Modbus full duplex																
Serial Port 1	For communication with either of the following: <ul style="list-style-type: none"><li>• A BACnet ARCNET network at 156,000 bps</li><li>• A BACnet MS/TP network at 9,600 to 115,200 bps</li><li>• A Modbus at 1200 to 115200 bps</li></ul>																
Serial Port 2	For communication with a BACnet MS/TP network at 9,600 to 115,200 bps, or Modbus at 1200 to 115200 bps																
Local Access Port	Ethernet port at 10 or 100 Mbps for system start-up and troubleshooting																
Microprocessor	32-bit ARM Cortex-A8, 600 MHz, processor with multi-level cache memory, two Ethernet controllers, and USB 2.0 host port																
Protection	Device is protected by a replaceable, fast acting, 250 Vac, 2A, 5mm x 20mm glass fuse. The power and network ports comply with the EMC requirements EN50491-5-2																
Environmental Range	32 to 140° F (0 to 60° C); 10 - 90% relative humidity, non-condensing																
Physical	Fire-retardant plastic ABS, UL94-5VA																
Memory	16 GBs eMMC Flash memory (120 MB available for use) and 256 MB DDR3 DRAM. User data is archived to non-volatile Flash memory when parameters are changed, every 90 seconds, and when the firmware is deliberately shutdown or restarted.																
Real Time Clock	Real-time clock keeps track of time in the event of a power failure for up to 3 days																
Compliance	United States of America: FCC compliant to Title CFR47, Chapter 1, Subchapter A, Part 15, Subpart B, Class A; UL Listed to UL 916, PAZX, Energy Management Equipment; Canada: Industry Canada Compliant, ICES-003, Class A cUL Listed UL 916, PAZX, Energy Management Equipment; Europe: Mark EN50491-5-2:2009; Part 5-2: EMC requirements for HBES/BACS used in residential, commercial and light industry environment; EN50491-3:2009, Part 3: Electrical safety requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS); Low Voltage Directive: 2014/35/EU; RoHS Compliant: 2011/65/EU; Australia and New Zealand: C-Tick Mark AS/NZS 61000-6-3																
Mounting	DIN rail mounting or screw mounting																
Program Capabilities	<table><tr><th>Controller</th><th>Programs</th><th>Programmed with</th><th>Objects   Points</th></tr><tr><td>OFHI</td><td>999*</td><td>EIKON® software</td><td>Up to 12,000 network visible BACnet objects*</td></tr><tr><td colspan="3"></td><td>Up to 1,500 third-party BACnet integration points*</td></tr><tr><td colspan="3"></td><td>Up to 1,000 modbus integration points*</td></tr></table>	Controller	Programs	Programmed with	Objects   Points	OFHI	999*	EIKON® software	Up to 12,000 network visible BACnet objects*				Up to 1,500 third-party BACnet integration points*				Up to 1,000 modbus integration points*
	Controller	Programs	Programmed with	Objects   Points													
	OFHI	999*	EIKON® software	Up to 12,000 network visible BACnet objects*													
				Up to 1,500 third-party BACnet integration points*													
			Up to 1,000 modbus integration points*														
* Depending upon available memory																	

Figure 1: Physical Dimensions



**Weight: 1.1 lbs 0.482 kg**

Assembled in the United States

# OPTIFLEX™ BACNET INTEGRATOR



Automated  
Logic

## HIGH-SPEED BACNET ROUTING AND INTEGRATION

The Automated Logic OptiFlex BACnet Integrator is an integral component of the WebCTRL® building automation system.

The OptiFlex Integrator supports routing between multiple BACnet networks. It also supports custom control programs to easily integrate with third party BACnet or Modbus equipment such as variable speed drives, boilers, and lighting.



## KEY FEATURES AND BENEFITS

### BACnet Features

- Supports routing between BACnet/IP, BACnet/Ethernet, BACnet ARCnet, and BACnet MS/TP networks
- Supports up to 1,500 third party BACnet points
- Supports up to two BACnet/IP networks on the Gig-E port
- Includes two additional BACnet ports for supporting either two simultaneous BACnet MS/TP networks (with up to 127 controllers each), or one ARCnet network (with up to 254 ARCnet controllers) and one BACnet MS/TP network (with up to 127 controllers)
- Can serve as a BACnet Broadcast Management Device (BBMD), routing any BACnet broadcast messages directly to other BBMD devices on the BACnet network
- Supports BACnet Foreign Device Registration (FDR)

### Modbus Features

- Can act as a master or slave on a Modbus serial network
- Can act as a server or client on a Modbus TCP/IP network

### Hardware Features

- Supports and executes control programs
- Supports Gig-E, 1,000Mbps BACnet IP and DHCP IP addressing
- Ethernet port provides local access for system start-up and troubleshooting
- Supports network captures for advanced diagnostics
- Provides network statistics numerically or as trend graphs inside the WebCTRL building automation system
- Supports DIN rail and screw mounting
- Capacitor-backed real-time clock keeps time in the event of power failure or network interruption for up to three days
- Connects seamlessly to the [WebCTRL building automation system](#)



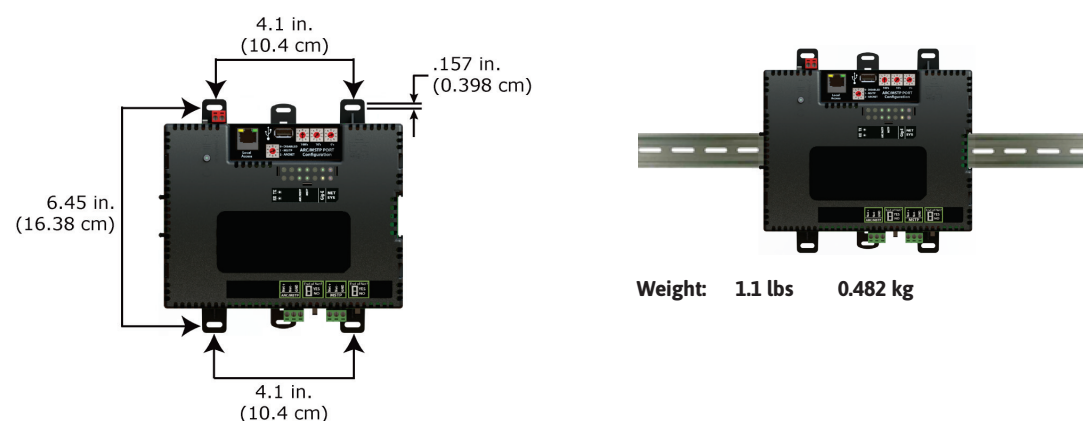
The WebCTRL building automation system gives you the ability to understand your building operations and analyze the results. Integrate environmental, energy, security and safety systems into one powerful management tool that helps you reduce energy consumption, increase occupant comfort, and achieve sustainable building operations.

## SPECIFICATIONS



Part #	G5CE OptiFlex BACnet Integrator
Control Program Execution	Maximum number of control programs: 999 depending upon available memory.
BACnet Objects	Maximum number of BACnet objects: 12,000 for programming purposes.
Third-Party Integration	Supports up to 1,500 third-party BACnet integration points, and 25 modbus integration points
Power	24 Vac $\pm 10\%$ , 50–60 Hz, 50 VA   26 Vdc $\pm 10\%$ , 15 W
Communication	
Gig-E Port	10/100/1000 BaseT Ethernet port for BACnet/IP and/or BACnet/Ethernet and/or Modbus full duplex
Serial Port 1	For communication with either of the following: <ul style="list-style-type: none"> <li>• A BACnet ARCNET network at 156,000 bps</li> <li>• A BACnet MS/TP network at 9,600 to 115,200 bps</li> <li>• A Modbus at 1200 to 115200 bps</li> </ul>
Serial Port 2	For communication with a BACnet MS/TP network at 9,600 to 115,200 bps, or Modbus at 1200 to 115200 bps
Local Access Port	Ethernet port at 10 or 100 Mbps for system start-up and troubleshooting
Microprocessor	32-bit ARM Cortex-A8, 600 MHz, processor with multi-level cache memory, two Ethernet controllers, and USB 2.0 host port
Environmental Range	32 to 140° F (0 to 60° C); 10 - 90% relative humidity, non-condensing
Memory	16 GBs eMMC Flash memory (120 MB available for use) and 256 MB DDR3 DRAM. User data is archived to non-volatile Flash memory when parameters are changed, every 90 seconds, and when the firmware is deliberately shutdown or restarted.
Real Time Clock	Real-time clock keeps track of time in the event of a power failure for at least 3 days
Protection	Device is protected by a replaceable, fast acting, 250 Vac, 2A, 5mm x 20mm glass fuse. The power and network ports comply with the EMC requirements EN50491-5-2
Compliance	United States of America: FCC compliant to Title CFR47, Chapter 1, Subchapter A, Part 15, Subpart B, Class B; UL Listed to UL 916, PAZX, Energy Management Equipment; Europe: Mark EN50491-5-2:2009; Part 5-2: EMC requirements for HBES/BACS used in residential, commercial and light industry environment; EN50491-3:2009, Part 3: Electrical safety requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS); Low Voltage Directive: 2014/35/EU RoHS Compliant: 2011/65/EU; Australia and New Zealand: 61000-6-3 CE; Canada: Industry Canada Compliant, ICES-003, Class A; cUL Listed UL 916, PAZX, Energy Management Equipment
Plastic Rating	Fire-retardant plastic ABS, UL94-5VA
Mounting	DIN rail mounting or screw mounting

Figure 1: Physical Dimensions



# CUSTOMER COURSE CATALOG

## Contact Us

**Automated Logic Training Department**

**Telephone:** 770-795-5188

**E-mail:** [training@carrier.com](mailto:training@carrier.com)

Please contact your local [Automated Logic dealer](#) for course pricing and schedules.





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## ABOUT US

Thank you for your interest in Automated Logic training courses, which include hands-on labs to build proficiency with our **WebCTRL® building automation system** and associated products.

## LOCATIONS

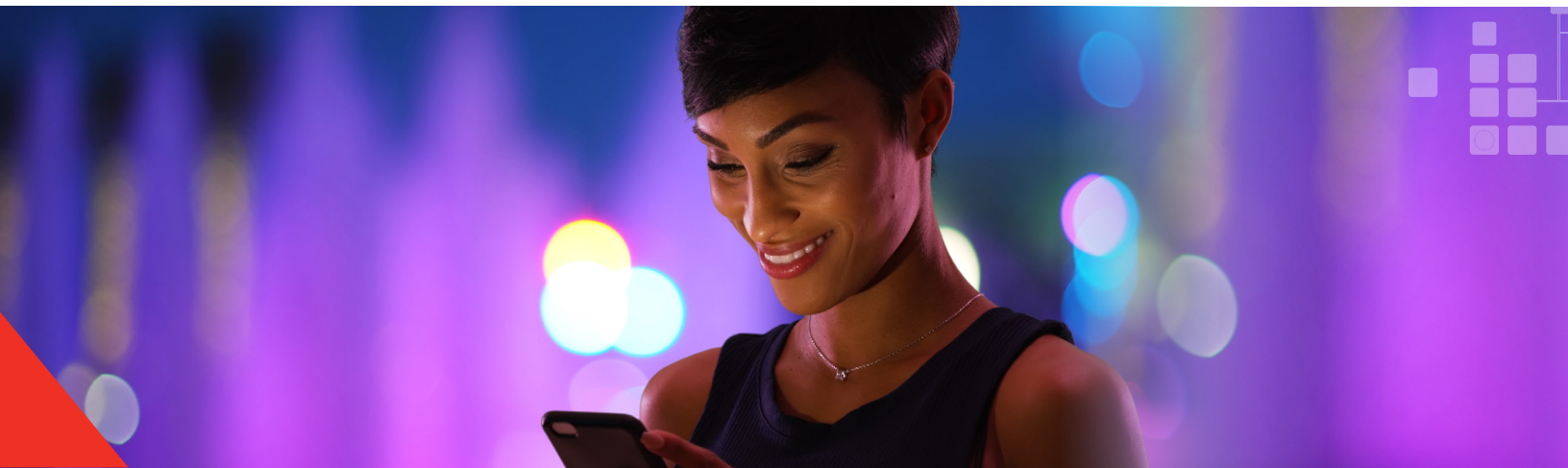
The **Automated Logic World Headquarters (WHQ) Training Center** is located north of Atlanta, GA. All in-person courses include a tour of the Automated Logic Factory to see where our products are made, as well as the opportunity to meet Automated Logic WHQ staff.

Automated Logic also has **factory-certified training centers around the world**. These **Partners in Training** locations make it easy for you to get trained, no matter where you are.



Automated Logic is an accredited provider of the **International Association for Continuing Education and Training (IACET)**. **IACET Continuing Education Credits (CEUs)** are available for select courses at select locations.

FACTORY CERTIFIED LOCATIONS	INSTRUCTOR(S)
<b>North America</b>	
Atlanta (WHQ)	James Ennis
Chicago	Daniel Maltese
Houston	John Diaz de Leon
Las Vegas	Kirk Strobel
Los Angeles	Kirk Strobel
New England	Glenn Tarulli
New York / New Jersey	Glenn Tarulli
Pennsylvania	Jeff Majetic
Sacramento	Derick Hopkins
San Diego	Kirk Strobel
San Francisco	Derick Hopkins
Toronto	Jeffrey Streutker
<b>International</b>	
Europe — Central	Marcel Maijers
Europe — Southern	Mauro Sala
Europe — North West	Clive Caplin
India	Guru S
Latin America	David Ramos
Middle East	Najam Iqbal
South Asia	Kevin Tsai



## TRAINING FORMATS

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Format
Classroom

### Traditional Classroom

A live instructor will lead up to 12 students (course dependent) in hands-on exercises with minimal lecture in between. Using the situated learning techniques of the [Kirkpatrick Model](#), this methodology fosters a collaborative learning environment where students are positioned to maximize knowledge retention.

Format
eLearn

### Instructor-Led eLearning

A live instructor will lead students using video conferencing and remote access software. The student will have remote access to a training station to complete hands-on tasks, giving them a virtual classroom experience from many miles away. These courses are hosted in the same time and manner as the traditional classroom format.

Format
On-Site

### Classroom On-Site

This option brings our traditional classroom to your location of choice. Pricing and availability vary by course.

Format
Virtual

### Video-Led Virtual

The video-led virtual training allows the student to take up to 9 business days to complete the equivalent of a 1-3 day, instructor-led course. Using video tutorials as the instructor, students will execute the workbook tasks and upload assignments using the Automated Logic Training Portal, asking questions through the discussion board where a dedicated instructor will facilitate. This format also offers “instructor hours” where students have live contact with a certified instructor and other registered students.





Format

Self-Paced

### Self-Paced Video Tutorials

Our self-paced video tutorials allow the student to watch and re-watch videos at their own pace. This is a good option for those who would like a refresher on what they've learned elsewhere, or as a prerequisite to another course. Not recommended as the only means of learning something new. Certification exams are available after viewing the video(s).

**The self-paced video tutorials are available in our Training Portal and are available 24/7/365.**

Format

Shop

### ALC Workshops

These in-person or online events are short, 2-3 hour sessions that focus on one main topic for customers and ALC dealer/branch personnel. The informal format encourages discussions among students.

Format

LNL

### Lunch and Learn Events

These in-person or online one-hour events are designed to provide industry thought leadership to consulting/specifying engineers and offer IACET CEU credits.



## CUSTOMER CERTIFICATION TRACKS

### WebCTRL® Owner/Operator

The Owner/Operator certification track is for those who would like to learn how to use the capabilities and features of the WebCTRL® system to effectively manage and maintain their facility, regardless of industry type or size.

All courses in this track are available a la carte (note, some do require prerequisites), but the most balanced, comprehensive training will come by following the certification path shown.

### WebCTRL Owner/Operator: 1 Certification Track

This track is for owners/operators who are new to the WebCTRL system. Students will connect to a live WebCTRL system to learn how to manage their building.

Once certified, students will understand schedules, trends, alarms, and other fundamental WebCTRL features.

#### Requirements

- WebCTRL Owner/Operator: I Course



### WebCTRL Owner/Operator: 2 Certification Track

This track is designed for owners/operators who would like to learn more about WebCTRL's advanced features, including advanced reporting, advanced security, alarm actions, and WebCTRL add-ons.

Once certified, students will be able to diagnose and troubleshoot their WebCTRL system using WebCTRL alarms, trends, reports, and live logic pages.

#### Requirements

- WebCTRL Owner/Operator: I Certificate
- Networking: I Course
- WebCTRL Owner/Operator: II Course

### WebCTRL Owner/Operator: 3 Certification Track

This track is designed for owners/operators who would like to enhance their skills with the entire WebCTRL application suite, including the EIKON® graphical programming tool, SiteBuilder, and ViewBuilder.

Once certified, students will be able to create custom control programs and graphics, and also build/manage their WebCTRL system in SiteBuilder. Networking standards, as well as how to troubleshoot advanced networking issues on their WebCTRL system, are also included.

#### Requirements

- WebCTRL Owner/Operator: II Certificate
- EIKON: I Course
- ViewBuilder: I Course
- WebCTRL Owner/Operator: III Course

# A LA CARTE CUSTOMER COURSES — ESSENTIAL SERIES

## EIKON: I

Learn the basics of EIKON graphical programming. Students who successfully complete this course will be able to identify the different types of microblocks, read a sequence of operation and translate it to a control program, simulate the program to find errors, and define microblock properties. This course is offered with the same content in a 2-day or 3-day format to allow students more time for questions and discussion about their systems.

IACET CEUs	Length
1.6 or 2.4	2 or 3 days
Formats Available	
Class, On-Site, eLearn, Virtual	
Requirements	
None	

## Networking: I

This course covers setup and troubleshooting techniques affiliated with basic Automated Logic networks. In addition, students will build source trees, define and identify the fundamentals of IP, ARC156, and MS/TP networks, and gain an understanding of how these concepts allow devices to communicate. Students will also learn the basics of Wireshark captures, clippings, and BACnet Discovery.

Upon successful completion of this course, students will be able to properly set up and troubleshoot basic Automated Logic networks, including gathering Wireshark captures of IP traffic at the server, as well as IP and ARC156 traffic at devices. This course is offered with the same content in a 2-day or 3-day format to allow students more time for questions and discussion about their systems.

IACET CEUs	Length
1.6 or 2.4	2 or 3 days
Formats Available	
Class, On-Site, eLearn	
Requirements	
None	

## WebCTRL® Owner/Operator: I

This course is a great place to start your WebCTRL journey! If you have little or no experience with the Automated Logic WebCTRL system or you've never attended an Automated Logic training course, Owner/Operator: 1 is for you.

In this course, you will work with the WebCTRL user interface, create operators and privileges, develop schedules, troubleshoot with alarms and trends, and document using WebCTRL's reporting features. Higher-end topics are also included.

IACET CEUs	Length
1.6	2 days
Formats Available	
Class, On-Site, eLearn	
Requirements	
None	

## ViewBuilder: I

This course introduces area and equipment graphics for the WebCTRL system. A complete ViewBuilder overview is provided, as well as its tools, controls, images, and available symbols. Custom topics include the use of conditional expressions and programming floorplans.

In this course, the student will successfully develop basic ViewBuilder graphics and will learn how to edit existing equipment and area graphics. This course is offered with the same content in a 2-day or 3-day format to allow students more time for questions and discussion about their systems.

IACET CEUs	Length
1.6 or 2.4	2 or 3 days
Formats Available	
Class, On-Site, eLearn, Virtual	
Requirements	
None	

# A LA CARTE CUSTOMER COURSES — ADVANCED SERIES

## BACnet Integration: II

The BACnet protocol has become the standard protocol within the building automation industry. Students will learn the theory behind the BACnet protocol and how to seamlessly integrate third-party BACnet devices into a WebCTRL system. Students will utilize EIKON, Networking, and ViewBuilder skills to read and write BACnet objects while following a sequence of operation to incorporate them into a WebCTRL system without stressing the network.

A successful integration is never complete without providing the programming, graphics, and network, so students will be equipped with tips and tricks to streamline integration to multiple pieces of equipment. They will also fine-tune their BACnet integration to achieve a healthy WebCTRL system, all with emphasis on efficiency.

IACET CEUs	Length
0.8	1 day
Formats Available	
Class, eLearn	
Requirements	
EIKON: I ViewBuilder: I Networking: I	

## EIKON: II

Students will expand on knowledge from the EIKON: I course to learn how to create complex control programs and logic symbols. Students will also be able to identify programming as it is implemented within a complete system, and will utilize naming standards to create a library for quickly placing previously developed logic into new systems, thus making programming more efficient. Building a properties page, simulating a control program, and major customization to EquipmentBuilder programs are among several other intermediate EIKON features offered in this course.

IACET CEUs	Length
1.6	2 days
Formats Available	
Class, On-Site, eLearn	
Requirements	
EIKON: I	

## Networking: II

This course is designed for individuals who wish to design complex network systems as well as troubleshoot networks with Wireshark. Students will set up complex Automated Logic networks, troubleshoot networks, and create a secure WebCTRL site. They will also focus on troubleshooting a WebCTRL system by reading and understanding a Wireshark capture. The dynamic BACnet binding process is also featured in this course.

IACET CEUs	Length
1.6	2 days
Formats Available	
Class, eLearn	
Requirements	
Networking: I	

## Modbus Integration: II

The Modbus protocol can be found in many industrial controls, from energy metering to variable frequency drives. In this course a student will learn the theory behind the Modbus protocol and how to integrate third-party Modbus devices into a WebCTRL system. Students will utilize EIKON, Networking, and ViewBuilder skills to read and write to/from Modbus registers while following a sequence of operation to incorporate them into a WebCTRL system without stressing the network.

A successful integration is never complete without the programming, graphics, and network. The student will be equipped with tips and tricks to streamline integration to multiple pieces of equipment and fine-tune their Modbus integration to achieve a healthy WebCTRL system, all with emphasis on efficiency.

IACET CEUs	Length
0.8	1 day
Formats Available	
Class, eLearn	
Requirements	
EIKON: I ViewBuilder: I Networking: I	

## ViewBuilder: II

Students will create equipment graphics from a schematic drawing and technician pages. As an example, students will be tasked to create one graphic for different types of similar equipment with the idea of creating a master graphic for all VAVs to shorten engineering time. In addition, students will create a standard template for their company.

Upon successful completion of this course, students will be able to identify, define, and/or apply advanced conditional expressions, WebCTRL paths for system/equipment linking, and complete customization of equipment graphics, including HTML controls, external links, document links, email links, and custom images and symbols for WebCTRL graphics.

IACET CEUs	Length
1.6	2 days
Formats Available	
Class, On-Site, eLearn	
Requirements	
ViewBuilder: I	



# A LA CARTE CUSTOMER COURSES — CAPSTONE SERIES

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## WebCTRL® Owner/Operator: II

Designed for WebCTRL system owners/operators, this course covers many of the same skills and techniques taught in the Field Technician: I course, such as installing, basic commissioning, and troubleshooting a WebCTRL system. Upon successful completion of the course, students will be able to apply these skills, as well as edit a WebCTRL system utilizing EIKON, SiteBuilder, ViewBuilder, and WebCTRL.

This course provides a complete day of real-life troubleshooting in a WebCTRL system. Owners/Operators should not be discouraged by not fully completing the troubleshooting day as all errors will be discussed by the end of the course.

IACET CEUs	Length
2.4	3 days
Formats Available	
Class, On-Site, eLearn	
Requirements	
WebCTRL Owner/Operator: I	

**WebCTRL® Owner/Operator: III**

This course covers more advanced features and scenarios associated with the WebCTRL system. Troubleshooting is a focus with an emphasis on deciphering logic pages and using add-on features to enhance the user’s experience.

Upon successful completion of this course, the student will be able to configure and deploy complex features, such as advanced alarming and custom trending. They will also learn to set up location-dependent security privileges, as well as operators and privileges within groups.

IACET CEUs	Length
2.4	3 days
Formats Available	
Class, On-Site, eLearn	
Requirements	
WebCTRL Owner/Operator: I	

# NOTES

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## NOTES

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**DGS-30-360**

(Rev. 06/20)

**PART II**  
**DATA ON FIRM SUBMITTING PROPOSAL**

**OFFEROR / PROPOSER:**

**Firm Name:** Automated Logic Contracting Services

**Contact Person:** John D. Adams, Jr.

**Phone Number:** 804-928-3318

**DPOR Registration # :** [REDACTED]

**PROPOSAL FOR:**

**Agency:** Virginia Tech

**Project Title:** Building Automation Systems Program

**Project Code No.:** 218672306

**PARTICIPATION STATUS:**

As defined by Part I:

**VA Department of  
Small Business and  
Supplier Diversity  
(DSBSD) Certificate #**

Is the Proposer a Micro Business?

N

Is the Proposer a Small Business?

N

Is the Proposer a Woman-Owned Business?

N

Is the Proposer a Minority-Owned Business?

N

Is the Proposer a Service-Disabled Veteran-Owned Small Business?

N

**REMARKS / COMMENTS:**

(Rev. 06/20)

(Complete additional pages if needed.)

OFFEROR / PROPOSER:

<b>Firm Name:</b>	ALCS
<b>Contact Person:</b>	John Adams
<b>Phone Number:</b>	804-928-3318

Date Form Completed: December 1, 2022

**PROPOSAL FOR PROJECT:**

Agency:	Virginia Tech
Project:	BAS RFP
Project Code No.:	218672306

List Offeror's plans to involve micro businesses, small businesses, businesses owned by women, businesses owned by minorities, and businesses owned by service-disabled veterans in the performance of this contract either as part of a joint venture, as a partnership, as subcontractors, as consultants, or as suppliers. Offerors are encouraged to provide additional information and expand upon the following format.

[illegible]



## ATTACHMENT B

### PRICE PROPOSAL/ LABOR RATES & MATERIAL PRICING

#### A. Preventive Maintenance

Initial Term - \$9,477.00

#### B. Labor

Firm's must provide the net labor rates in the "Price per hour" column, and in the "Other expenses" column to include: other associated labor costs, bond costs, insurance costs, all general and administrative expenses, benefits, supervision, and overhead and profit per hour. Tradesperson tools and equipment shall be included as part of overhead. The Firm should provide a price for each discipline listed. It is acceptable for the Firm to edit the discipline/ labor categories to match the Firm's organization. Firms shall supply these rates for the first three (3) years of the contract:

Labor	Price per Hour	Other Expenses	Extended Labor Rate
Technician	\$55.32	\$89.68	\$145.00
Service Technician	\$55.32	\$103.68	\$159.00
Project Manager	\$63.26	\$118.74	\$182.00
Service Project Manager	\$63.26	\$130.74	\$194.00
Engineer	\$57.44	\$96.56	\$154.00

#### B. Material Pricing

1. All Material in Firm's Price Catalog  
Discount off of List Price 50%

All Shipping shall be at cost. Material discount is the percentage discount Virginia Tech shall receive that will be deducted from published list prices. **Selected Firms shall provide within their proposal a copy of the commonly used vendor's most recent price catalog.**

## **Summary of Negotiations**

1. As part of Virginia Tech standard procedures, all awarded contracts will be publicly posted on an online contracts portal. If the Offeror's proposal contains proprietary information, Offeror was to provide a redacted copy of the proposal. See RFP for additional information on redacted copies, specifically, Sections C.1.d and C.2.d. However, no redacted copy was submitted. If this was an oversight, please provide a redacted copy of your proposal. Please note, as stated in the RFP, "The classification of an entire proposal document, line item prices and/or total proposal prices as proprietary or trade secrets is not acceptable."

***ALC Response:***

A copy of the redacted proposal will be forwarded under separate cover.

2. Are there any additional financial or value-added incentives you would like to offer Virginia Tech at this time?

***ALC Response:***

Automated Logic will incorporate any additional incentives into the best and final offer provided in accordance with item #17 below.

3. Are there any additional forms or documents that you will require to be incorporated into the contract documents? If so, please submit.

***ALC Response:***

Automated Logic has no additional documentation requirements.

4. Does Automated Logic, agree to provide monthly invoices with payment due thirty (30) days after receipt of invoice or goods/services, whichever is later?

***ALC Response:***

Automated Logic agrees to this provision.

5. Do you agree that you will be performing services as an Independent Contractor, Company, Corporation or other business entity and are not an employee of Virginia Tech or any other Commonwealth entity?

***ALC Response:***

Automated Logic agrees to this provision.

6. Do you further agree that Virginia Tech will not withhold any income taxes from its payments, nor will it provide any employment benefits to the Offeror or Offeror's employees?

***ALC Response:***

Automated Logic agrees to this provision.

7. Will this equipment/material conform to all standards described in the solicitation?

***ALC Response:***

All equipment provided for in this offer conforms to solicitation standards.

8. End of Contract Service Transition Expectations: If a transition of service to another provider is required (end of contract life or otherwise), Virginia Tech would require the incumbent firm to cooperate fully in a transitioning of the services. Should this be requested by Virginia Tech, Offeror shall describe any requirements Offeror might have in preparing for such a transition of services. Additionally, please indicate Offeror's willingness to establish a transition plan alongside the new provider of service which may include but not be limited to sharing important data and/or existing service information via a cooperative knowledge transfer process.

***ALC Response:***

Automated Logic will fully support any transition process requested by Virginia Tech. Our only limitation to this support would be limits on the intellectual property of Automated Logic / Carrier. Should Virginia Tech request our assistance in a transition, we will work with Virginia Tech staff to develop a transition plan for any installed Automated Logic systems.

9. How did Automated Logic arrive at the figure for price adjustments? Are the prices provided with your proposal as favorable (or more favorable) as pricing provided to other Higher Educational Institutions?

***ALC Response:***

Automated Logic based our figure for price adjustments at an annual rate of increase of 3%.

The provided pricing is as favorable as pricing provided to other Universities & colleges. No other customer of the Virginia office has more favorable pricing.

10. Virginia Tech is precluded by law from entering into a contract that contains a cost plus a percentage of cost price arrangement. Therefore, please propose another pricing arrangement.

***ALC Response:***

Automated Logic will provide list less discount pricing (in accordance with the submitted pricing sheet) for all regularly provided devices with a published list price.

For the rare instance where custom quoted devices or equipment are required, Automated Logic will secure quotes and will provide firm, fixed pricing for these devices for review and approval by Virginia Tech prior to any equipment orders.

11. Do you agree that the initial contract period shall be one (1)?

***ALC Response:***

Automated Logic agrees to the initial contract period of one (1) year.

12. Upon completion of the initial contract period, does Automate Logic agree that the contract may be renewed by Virginia Tech upon written agreement of both parties for nine (9) one (1) year periods, under the terms of the current contact?

***ALC Response:***

Automated Logic agrees to this provision.

13. If awarded a contract, do you agree to limit price increases to no more than the increase in the Consumer Price Index, CPI-W, All Items category for the latest twelve (12) months for which statistics are available at the time of renewal or 5 percent, whichever is less?

***ALC Response:***

Automated Logic agrees to tie price increases to CPI-W, however in this highly inflationary period, a cap of 5% would be very restrictive. We would request an adjustment of this cap to 7.5%. Alternately, in lieu of raising the cap, we would accept a cap of 5% with a lower bound of 3% per year.

14. If awarded a contract, are you willing to hold prices firm for the initial contract period and the first renewal year?

***ALC Response:***

Automated Logic agrees to this provision.

15. Will Automated Logic agree to participate in the Wells One AP Control Payment System?

***ALC Response:***

Automated Logic agrees to this provision.

16. Please describe your quickest turn-around time to arrive onsite for on campus emergency services.

***ALC Response:***

Automated Logic will be on-site within 3 hours of receipt of notification from campus emergency services. Please note that as our footprint grows on campus, we will be adding and relocating staff to the immediate area, and this response time will be significantly reduced.

17. As we enter into final negotiations, please provide us with your best and final pricing.

***ALC Response:***

We will forward a best and final pricing offer under separate cover. This BAFO represents all financial incentives and discounts available. This offer meets or exceeds the best pricing and terms offered to any other customer of the Automated Logic Virginia Branch office.

18. If awarded a contract, will you agree to work with each user department before you begin to provide service so that issues such as pick-up/delivery times and days and service requirements may be addressed?

***ALC Response:***

Automated Logic agrees to this provision.

19. How soon after contract award can you begin providing services?

***ALC Response:***

Automated Logic can begin servicing within 30 days of contract execution.

20. Are you registered with and/or willing to participate in the eVA internet procurement solution described in the terms and conditions of the RFP?

***ALC Response:***

Automated Logic is registered and willing to participate in the eVA procurement system.

21. Do you acknowledge, agree and understand that Virginia Tech cannot guarantee a minimum amount of business if a contract is awarded to your company?

***ALC Response:***

Automated Logic agrees to this provision and understands that there is no guarantee of minimum business.

22. Are the prices for all goods/services listed in your proposal inclusive of all applicable eVA system transaction fees?

***ALC Response:***

The prices provided are not subject to any additions for eVA system transaction fees. All eVA fees are absorbed by Automated Logic as a normal cost of business. These fees are not passed on to Virginia Tech.

23. Does the Offeror agree that no import customs clearance fees, customs duties, taxes, or other costs or fees shall apply to this contract and related orders.

***ALC Response:***

Automated Logic agrees with this provision.

24. Are you willing to rescind your Standard Terms and Conditions of Sale?

***ALC Response:***

Automated Logic is willing to rescind our standard terms & conditions.

25. Does the vendor acknowledge, agree, and understand that any Offer-provided terms and conditions of sale are rescinded, and the terms and conditions of the RFP # 218672306 shall govern the contract if a contract is awarded to your company?

***ALC Response:***

Automated Logic acknowledges and agrees with this provision.

26. Virginia Tech's Communication Network Services Department (CNS) network utilizes the entire frequency range allocated to the Industrial, Scientific, and Medical (ISM) band, 2.4 to 2.4835 GHz. Does vendor agree that there will be no conflicts with the existing CNS wireless 802.11g network at (dept)? (Always consult CNS to approve wording).

***ALC Response:***

Automated Logic confirms that our regularly provided devices will not conflict with the CNS wireless network spectrum as defined. All devices will be selected with this network protection in mind.

27. Does Automated Logic acknowledge and agree, at the request of Virginia Tech, that they may be required to participate in a preliminary installation immediately upon award?

***ALC Response:***

Automated Logic agrees with this provision.

28. Virginia Tech aims to have an undisclosed number of its building automation systems technicians certified as "Master Operators", or its equivalent, within three (3) years of the contract award. In support of that target, Virginia Tech would like to request a training plan, including all associated costs, to meet this deadline. The training plan should identify the cost, if any, to Virginia Tech for the respective training course(s). Virginia Tech will provide a definitive number of attendees at a later date.

***ALC Response:***

Please see attached Virginia Tech Training Track & Pricing sheet. Please note that pricing is good for the first year of the contract. Training costs beyond year 1 are subject to escalation in line with all other provided pricing.

## Summary of Negotiations Continued

29. Please provide a cost break down of the expenses included in the “Other Expenses” category located in your pricing proposal?

***ALC Response:***

ALC has provided the information as a separate attachment, including a redacted copy. ALC invokes the protections afforded by Section 2.2-4342F of the Virginia State Code.

30. How did you arrive at the cost listed for the initial term of Preventive Maintenance? What is this Initial Term in reference to?

***ALC Response:***

The PM cost was derived by using Shanks Hall as an example of the process ALC utilizes in determining agreement value. ALC bases PM agreement cost on number of DDC modules and ancillary components installed at the facility, and level of service requested. Please refer to RFP response for a detailed description of our Assurance Plan offering. The initial terms references the first year of the agreement.

31. If awarded a contract, do you agree to limit price increases to no more than the increase in the Consumer Price Index, CPI-W, with a cap of 5% and a lower bound of 0%?

***ALC Response:***

Automated Logic agrees to this provision.

32. Do you agree to provide training to two (2) of our building automation systems technicians to become “Master Operator” certified at no additional cost? All other technicians will abide by the rate structure listed in the Operator Training Track.

***ALC Response:***

All certification track training is an external cost to Automated Logic Contracting Services. As Virginia Tech cannot guarantee any amount of work, we cannot absorb this cost with no revenue offset.

Automated Logic would offer the following compromise. ALC will absorb the cost of 1 training class for every \$50,000 of total project value awarded to Automated Logic up to a total of 24 courses (equivalent to 3 total complete Operator Training tracks). This includes the direct cost of training only.

33. Are the rates provided in the Operator Training Track inclusive of all travel and lodging costs? If not, are you willing to provide an “all inclusive”, or turn-key cost to include those costs associated?

***ALC Response:***

Rates provided do not include travel and lodging costs. Currently, the majority of training courses are offered virtually, as well as in-person. ALC cannot provide all inclusive cost to include travel and lodging because in-person courses are held at various locations across the country



34. Please provide your pricing structure for all 3<sup>rd</sup> party materials and equipment.

***ALC Response:***

Our understanding of the restriction on cost-plus contracting is that it prevents a contracting vehicle with an open-ended framework of a cost percentage added to any extended costs. Automated Logic suggest that we would offer all third-party materials and equipment at a fixed price to Virginia Tech.

This fixed price would be our cost and a fixed handling, overhead and profit markup of 25%. This would be provided to Virginia Tech with verifiable backup documentation. This would be provided PRIOR to any authority to proceed, and Virginia Tech would be under no obligation to purchase any materials in this manner. This removes the open-ended nature of a cost-plus contract. This would be a cost plus for cost development only, but would be converted to a fixed price offer of services prior to acceptance by Virginia Tech.

35. Please specify the difference between a technician and an on-site system specialist.

***ALC Response:***

Either term describes the same position within ALC. System Specialists are our on-site technical personnel responsible for start-up, check-out and troubleshooting of our systems

36. Please provide a cost breakdown for the "Other Expenses" column you have listed within your pricing proposal.

***ALC Response:***

Please see response to Question 29. ALC has provided the cost breakouts requested as a separate attachment.

37. Does Automated Logic Understand that this contract will not auto renew at the Agreement Anniversary?

***ALC Response:***

ALC acknowledges that this contract will not auto renew on the anniversary date.

38. Please provide an updated pricing proposal to reflect annual preventative maintenance v. quarterly.

***ALC Response:***

Please see revised annual proposal provided as a separate attachment to this proposal.

39. Please acknowledge that no payment will be made on March 1, 2024. The building you provided pricing for was an example for scoring purposes only, and did not represent an actual project.

***ALC Response:***

ALC acknowledges that no payment is due on March 1, 2024.

40. Please confirm that the minimum warranty offered on all parts installed by Automated Logic will be 2 years.

***ALC Response:***

ALC is providing a two (2) year warranty on all provided components

41. The discount offered off of list price was lower than we anticipated. Would Automated Logic be willing to reconsider a 70% discount off of list price?

***ALC Response:***

70% off of list price is not sustainable for Automated Logic. Our internal percentage of list price is too high to make that work. The discount offered matches or exceeds the discount offered to any other partner in Virginia.

It is important to understand the final price / value of the discounted products. Many of our competitors publish a much higher list price, and their internal cost is 10-12% of that list. Our cost as a percentage of list is significantly higher.

42. A 3-hour response for emergency services is not consistent with the requirements listed within the RFP. Please confirm that you will comply with the 2-hour requirement called for within the RFP.

***ALC Response:***

ALC will comply with the two (2) hour emergency response requirement

43. Please provide the copy of the pricing proposal mentioned in your response to question 17 for BAFO.

***ALC Response:***

ALC has provided the pricing proposal as a separate attachment to this response