



AUDITING (WITH) BAS

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HONEY BERK, DIRECTOR OF TECHNOLOGY
MARCO ASCAZUBI, TECHNOLOGY SPECIALIST

CUNY BUILDING PERFORMANCE LAB
THE CITY COLLEGE OF NEW YORK

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BAS IN NYC BUILDINGS

- BAS in larger commercial-institutional buildings – est. 3,000-5,000 in NYC
- Two basic forms of infrastructure
 - Digital overlay on top of pre-existing pneumatic controls
 - Direct digital control (DDC)
- Interoperability protocols
 - BACnet – dominant protocol
 - Modbus – plays an increasingly minor role
 - LonWorks – becoming a “legacy” protocol
- Multiple vendors, long history with multiple generations
 - Early systems were fully proprietary

BAS IN THE ENERGY AUDIT PROCESS

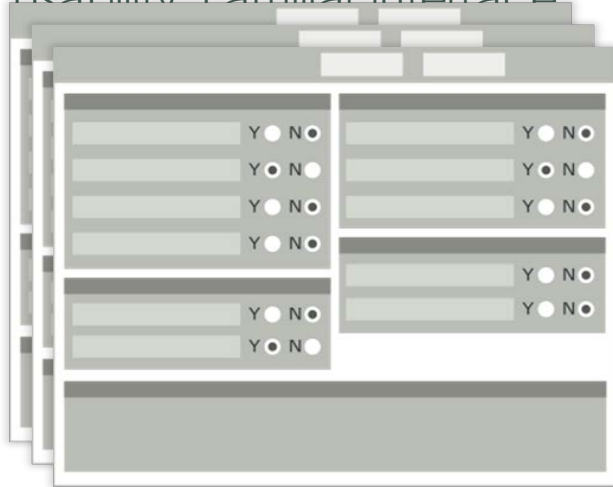
- Use to view and understand major HVAC system components
 - Basic practice of reviewing “screens” with operating engineers
 - View real-time operating conditions
- Trend logs for understanding control sequences
 - Often requires specialized knowledge of specific vendor systems
 - Data storage limitations
 - Data acquisition facilitated by interoperability protocol

AUDIT OF THE BAS

- Need to systematically understand what any given BAS can do
 - Standardization, automation, compliance
 - For audit purposes, retro-commissioning, ongoing commissioning and controls optimization
- Tool Development: BASAT (Building Automation System Assessment Tool)
 - Audit of available data points (sensors, actuators)
 - Structured spreadsheet to assess capabilities
 - Identification of “key sensors” (LL87 requirement)

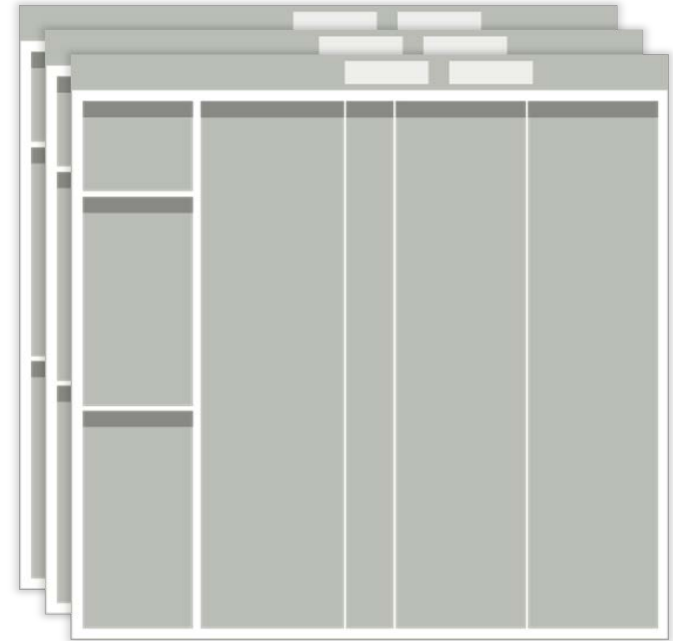
BASAT FRAMEWORK

- Organization: Structured spreadsheets
- Usability: Familiar interface



The image shows a stack of three spreadsheets. The top spreadsheet displays a form with two columns of input fields. Each field is a light gray rectangle with a label to its left and a radio button to its right. The radio buttons are labeled 'Y' and 'N'. Below the input fields, there is a large, empty gray rectangular area at the bottom of the form.

Inputs



The image shows a stack of three spreadsheets. The top spreadsheet displays a structured layout with several columns. The first column is narrow and contains a few rows of data. The second column is wider and contains a few rows of data. The third column is the widest and contains a few rows of data. The fourth column is narrow and contains a few rows of data. The fifth column is the widest and contains a few rows of data.

Outputs

BASAT INPUTS

Unit ID

Identifies unit being assessed

List of Point Names

List of points being audited by BASAT

Yes/No Radio Buttons

Indicate availability of points from BAS front end

Generate Results

Run the embedded (VB) logic and populate results sheets

Notes

Any pertinent information for the system being surveyed

Reset Selections

Clear selections and notes

AIR HANDLER UNITS

Unit ID: AHU-1

Generate Results

Reset Selections

Menu

Please indicate if the following points are available from the BAS or additional sensors/meters. When finished, click "generate results"

TEMPERATURES

Mixed Air Temperature	<input type="radio"/> Yes <input checked="" type="radio"/> No
Supply Air Temperature	<input type="radio"/> Yes <input checked="" type="radio"/> No
Supply Air Temperature Setpoint	<input type="radio"/> Yes <input checked="" type="radio"/> No
Exhaust Air Temperature	<input type="radio"/> Yes <input checked="" type="radio"/> No
Return Air Temperature	<input type="radio"/> Yes <input checked="" type="radio"/> No
Supply Air Relative Humidity	<input type="radio"/> Yes <input checked="" type="radio"/> No

DAMPER POSITIONS

Outside Air Damper Position	<input type="radio"/> Yes <input checked="" type="radio"/> No
Return Air Damper Position	<input type="radio"/> Yes <input checked="" type="radio"/> No
Exhaust Air Damper Position	<input type="radio"/> Yes <input checked="" type="radio"/> No

FANS

Supply Fan Speed	<input type="radio"/> Yes <input checked="" type="radio"/> No
Supply Fan Current	<input type="radio"/> Yes <input checked="" type="radio"/> No
Supply Fan Status	<input type="radio"/> Yes <input checked="" type="radio"/> No
Return Fan Speed	<input type="radio"/> Yes <input checked="" type="radio"/> No
Return Fan Current	<input type="radio"/> Yes <input checked="" type="radio"/> No
Return Fan Status	<input type="radio"/> Yes <input checked="" type="radio"/> No
Exhaust Air Fan Status	<input type="radio"/> Yes <input checked="" type="radio"/> No
Duct Static Pressure	<input type="radio"/> Yes <input checked="" type="radio"/> No
Duct Static Pressure Setpoint	<input type="radio"/> Yes <input checked="" type="radio"/> No
Air Volume	<input type="radio"/> Yes <input checked="" type="radio"/> No

COILS / VALVES

Chilled Water Coil Valve Position	<input type="radio"/> Yes <input checked="" type="radio"/> No
Chilled Water Coil Valve Position Setpoint	<input type="radio"/> Yes <input checked="" type="radio"/> No
Chilled Water Entering Temperature	<input type="radio"/> Yes <input checked="" type="radio"/> No
Chilled Water Leaving Temperature	<input type="radio"/> Yes <input checked="" type="radio"/> No
Heating Coil Valve Position	<input type="radio"/> Yes <input checked="" type="radio"/> No
Heating Coil Valve Position Setpoint	<input type="radio"/> Yes <input checked="" type="radio"/> No
Re-Heat Coil Valve Position	<input type="radio"/> Yes <input checked="" type="radio"/> No
Pre-Heat Coil Valve Position	<input type="radio"/> Yes <input checked="" type="radio"/> No
Re-Heat Entering Temperature	<input type="radio"/> Yes <input checked="" type="radio"/> No
Re-Heat Leaving Temperature	<input type="radio"/> Yes <input checked="" type="radio"/> No
Pre-Heat Entering Temperature	<input type="radio"/> Yes <input checked="" type="radio"/> No
Pre-Heat Leaving Temperature	<input type="radio"/> Yes <input checked="" type="radio"/> No

FILTER

Air Filter Pressure Differential	<input type="radio"/> Yes <input checked="" type="radio"/> No
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Notes

BASAT SYSTEMS AND PROTOCOLS

■ Systems

- Ambient
- Zone
- Cooling Plant
- Heating Plant
- Air Handlers

■ Protocols

- Building Re-tuning
- LEAN Energy Analysis
- Local Law 87
- Demand Response

The image displays a stack of software interface windows from the BASAT (Building Automation System Analysis Tool) application. The windows are titled 'DEMAND RESPONSE', 'COOLING PLANT', 'AIR HANDLER UNITS', and 'GENERAL BUILDING DETAILS'. Each window contains a sidebar with a tree view of system components and a main area with data entry fields and tables. The 'DEMAND RESPONSE' window shows a table for 'Demand Response' with columns for 'Device ID', 'Device Name', 'Device Type', 'Device Status', and 'Device Location'. The 'COOLING PLANT' window shows a table for 'Cooling Plant' with columns for 'Plant ID', 'Plant Name', 'Plant Type', 'Plant Status', and 'Plant Location'. The 'AIR HANDLER UNITS' window shows a table for 'Air Handler Units' with columns for 'Unit ID', 'Unit Name', 'Unit Type', 'Unit Status', and 'Unit Location'. The 'GENERAL BUILDING DETAILS' window shows a table for 'General Building Details' with columns for 'Building ID', 'Building Name', 'Building Type', 'Building Status', and 'Building Location'. The interface is designed for data entry and analysis of building systems.

BASAT OUTPUTS

Unit ID(s)

Identifies unit(s) being assessed

Building and BAS Info

Summary of BAS and building info

Data Points Available Now

List of points marked available
(Yes) on input sheet

Capabilities List

List of potential BAS capabilities

Availability of Measure or Trend

Indicates whether BAS capability is
present

based on currently available points

Data Points to Add

List of points not available

Additional Data Points Needed

Per-measure list of points missing and
needed to implement specific measure
or trend

Points to Trend/Notes

Specific points to trend and what
to expect from the time series plot

BRT		Generate Results	Update Cooling Plant	Update AHU	Update Heating Plant	Menu
Results apply to the following: AC-B-1, CHILLER-01, HX-1,2,3		Tracer Summit BAS has 12 out of 33 BRT trends available				
To see the capability of the BAS to implement and monitor BRT - related control strategies, click on "Generate Results"		TRENDS TO LOOK FOR:	Available?	Points needed:	Points to Trend:	
AHU DISCHARGE - AIR TEMP CONTROL	BUILDING & BAS: BUILDING: Sun Building 280 Broadway Office, Retail, Commercial CONTROL SYSTEM: Trane Tracer Summit	Is reset being used to control the discharge-air set point?	Yes		Supply Air Temperature: Supply Air Temperature Setpoint	
		Is the discharge-air meeting set point, or do deviations occur?	Yes		Supply Air Temperature: Supply Air Temperature Setpoint	
		Are set points too high or too low; discharge-air temperature too warm or too cold?	Yes*		Supply Air Temperature: Supply Air Temperature Setpoint; Outside Air Temperature (Requires Reheat Valve Signal to determine if excessive reheat occurs at the zones)	
		Do the discharge-air temperatures remain relatively stable?	Yes		Supply Air Temperature: Supply Air Temperature Setpoint	
AHU HEATING AND COOLING CONTROL	DATA POINTS AVAILABLE NOW: AHU DISCHARGE - AIR TEMP CONTROL Supply Air Temperature Outdoor Air Temperature	Are outdoor-air temperature lockout set points for heating and cooling reasonable, do they overlap?	No	Chilled Water Coil Valve Position; Heating Coil Valve Position		
		Is there simultaneous heating and cooling occurring in the AHU?	No	Chilled Water Coil Valve Position; Heating Coil Valve Position		
AHU MINIMUM OUTDOOR-AIR OPERATION	AHU HEATING AND COOLING CONTROL Outdoor Air Temperature AHU MINIMUM OUTDOOR-AIR OPERATION: Return Air Temperature Occupancy Mode	Is outdoor air sufficient for ventilation or is over-ventilation occurring?	No	Outside Air Damper Position; Mixed Air Temperature		
		Are there unoccupied times?	No	Outside Air Damper Position		
AHU STATIC PRESSURE CONTROL	AHU STATIC PRESSURE CONTROL: Duct Static Pressure Duct Static Pressure Setpoint AIR-SIDE ECONOMIZER OPERATION: Outdoor Air Temperature Return Air Temperature Supply Air Temperature Supply Air Temperature Setpoint	Is there a reset-schedule for the duct static pressure?	Yes		Duct Static Pressure; Duct Static Pressure Setpoint	
		Determine whether the static pressure set point is too high or too low	No	Terminal Unit Damper Position		
		When conditions are not favorable for economizing, is the mixed-air temperature closer to return-air or outdoor-air?	No	Mixed Air Temperature		
CENTRAL UTILITY PLANT COOLING CONTROL	DATA POINTS TO ADD: AHU DISCHARGE - AIR TEMP CONTROL Terminal Unit Reheat Valve Position AHU HEATING AND COOLING CONTROL: Chilled Water Coil Valve Position Heating Coil Valve Position AHU MINIMUM OUTDOOR-AIR OPERATION: Outdoor Air Damper Position Mixed Air Temperature AHU STATIC PRESSURE CONTROL:	POSSIBLE DETECTION CAPABILITIES:	Available?	Points needed:	Points to Trend:	
		Is reset utilized on the chilled water supply temperature?	Yes		Chilled Water Supply Temperature; Outside Air Temperature	
		Is the chilled water loop differential pressure set point constant and if so, can it be reset at partial load conditions?	No	Chilled Water Coil Valve Position	Chilled Water Supply Temperature; Chilled Water Return Temperature; Outside Air Temperature	

BASAT OUTPUTS: SAMPLE

Sample output from Building Re-tuning (BRT) protocol section

	TRENDS TO LOOK FOR:	Available?	Points needed:	Points to Trend:
AHU MINIMUM OUTDOOR-AIR OPERATION	Is outdoor air sufficient for ventilation or is over-ventilation occurring?	No	Outside Air Damper Position; Mixed Air Temperature	
	Does the outdoor-air damper close during unoccupied times?	No	Outside Air Damper Position	
AHU STATIC PRESSURE CONTROL	Is there a reset-schedule for the duct static pressure?	Yes		Duct Static Pressure; Duct Static Pressure Setpoint
	Determine whether the static pressure set point is too high or too low	No	Terminal Unit Damper Position	



IDENTIFICATION OF KEY SENSORS

Point Statistics

- Can be used to prioritize the addition of missing/unavailable sensors to the BAS
in relation to a particular protocol (DR, BRT, LL87)

Point Name ▼	Equipment/Section ▼	BRT ▼	LL87 ▼	LEAN ▼	DR ▼	TOTAL ▼
Supply Air Temperature Setpoint	AHU Temperatures	0	6	0	1	7
Zone Occupancy Status	Zone	0	5	0	1	6
Supply Air Temperature	AHU Temperatures	0	4	0	1	5
Chilled Water Coil Valve Position	AHU Coils/Valves	0	3	0	1	4
Duct Static Pressure	AHU Fans	0	3	0	1	4
Terminal Unit Reheat Valve Position	Zone	0	3	0	0	3
Chilled Water Supply Temp.	Chilled Water Loop	0	3	0	1	4

There are six Local Law 87 measures that require a Supply Air Temperature Setpoint

FACILITIES ASSESSED

NYC DCAS

- Manhattan Civil Court
- Manhattan Municipal Building
- Queens Supreme Court
- Queens Civil Court
- Bronx Hall of Justice
- 280 Broadway
- Brooklyn Family Court
- Q102

CUNY

- John Jay College
- City College of New York
- Medgar Evers

Commercial Real Estate

- 1500 Broadway
- 1740 Broadway
- 888 7th Avenue
- 330 Madison Avenue
- 111 8th Avenue

CASE STUDY: 1500 BROADWAY



Cooling: Steam Absorption Chillers

Heating: District Steam; HW loop for interior and perimeter induction units

Air side: Perimeter and interior Chilled Water AHUs

BAS: Andover (Schneider Electric)

- Found that setting up trends in the BAS was possible, however operators were not aware of capability
- BAS lacked functionality to set up programmable setpoint resets and setbacks
- Recommended the addition of:
 - Chilled and Condenser Water Flow sensors (needed to indicate condenser or evaporator fouling as well as setpoint tracking issues)
 - Mixed Air Temperature sensor (allow for calculation of Outside Air Fraction)

CASE STUDY: 1740 BROADWAY



Cooling: Steam Absorption Chillers

Heating: District Steam; HW FCUs

Air side: Interior, Perimeter and Lobby CHW AHUs

BAS: Andover (Schneider Electric)

- Site survey was carried out with two goals in mind:
 1. Identify the types of equipment and sensors the controlled by the BAS
 2. Provide insight on possible BRT measures that could be performed
- Recommended the addition of:
 - Mixed Air Temperature sensor
 - Outside Air Fraction (calculated virtual point)

CASE STUDY: 111 8TH AVENUE



Cooling: CHW provided by central plant; condenser water supplied by secondary loop from PHX system

Heating: District Steam and electric reheats

Air side: CHW and DX AHU units; perimeter FCUs

BAS: Three BASs: Trane, Alerton, Siemens (not connected)

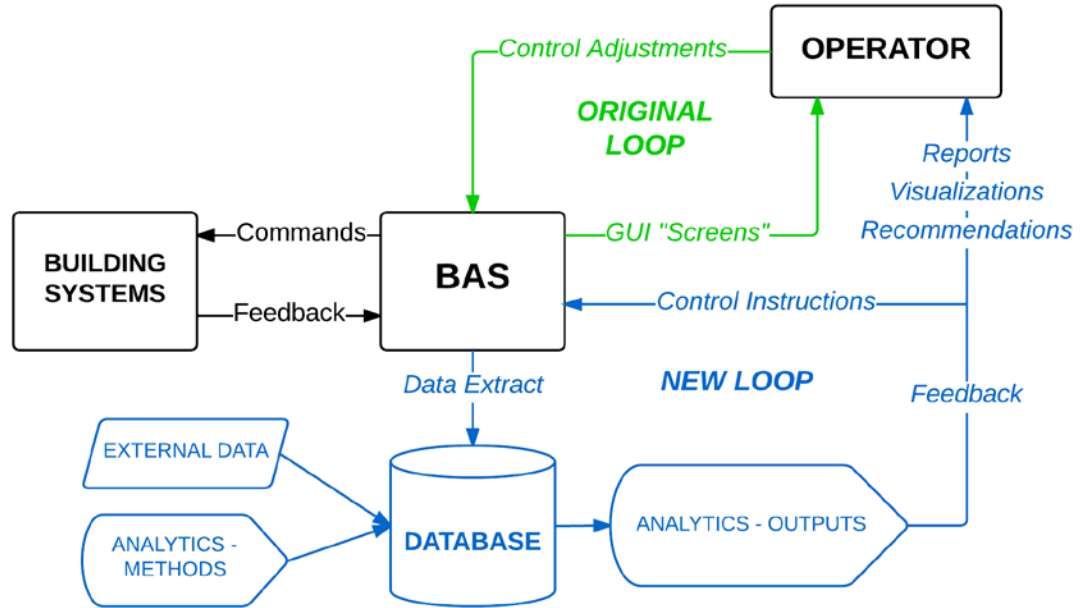
- Found that the following trends were available on the Alerton BAS:
 - Discharge-Air Temperature Control
 - Static Pressure Control
 - Zone Heating & Cooling Control
 - Occupancy Scheduling
 - AHU Heating and Cooling Control
- Demand Response: Found that the Trane BAS is capable of automatic, semi-automatic and manual DR strategies

BASAT: BENEFITS IN ENERGY AUDIT PROCESS

- Faster understanding of BAS capabilities in its current state
- Easier identification of additional sensors/actuators required for effective upgrade
- Leads to more systematic acquisition and use of data
- Enables lower level (less experienced) audit engineers to work more effectively with BAS
- Connects the audit process to retro-commissioning
- Connects the audit process to ongoing commissioning and control improvements

BASAT: PART OF INDUSTRY EVOLUTION

- Emergent Paradigm for using Big Data for buildings – data extraction from BAS and new feedback loop
- SAAS providers; NYSERDA programming
- BASAT to assess “readiness” of BAS for new process-information flow





BASAT: FUTURE ENHANCEMENTS

- More agile framework; additional systems, measures, trends
- Prioritization or ranking of capabilities and recommended actions based on energy and cost savings potential
- Cost analysis of sensor/actuator upgrades
- Test for alarms by exception
- Built-in simple, common calculations
- Part of BAS product suite for more complete analysis
- Ability to communicate directly with BAS to automate trend log setup

DEMONSTRATION



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Building Automation System Assessment Tool (BASAT)

Downloads: [BASAT 2.6](#) | [BASAT 2.6 User Manual](#)

The rapid advancement of building automation devices, coupled with the importance of improved environmental performance, has led to the installation of building automation systems (BAS) in an increasing number of buildings. The Building Automation System Assessment Tool (BASAT) created by the CUNY Building Performance Lab seeks to provide a basis for a standardized approach to evaluating existing building systems relative to desired BAS functionality and performance goals.

BASAT is a software tool that helps building owners, consultants and contractors uniformly assess building automation system infrastructure by classifying the availability of system capabilities based on specific combinations of sensors, actuators and points found during a survey of the BAS interface.

BASAT can provide insight into any specific controls optimizations of, or measures that can be realized with, the current BAS configuration; as well as an indication of the possible measures given additions of specific sensors, actuators and points to the BAS. The tool consists of the following:

- Input sections in the form of survey lists, in which the user selects the availability of sensors based upon examination of the BAS front-end and operator knowledge of the system
- System-, equipment-, and protocol-specific results sections in which the results of the survey are computed based on a decision matrix that determines the availability of measures, control strategies and controls optimizations.

The screenshot displays the BASAT software interface, which is organized into several tabbed sections. The visible tabs include 'DEMAND RESPONSE', 'COOLING PLANT', 'AIR HANDLER UNITS', and 'GENERAL BUILDING DETAILS'. Each section contains a table with various input fields and checkboxes for surveying building systems. The 'DEMAND RESPONSE' section is currently active, showing a table with columns for 'System', 'Control Strategy', and 'Availability'. The 'COOLING PLANT' section shows a table with columns for 'System', 'Control Strategy', and 'Availability'. The 'AIR HANDLER UNITS' section shows a table with columns for 'System', 'Control Strategy', and 'Availability'. The 'GENERAL BUILDING DETAILS' section shows a table with columns for 'System', 'Control Strategy', and 'Availability'. The interface also includes a sidebar on the left with navigation links and a search bar at the top right.

www.cunybpl.org



QUESTIONS?

HONEY BERK
Director of Technology
CUNY Building Performance Lab
honey.berk@cuny.edu
212-652-2041

MARCO ASCAZUBI
Technology Specialist
CUNY Building Performance Lab
marco.ascazubi@cuny.edu
212-652-2896