

GPG Outbrief 15

# High-Performing Commercial RTUs

Emerging Building Technologies, GPG Program | U.S. General Services Administration | September 6, 2018

The GSA logo consists of the letters "GSA" in a white, sans-serif font, positioned inside a dark blue square. The square is located in the bottom left corner of the slide.

GSA

# GPG-034 High-Performing Commercial RTUs @ gsa.gov/gpg

- ❑ Infographic
- ❑ 4-page Findings
- ❑ Full Report
- ❑ Additional Resources

The screenshot shows a web browser displaying the GSA website. The page title is "High-Performing Commercial RTUs". The navigation bar includes "GSA", "TRAVEL", "REAL ESTATE", "ACQUISITION", "TECHNOLOGY", "POLICY & REGULATIONS", and "ABOUT US". The breadcrumb trail is: Home > Governmentwide Initiatives > Sustainability > Emerging Building Technologies > Published Findings > HVAC > High-Performing RTUs >.

The main content area features a sidebar on the left with a menu for "EMERGING BUILDING TECHNOLOGIES". The "High-Performing RTUs" item is selected and expanded, showing a list of sub-topics: Overview, About GSA's Proving Ground (GPG), Published Findings, Building Envelope, Energy Management, HVAC, Condensing Boilers, Fan Belts, High-Performing RTUs (selected), Indirect Evaporative Cooler, Smart Ceiling Fans, Variable Refrigerant Flow, Variable-Speed Maglev Chiller, Variable-Speed Screw Chiller, Lighting, On-Site Power & Renewables, Water, Ongoing Assessments, Request for Information, About Pilot to Portfolio (P2P), Outbrief Webinars, GPG-Proven Technologies with GSA Deployment Potential, and Newsletters.

The main content area has a heading "High-Performing Commercial Rooftop Units". Below the heading is a paragraph: "GPG, in collaboration with Pacific Northwest National Laboratory researchers, evaluated the first RTU to meet the Department of Energy's High Performance RTU Challenge. Results from measurement and verification at a warehouse in Fort Worth, Texas demonstrated energy savings of 26%. A concurrent PNNL study of high-performance RTUs at two Florida supermarkets found payback of 3.8 years. [View full-size infographic.](#) [PDF - 263 KB]".

On the right side, there are three sections: "4-PAGE REPORT SUMMARY" with a PDF icon and "[PDF - 1 MB]", "FULL REPORT—MAY 2017" with a PDF icon and "[PDF - 414 KB]", and "ADDITIONAL RESOURCES" with a list of links: "Field Evaluation of the Performance of the RTU Challenge Unit (PNNL 03-2015)", "Part-load Performance and Characterization and Energy Savings Potential of the RTU Challenge Unit (PNNL 09-2013)", "RTU Comparison Calculator (PNNL)", and "Advanced Rooftop Control Retrofit: Field Test Results (PNNL 06-2013)".

At the bottom of the page, there is an infographic titled "GPG FINDINGS 034 APRIL 2018 HIGH-PERFORMING COMMERCIAL ROOFTOP UNITS". The infographic contains the following text: "OPPORTUNITY RTUs condition how much floor space nationwide? >50% OF COMMERCIAL FLOOR SPACE IN THE U.S. IS CONDITIONED BY ROOFTOP UNITS (RTUS) TECHNOLOGY How do advanced RTUs work? VARIABLE SPEED INVERTER COMPRESSOR MAINTAINS AIR TEMPERATURE SETPOINT". Below the text is a line graph showing "Temperature" on the y-axis and "Discharge-Air Temperature Setpoint" on the x-axis. The graph compares an "Advanced RTU Inverter" (green line) and a "Non-Inverter" (blue line). The advanced inverter line stays consistently near the setpoint, while the non-inverter line fluctuates significantly above and below it. Text on the left of the graph says "VARIABLE SPEED SUPPLY FAN RESPONDS TO ZONE CONDITIONS".

# Recording and Slides Available on [gsa.gov/gpg](https://gsa.gov/gpg)

**GSA** TRAVEL REAL ESTATE ACQUISITION TECHNOLOGY POLICY & REGULATIONS ABOUT US

Home > Governmentwide Initiatives > Sustainability > Emerging Building Technologies > Outbrief Webinars >

## EMERGING BUILDING TECHNOLOGIES


- Overview
- About GSA's Proving Ground (GPG)
- Published Findings
- Ongoing Assessments
- Request for Information
- About Pilot to Portfolio (P2P)

> Outbrief Webinars

- GPG-Proven Technologies with GSA Deployment Potential
- Newsletters
- GSA Technology Deployment Maps

## Outbrief Webinars

GPG Outbrief webinars are presented by national laboratory researchers and include results from real-world evaluations, as well as feedback from facility managers at test-bed locations. Following Outbrief presentations, researchers and other GSA subject experts field participant questions. Attendees are eligible to receive continuing education credits from the American Institute of Architects for attending webinars.

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## Upcoming Webinars (Thursdays at noon ET)

**High-Performing RTUs**  
Outbrief 15: September 6, 2018  
[Register now >>](#)

**Circulator Pumps with Automated Control**  
Outbrief 16: October 4, 2018

**Advanced Lighting Controls with LED Fixtures**  
Outbrief 17: November 8, 2018

**Alternative Water Treatment for Cooling Towers**  
Outbrief 18: December 6, 2018

## On-Demand Webinars and Presentation Slides

**Variable Refrigerant Flow**  
» [14 Webinar Recording June 7, 2018](#)  
» [Presentation Slides](#)

**Honeycomb Solar Thermal Collector**  
» [13 Webinar Recording May 24, 2018](#)  
» [Presentation Slides](#)

**Electrochromic Windows for General Office Space**  
» [12 Webinar Recording April 19, 2018](#)  
» [Presentation Slides](#)

# Upcoming 2018 GPG Outbriefs—Thursdays, 12 PM ET

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Oct 11 Small Circulator Pumps with Automated Control

## Webinar Recordings

Access all webinars on [GSA.gov](https://www.gsa.gov)

[GSA.gov/GPG](https://www.gsa.gov/GPG)

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This GPG webinar offers 1 Continuing Education Learning Unit through the American Institute of Architects

To receive credit:

Complete the post-webinar survey, or contact Michael Hobson,  
[michael.hobson@gsa.gov](mailto:michael.hobson@gsa.gov)



# How to Ask Questions

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Please chat your questions during the presentation for the Q&A segment



# Introduction

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**Michael Lowell**

Project Manager, GPG

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# Webinar Agenda

- ❑ Introduction (5 minutes)  
Kevin Powell, Program Manager, Emerging Building Technologies
- ❑ RTU Challenge Report (15 minutes)  
Srinivas Katipamula, Pacific Northwest National Laboratory
- ❑ On-the-ground Feedback R7, Fort Worth Depot (15 minutes)  
Frank Campagna, Stuart Lamkin
- ❑ Q & A (20 minutes)



# Introduction

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## **Kevin Powell**

Program Manager, Emerging Technologies

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Emerging Building Technologies' two programs—GSA Proving Ground (GPG) and Pilot to Portfolio (P2P)—enable GSA to make sound investment decisions in next-generation building technologies based on their real-world performance

# Partnership With DOE

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**2011**

DOE's Building Technologies Office developed a specification for high-performance commercial RTUs

**2013**

Daikin was first RTU to meet the challenge

**2015**

GPG: 5-ton unit tested at GSA warehouse in Fort Worth, Texas

HIT Catalyst: Two 7.5-ton units tested at Florida supermarkets

# Measurement & Verification

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**Srinivas Katipamula**

Senior Research Engineer  
Pacific Northwest National Laboratory

GPG-034

# High-Performing Commercial RTUs

General Services Administration  
Public Buildings Service



GPG-034 | APRIL 2018

## HIGH-PERFORMING COMMERCIAL RTUs



### Advanced RTU Yields Substantial Savings

Rooftop units (RTUs)—also known as packaged air conditioners—are used to condition nearly half of all commercial floor space in the United States and constitute the most common HVAC equipment found in low-rise commercial structures. RTUs are easy to install and have low first costs but legacy models, built with constant speed drives and without advanced controls, are inherently inefficient. To stimulate the market for higher-performing RTUs, the Department of Energy's (DOE's) Building Technologies Office issued a challenge to manufacturers to build an RTU 50% more efficient than ASHRAE 90.1 standards. The first RTU to meet DOE's "High Performance RTU Challenge" specification was installed in a GSA warehouse in Fort Worth, Texas, and compared, under real-world conditions, with an existing RTU typical of those in the field. Researchers from the Pacific Northwest National Laboratory (PNNL) found that the seasonal energy efficiency ratio (EER) of the "challenge RTU" was 16% higher than the baseline unit, which was already 4% more efficient than ASHRAE 90.1 standards. When ventilation energy from both units, with fans running 24-hours a day, was taken into account, savings increased to 26%. A concurrent study by PNNL of advanced RTUs at two Florida supermarkets demonstrated energy savings of 31% and payback of 3.8 years.<sup>1</sup>

# Opportunity

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**50%** of U.S. commercial floor space conditioned by RTUs

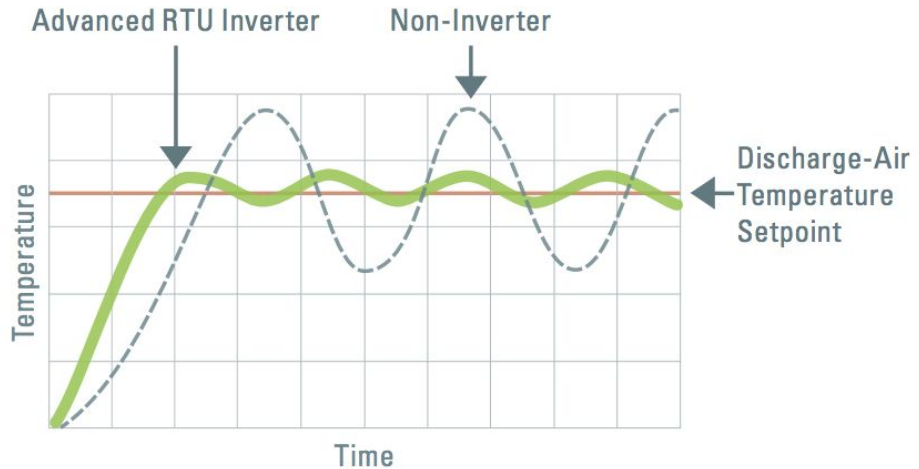


# Two Variations on High-Performing RTUs

## Variable-Speed Fans

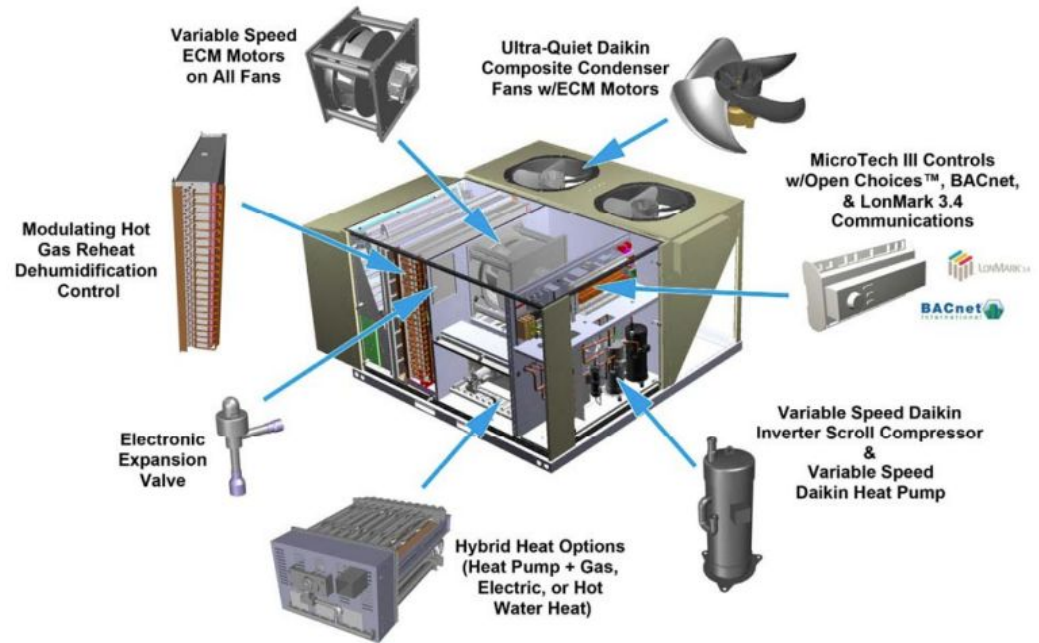
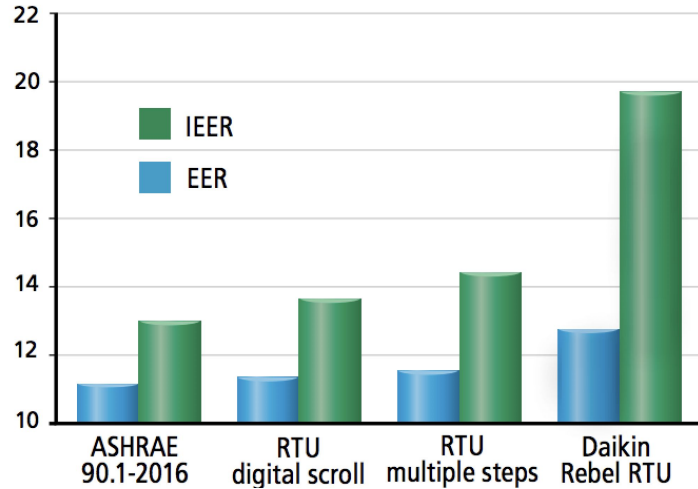
Fans are a fraction of compressor energy use but operate more hours and account for ~45% of annual energy use

## Variable-Speed Fans & Variable-Speed Compressor



# High-Performing RTU Components

Efficiency ratios (10-ton unit)

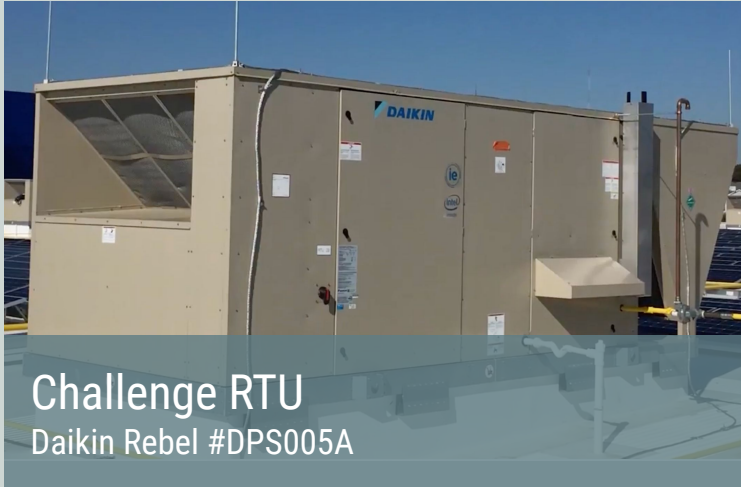




# Measurement & Verification

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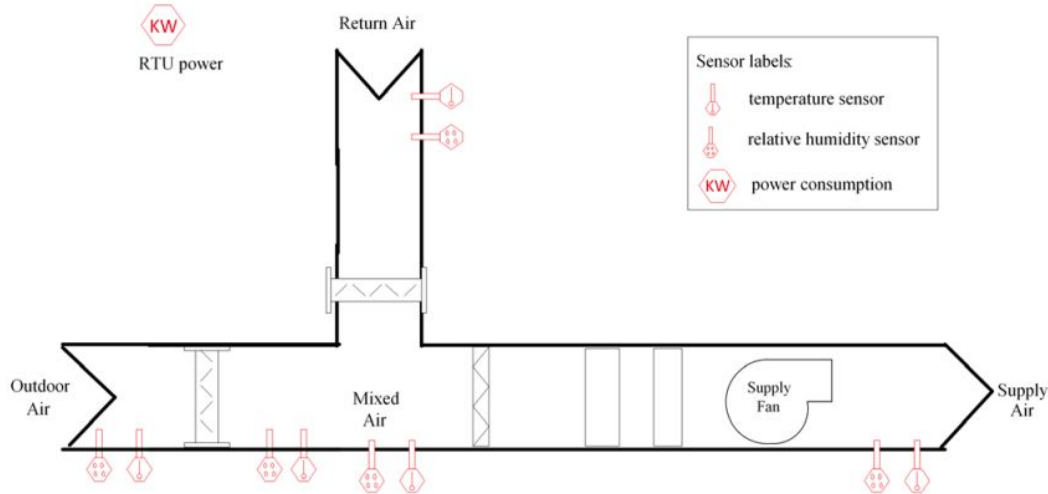
Researchers Monitored Performance at Fort Worth Depot. Concurrent PNNL Study at Two Florida Supermarkets.



# M&V Process

## Simultaneous Monitoring for 10-months

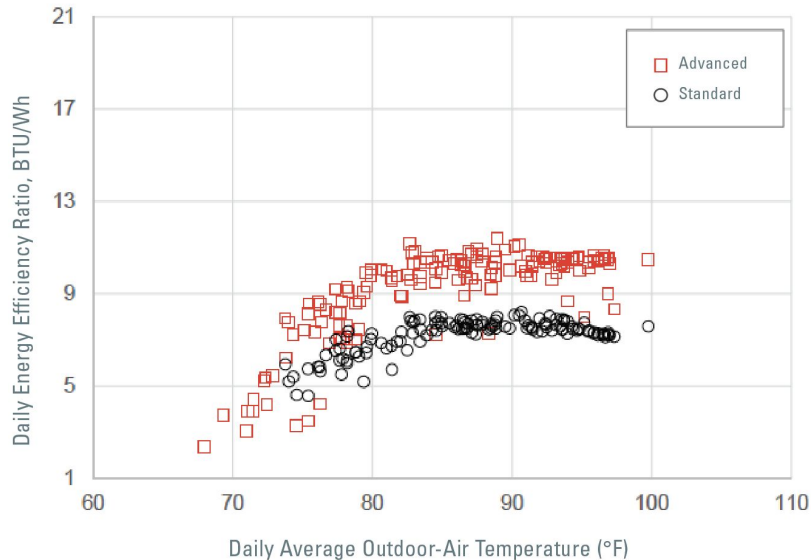
Temperature, humidity and power consumption sensors



# Energy Efficiency Ratio as a Function of Outdoor Air Temperature

## Seasonal Energy Efficiency Ratio (EER) 16% Higher Than Baseline

Advanced RTU exceeds baseline efficiency, particularly at higher outdoor air temperatures



Baseline at test bed was 4% more efficient than ASHRAE 90.1 standards

# Energy Savings Increases to 26% with Ventilation Energy

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## Savings Not as Great as Models Predicted

- The two units at the test bed served different loads, whereas in the simulation they served the same load.
- The baseline unit at the test bed had higher operating efficiency than the simulation: EER of 11.4 vs 11.
- The baseline unit recirculated 100% of the air, whereas the challenge unit introduced outside air, which creates additional friction and can consume more energy.
- The simulation assumed a 10-ton unit, which was slightly more efficient than the 5-ton unit: EER of 12.5 vs 12.3.

**26%**

### **ENERGY SAVINGS**

Models predicted 40% savings compared to a standard RTU

# Installation

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## Infrastructure Reinforcement and Other Adjustments

- The challenge unit had a different footprint from the legacy RTU and was considerably heavier, requiring roof infrastructure reinforcement.
- Commissioning required minor changes to the initial startup configuration and BAS.
- Support team modified Tridium network and power sensors to correct issues related to trending and power meter accuracy.
- Duct changes are sometimes required.



# Return on Investment

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## Installation Costs Vary

Heavier unit and different footprint may require infrastructure reinforcement or duct changes

	Standard RTU	Challenge RTU
Annual Consumption (kWh)	34,000 kWh	18,000 kWh
Savings (kWh)		16,000 kWh
Savings @ local electricity rate \$0.10/kWh		\$1,600
Incremental Cost		\$6,000
End-of-Life Payback		3.8 years

**3.8** YR  
**PAYBACK**

demonstrated  
at two Florida  
supermarkets

# Deployment for High-Performing RTUs

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## End-of-life Replacement

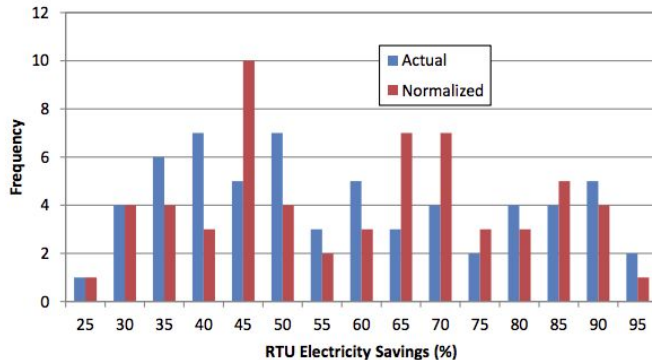
- Modeling indicates that savings will be greatest in hot, humid climates.
- High-Performance RTU with variable-speed compressor provides better humidity control and comfort.



# Advanced Rooftop Control (ARC) Retrofits

## For RTUs that Have Not Reached End-of-life, Less than 10 years old

A PNNL field study of 66 RTUs retrofitted with ARC found energy savings ranging from 22% to 90%, with an average 57% savings and 3 year payback (@ \$0.10/kWh).



RTU Capacity (tons)	Supply Fan Size (hp)	Controller <sup>1</sup> (\$)
≤ 5	1	\$2,200
> 5 and ≤ 10	2	\$2,600
> 10 and ≤ 15	3	\$3,500
> 15 and ≤ 20	5	\$4,000
> 20 and ≤ 25	7.5	\$4,142

**<sup>1</sup>2012 costs for reference only:**

Controller Labor \$750, Metering \$1,071, Metering Labor \$275, Fixed Monitoring \$2,403, Variable Monitoring \$50/month



# RTU Comparison Calculator

<https://www.pnnl.gov/uac/costestimator/main.stm>



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## Rooftop Unit Comparison Calculator

	Home	Submit	Restore
Welcome to the Rooftop Unit Comparison Calculator. The RTUCC simulates the energy usage of both a high efficiency and a standard efficiency air conditioner. It then compares their energy and economic performance.	Advanced Features	<input type="checkbox"/>	Hidden
	Show bin calculations	<input type="checkbox"/>	Hide bin calcs
The RTUCC displays best in Mozilla Firefox. Good second choices for a web browser are Internet Explorer, Microsoft Edge, and Google Chrome.	Building Type	Office-Medium	Office-Medium
	State / City	MO  Kansas City	MO Kansas City
To run the RTUCC, characterize the two systems and their environment using the features on this page. Then click the "Submit" button. Use your browser "back"	Schedule	M-Fri, 7 a.m. to 7 p.m.	M-Fri, 7a.m. to 7p.m.
	Indoor Temperature	75  °F Setback 5  °F	75 °F 5 °F
Total Capacity	084  xBtuh	84 kBtuh	

# GSA Feedback—Fort Worth Depot

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**Frank Campagna**

Supervisory Energy PM  
GSA Region 7



**Stuart Lamkin**

Property Manager  
GSA Region 7



**Felipe Gaytan**

Controls Integration  
JMS Building Solutions

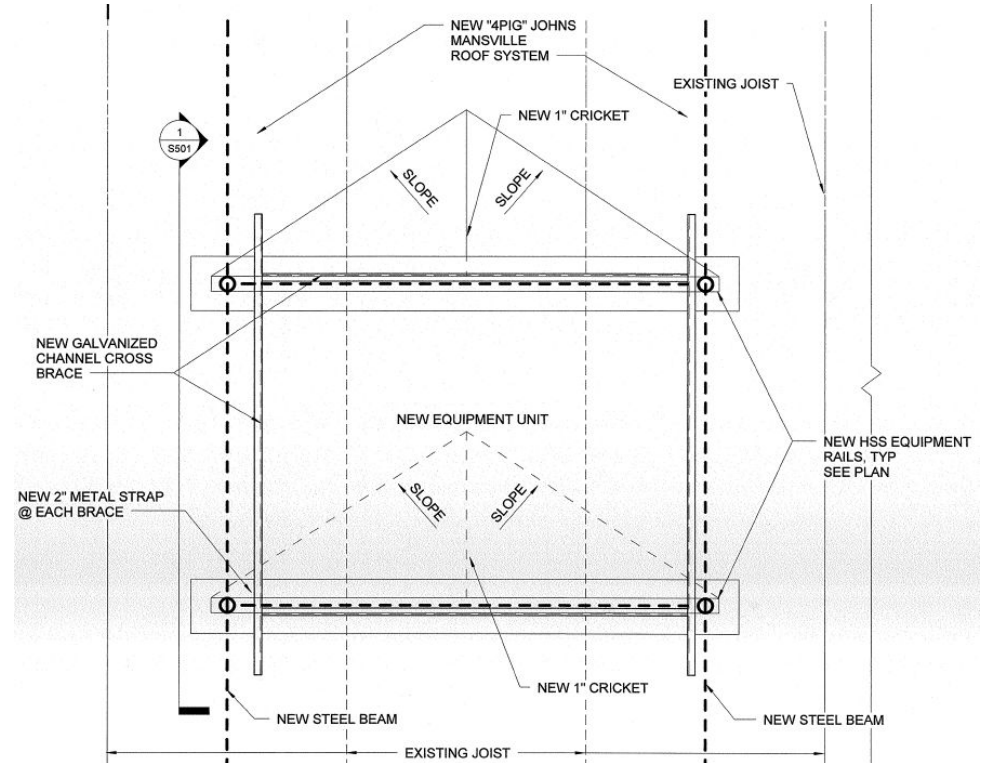
# Installation of the High-Performing RTU

## Biggest Challenge

- Integrating the RTU into the BAS (more points to customize)

## Heavier Unit

- Had to install more girders into the roof to support the unit

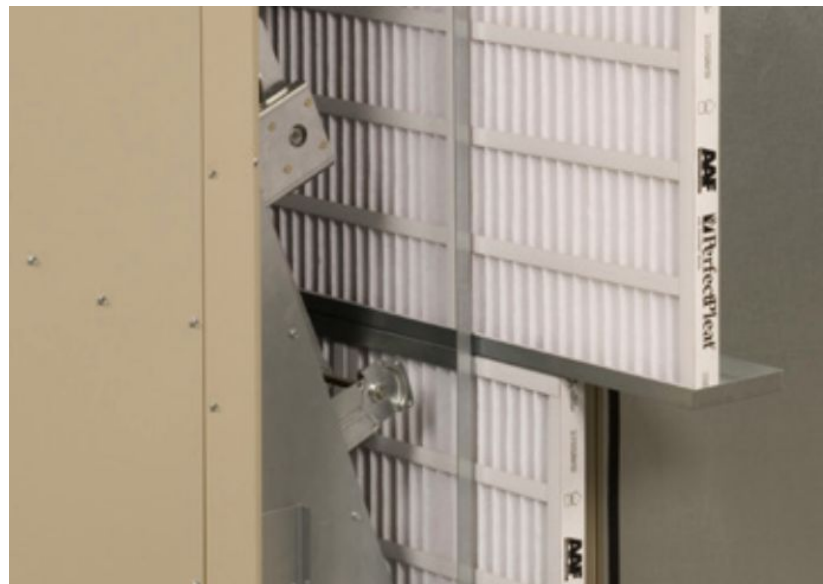


# Operations & Maintenance

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## No Maintenance Issues

- Quarterly PMs and replace filters as needed.
- Seeing more monitoring points gives you more information and helps operate the building better
- May be a bit quieter because not always running full-bore
- As in any construction project, it's important to keep tenants informed



# BAS Controls Integration

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## No Major Issues With Integration

- Unit lacked required sensors which had to be added on a separate controller

## Limited Operator Control

- Time schedule and set point adjustments



Q & A

# Survey and Continuing Education Credit

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[michael.hobson@gsa.gov](mailto:michael.hobson@gsa.gov)

## GPG Outbrief 15: High-Performing Commercial RTUs

\* Required

Email address \*

Your email

Continuing Education Credit

Check here to request a certificate for 1 CE units.

AIA Number

Your answer

First and Last Name

Your answer

The information presented in the Outbrief webinar was helpful.

1 2 3 4 5  
Strongly Disagree      Strongly Agree

I am interested in installing high-performing commercial RTUs.

- Yes, in the next 2 years.
- Yes, in the next 5 years.
- Maybe
- No

Comments or questions about the webinar or high-performing commercial RTUs

Thank you





For more information: [gsa.gov/GPG](https://gsa.gov/GPG)

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