

*Thank you for signing in early*

The webinar will begin promptly at  
12:00 pm ET, 9:00 am PT



# SERDP and ESTCP Webinar Series

***The webinar will begin promptly at 12:00 pm ET,  
9:00 am PT***

- You have two options for accessing the webinar
  1. Listen to the broadcast audio if your computer is equipped with speakers
  2. Call into the conference line: 303-248-0285  
Required conference ID: 6102000
- For any question or issues, please email [serdp-estcp@noblis.org](mailto:serdp-estcp@noblis.org) or call 571-372-6565

# Building Envelope Technologies

November 16, 2017



## Welcome and Introductions

Rula A. Deeb, Ph.D.  
Webinar Program Coordinator



# Webinar Agenda

- **Webinar Logistics** (5 minutes)  
**Dr. Rula Deeb, Geosyntec Consultants**
- **Overview of SERDP and ESTCP** (5 minutes)  
**Mr. Timothy Tetreault, SERDP and ESTCP**
- **SonicLQ: The Sonic Leak Quantifier** (20 minutes + Q&A)  
**Dr. Ralph Muehleisen, Argonne National Laboratory**
- **Automated Aerosol-Sealing of Building Envelopes** (25 minutes + Q&A)  
**Mr. Curtis Harrington, University of California, Davis**
- **Final Q&A session**

# How to Ask Questions

Type and send questions at any time using the Q&A panel

Chat with Presenter:

Question|

Send

# In Case of Technical Difficulties

- Delays in the broadcast audio
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    - Required conference ID: 6102000
- Submit a question using the chat box

# SERDP and ESTCP Overview

Timothy Tetreault  
Energy and Water Program  
Manager



# SERDP

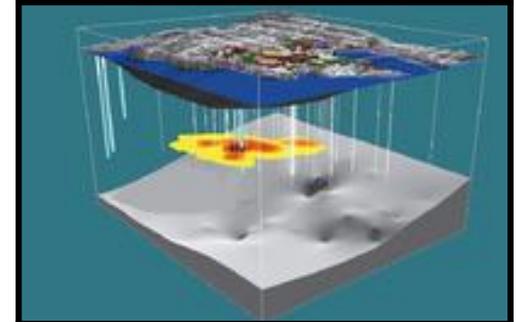
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

# ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

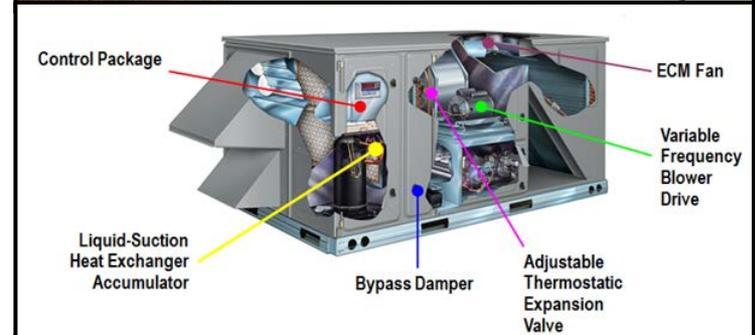
# Program Areas

1. Energy and Water
2. Environmental Restoration
3. Munitions Response
4. Resource Conservation and Resiliency
5. Weapons Systems and Platforms



# Energy and Water

- Smart and secure installation energy management
  - Microgrids
  - Energy storage
  - Ancillary service markets
- Efficient integrated buildings and components
  - Design, retrofit, operate
  - Enterprise optimized investment
  - Advanced components
  - Intelligent building management
  - Non-invasive energy audits
- Distributed generation
  - Cost effective
  - On-site
  - Emphasis on renewables



# SERDP and ESTCP Webinar Series

- Remaining 2017 webinar
  - December 7: Management of Novel Hawaiian Ecosystems
- Webinars will continue every two weeks in 2018
- For upcoming webinars, please visit <http://serdp-estcp.org/Tools-and-Training/Webinar-Series>

# SERDP • ESTCP SYMPOSIUM

2017 | Enhancing DoD's Mission Effectiveness

A three-day symposium showcasing the latest technologies that enhance DoD's mission through improved environmental and energy performance

- November 28 - November 30, 2017
- Washington Hilton Hotel  
1919 Connecticut Avenue, NW  
Washington, DC 20009
- ***Program agenda available online and registration is still open...***

## SonicLQ: The Sonic Leak Quantifier

Ralph T. Muehleisen, Ph.D.  
Argonne National Laboratory



# Agenda

- Project need
- DoD benefits
- Technology description and benefits
- ESTCP demonstration plan
- Conclusions

# DoD Need

- DoD has strict requirements for air leakage for new and existing buildings
- Existing methods of testing buildings (blower doors + infrared [IR] camera) have major limitations
  - Cannot be used during construction
  - Disruptive to operations
  - IR camera needs inside-outside  $\Delta T > 10$  °F
  - Cannot locate and size specific leaks
- SonicLQ can overcome these limitations and can provide more information for base managers to prioritize sealing of leaks

# DoD Energy Benefits



## ENERGY SAVINGS

- 4 TBtu and \$76M a year in energy savings
  - 10% energy savings from better sealing



- 2 year payback
  - \$10K cost, 10 extra retrofits per year, \$500 savings from each

# Additional DoD Benefits

- Sealing buildings better reduces CBR vulnerability and improves indoor air quality

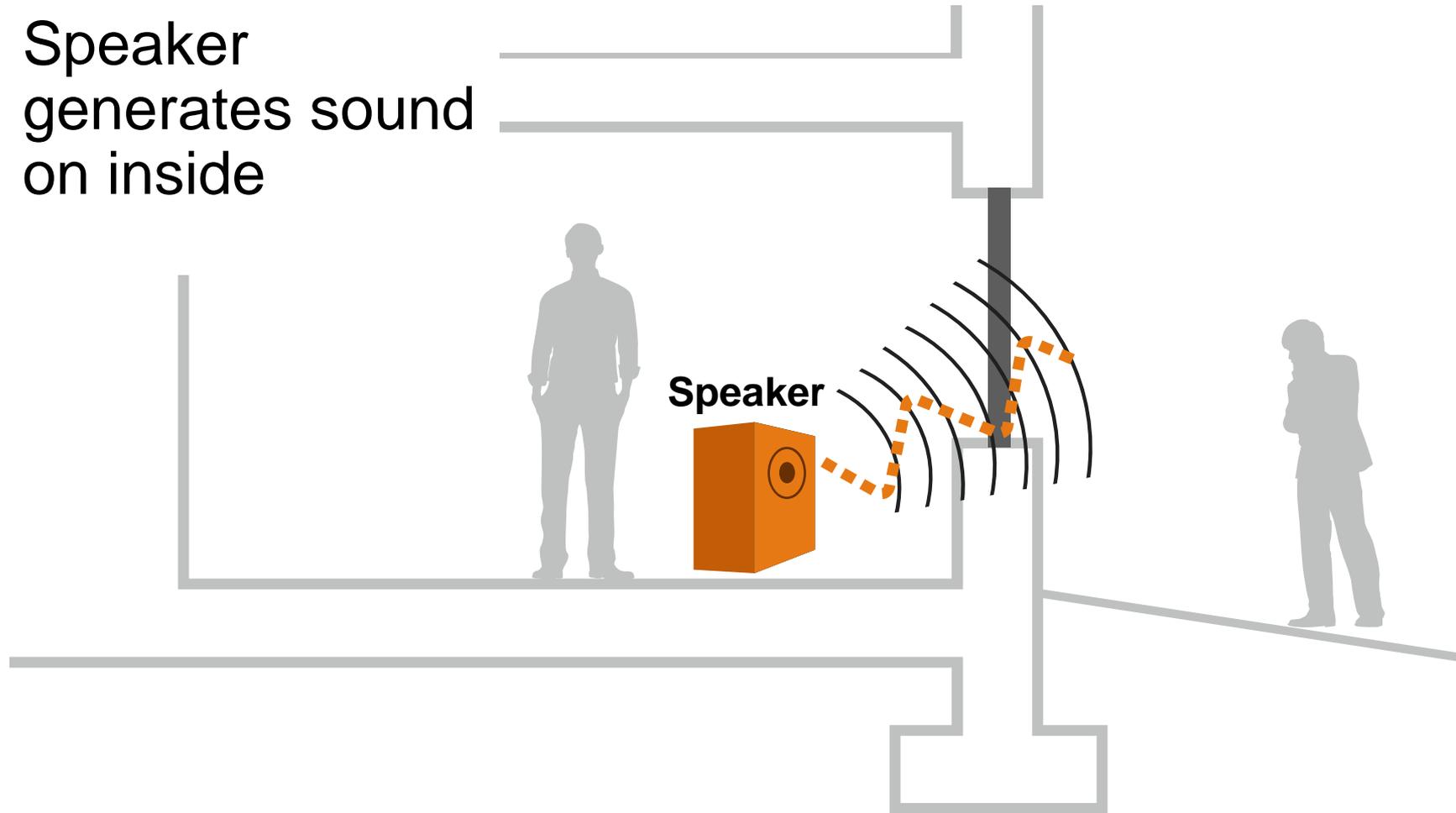


- Sealing buildings better reduces damage due to moisture accumulation



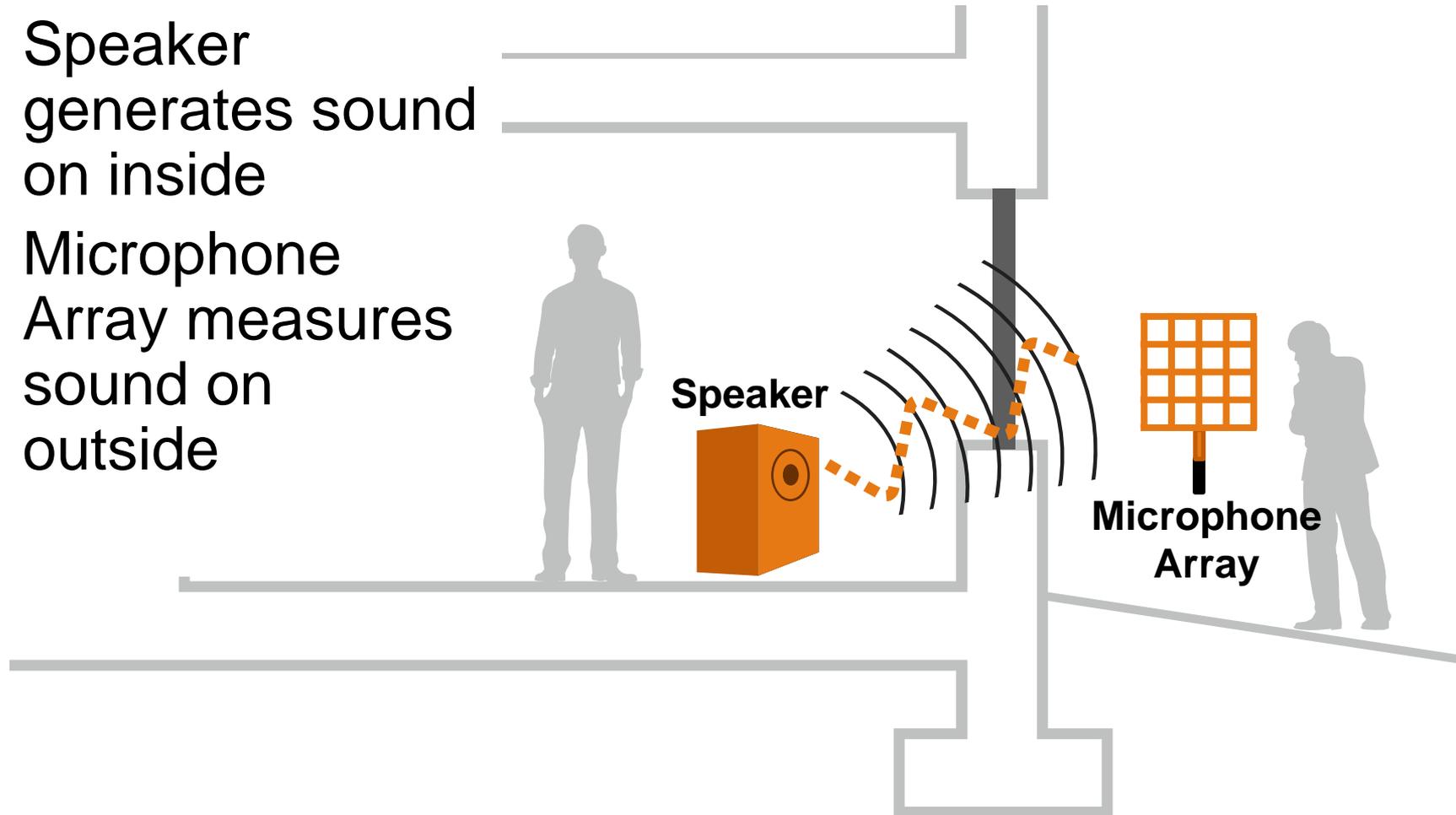
# The Technology: SonicLQ

1. Speaker generates sound on inside



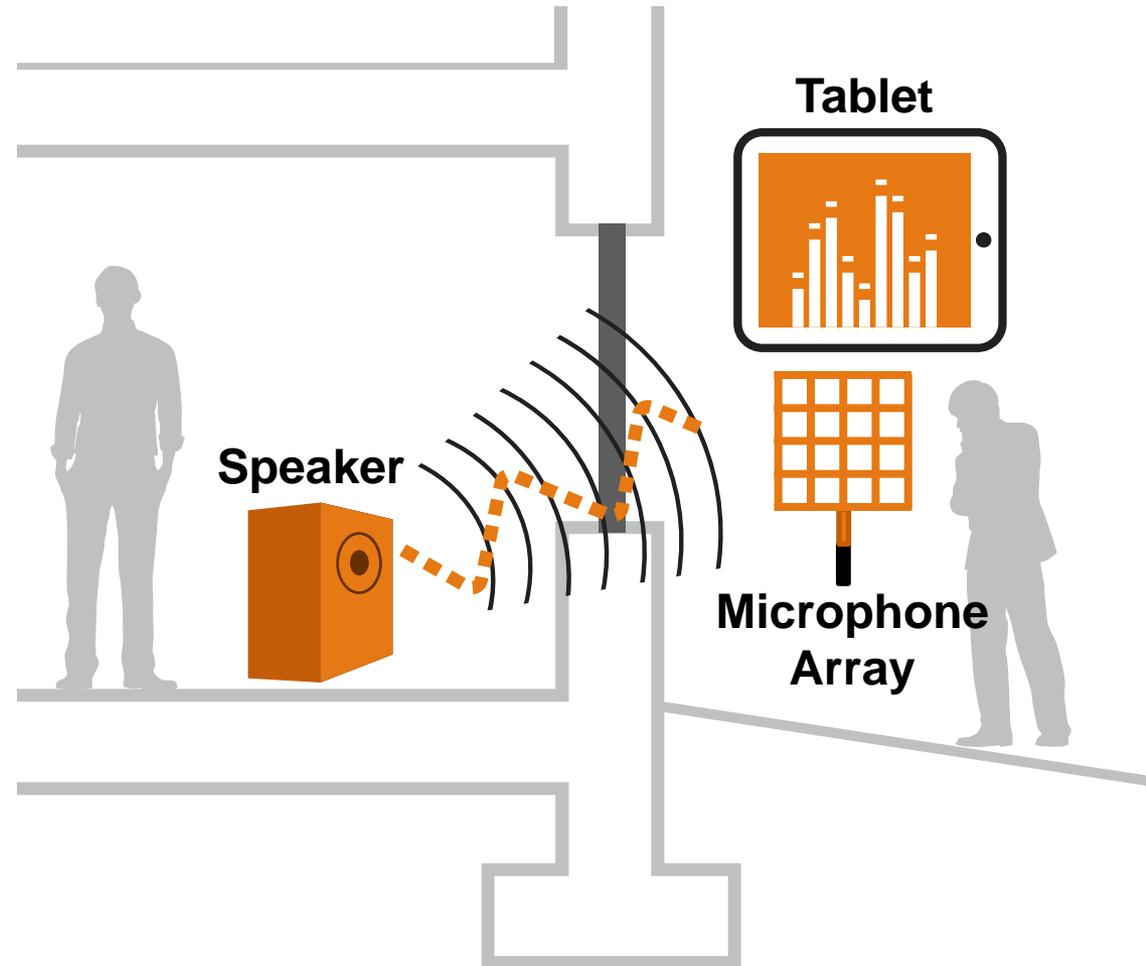
# The Technology: SonicLQ

1. Speaker generates sound on inside
2. Microphone Array measures sound on outside



# The Technology: SonicLQ

1. Speaker generates sound on inside
2. Microphone Array measures sound on outside
3. Tablet computes size and location of cracks



# SonicLQ Benefits

## *Acoustic Picture*



# SonicLQ Benefits

*Any Building Type*



Office



Barracks

# SonicLQ Benefits

*Any Phase*



Under Construction



Occupied

# SonicLQ Benefits

## *Any Season*



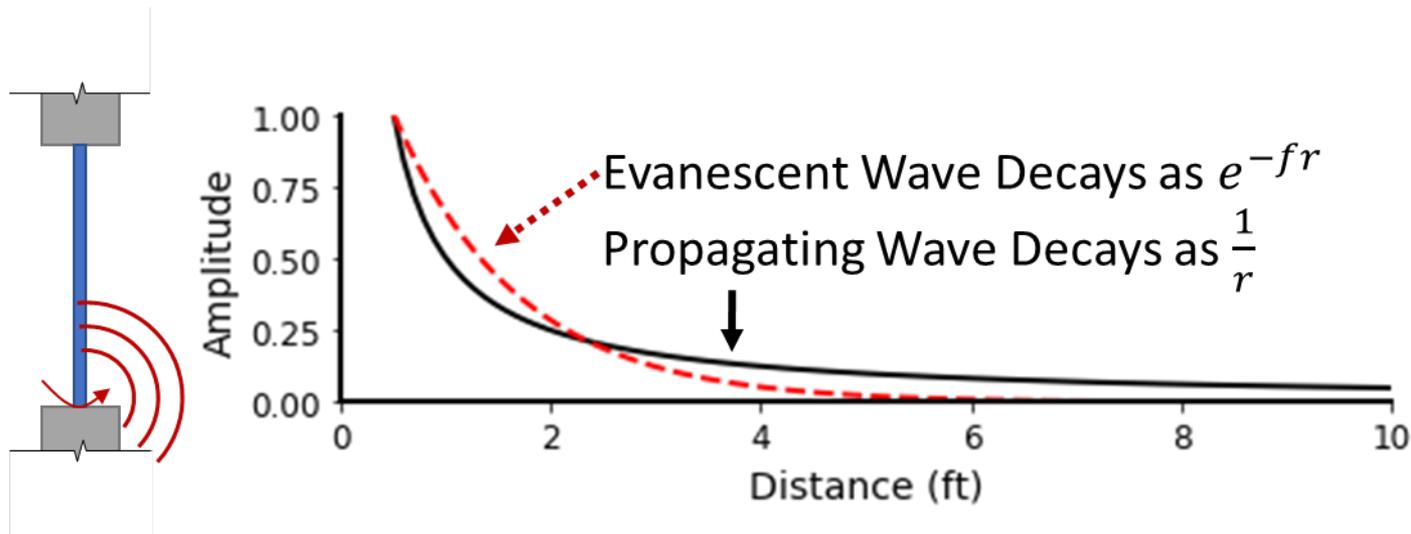
Summer



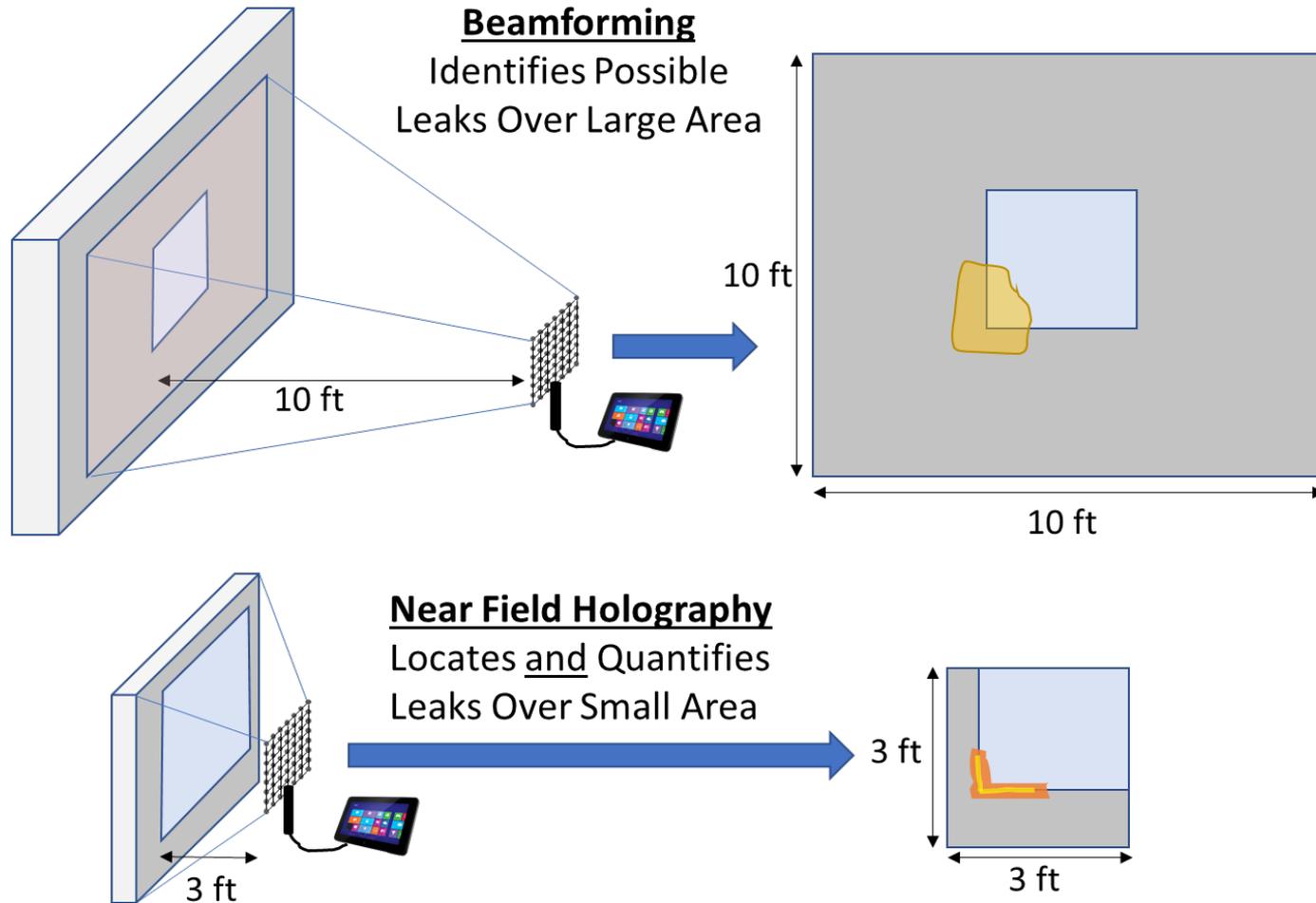
Winter

# Key: Nearfield Acoustic Holography

- Nearfield Acoustic Holography (NAH) measures both propagating and evanescent waves



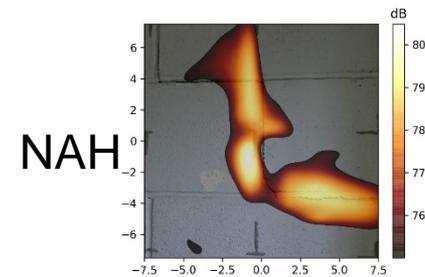
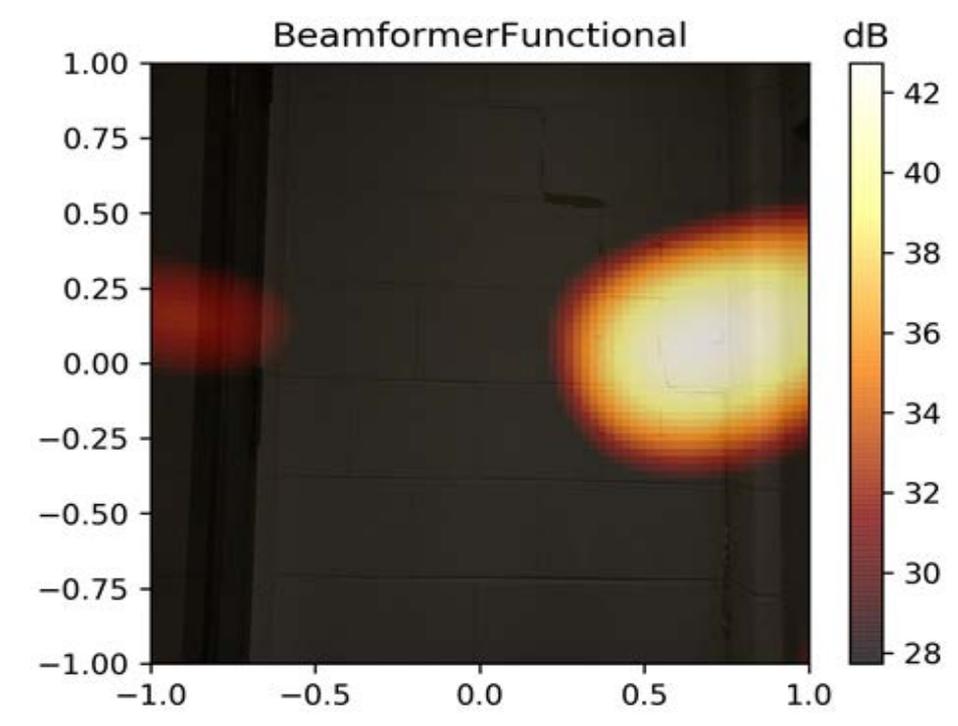
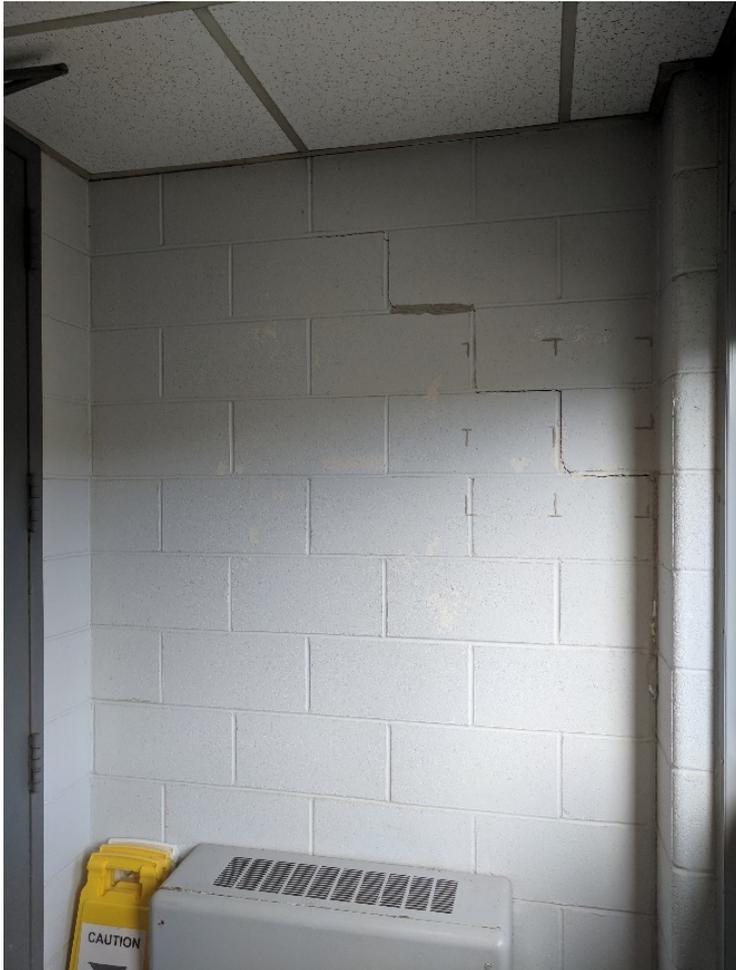
# SonicLQ Uses Both Beamforming and NAH



# SonicLQ Details

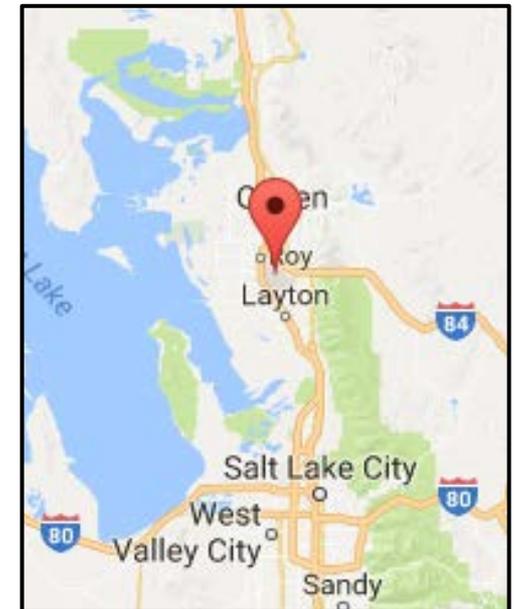
- Frequencies
  - NAH: 50-300 Hz
  - Beamforming: 1-5 kHz
- Sound Levels
  - Inside: 60-75 dBA
  - Outside: 40-70 dBA
- Microphone Array
  - Uses MEMS digital microphones with 24 bit converters
- Measurement Distance
  - NAH: 3 ft or less
  - Beamforming: 10-20 ft
- Measurement Area
  - NAH: up to 3x3 ft
  - Beamforming: up to 20x20 ft

# Field Validation



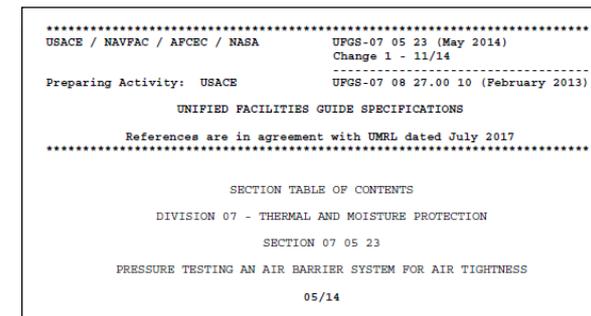
# Demonstration Project

- Compare SonicLQ to blower door + IR at Ft. Leavenworth and Hill AFB
  - Compare accuracy, time for testing, ease of use
  - Compute cost/benefit analysis compared to standard methods



# Project Deliverables

- Start of a new US Army Corp of Engineers (USACE) Air Leakage Testing Protocol
- Whole Building Design Guide (WBDG) entry
- New Unified Facilities Guide Specification (UFGS) for using SonicLQ
- Engineering Instructions (EI), Technical Instructions (TI), and Technical Manual (TM) as appropriate
- Case Studies for SonicLQ based on Site Testing



# DoD Benefits



## ENERGY SAVINGS

- 4 TBtu and \$76M a year in energy savings
  - 10% energy savings from better sealing



- 2 year payback
  - \$10K cost, 10 extra retrofits per year, \$500 savings from each

# Conclusions

- SonicLQ uses sound waves to measure building leakage
  - Locates and sizes individual leaks using NAH
  - Less intrusive than blower door + IR camera
- Testing will be done at Ft. Leavenworth and Hill AFB
  - Compare to blower door + IR Camera
- New testing standards will be developed
- Potential to save DoD upwards of \$70M/yr
  - ROI is under 2 years for cost recovery

# *SERDP & ESTCP Webinar Series*

For additional information, please visit

<https://www.serdp-estcp.org/Program-Areas/Energy-and-Water/Energy/Conservation-and-Efficiency/EW-201719>

## **Speaker Contact Information**

rmuehleisen@anl.gov; 630-252-2547



# Q&A Session 1



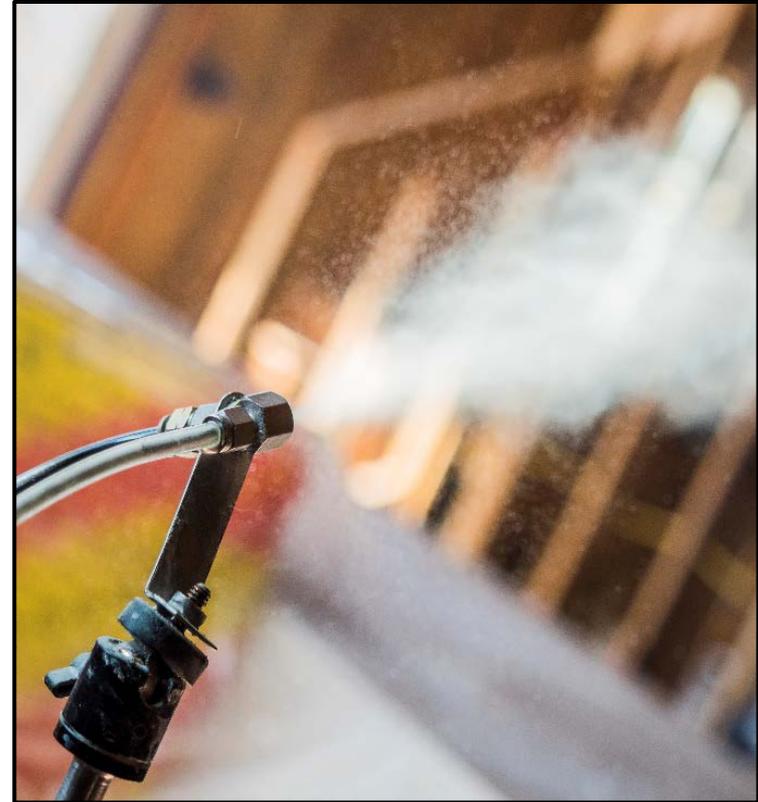
# Automated Aerosol-Sealing of Building Envelopes

Curtis Harrington  
University of California, Davis



# Agenda

- Project objectives
- Overview of technology
- Demonstration results
- Modeled energy savings
- Durability testing results



# Benefits of Air Sealing

- Large fraction of energy use for heating and cooling
  - 48% in residential
  - 35% in commercial
- Reducing leakage could reduce HVAC energy use by 30%
- USACE tightness standards were recently introduced
- Cost-effective approaches to seal would improve adherence

# Test Design and Objectives

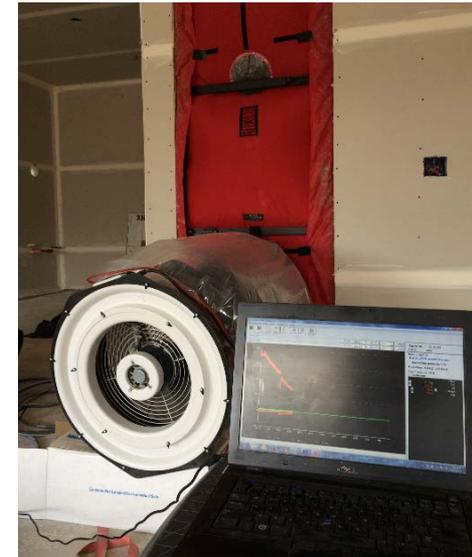
- Demonstrate new technology for automating sealing process
- Measure baseline and post-retrofit air leakage
  - Real-time tracking of leakage during sealing
- Technical objectives for project
  - Determine feasibility
  - Develop application protocols for larger buildings
  - Model expected energy savings
  - Measure seal durability



*Seal formed around plumbing penetration*

# Technology/Methodology Description

- “Blower Door” maintains positive pressure difference
- Aerosolized sealant particles injected into space
- Particles carried to leaks by escaping air flow
- Sealing process is tracked in real time
- Documented electronically
- Finds and seals leaks typically missed or inaccessible



*Blower door setup for pressurization*



*Seal formed between gap in foam*

# Demonstrations

Site Location	Number of Demos	Building Type	Building Description
Fort Bragg	3	Non Residential	Barracks, Temp Building
Quantico	5	Non Residential	Elementary School
Quantico	1	Non Residential	Office
Mechanicsburg	1	Non Residential	Industrial building
Mechanicsburg	2	Non Residential	Officer's Club
Mechanicsburg	5	Multifamily	Apartments
Mechanicsburg	1	Section of large warehouse	Office/Storage

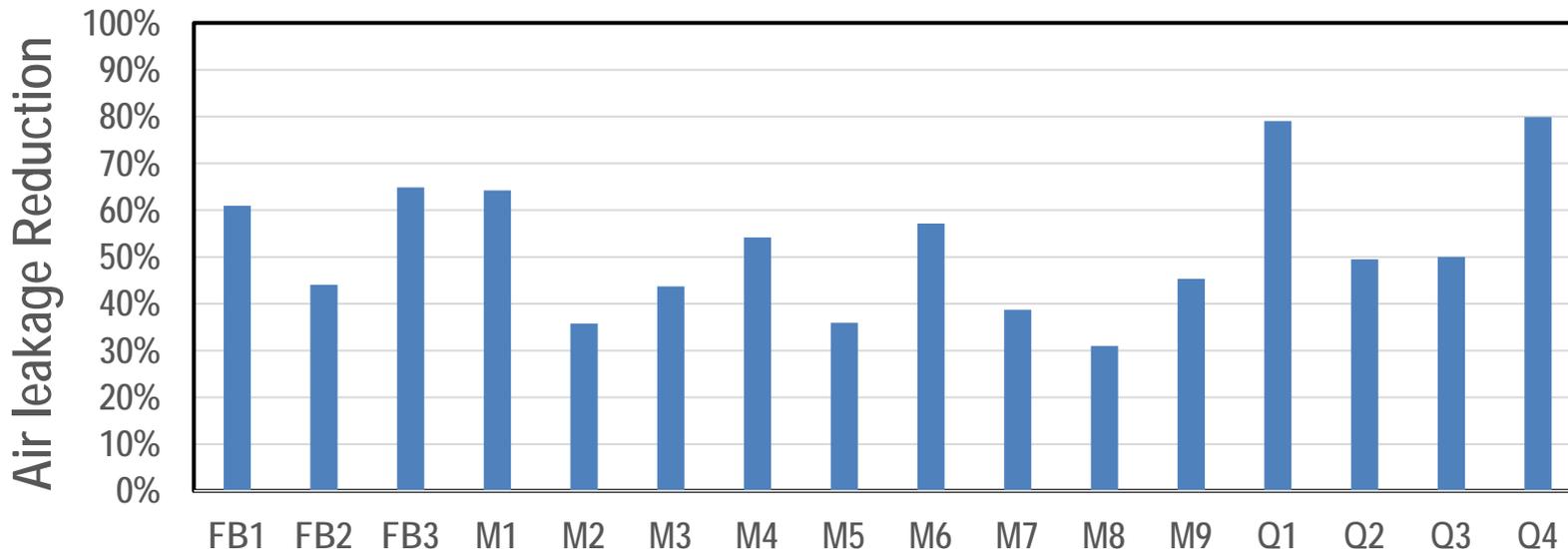
# Demonstrations

- Sealed 15 small spaces (<3,000 ft<sup>2</sup>)
- Sealed three medium spaces (>3,000 ft<sup>2</sup>)
- Largest building sealed was 22,000 ft<sup>2</sup>
- Over 75,000 CFM75 sealed



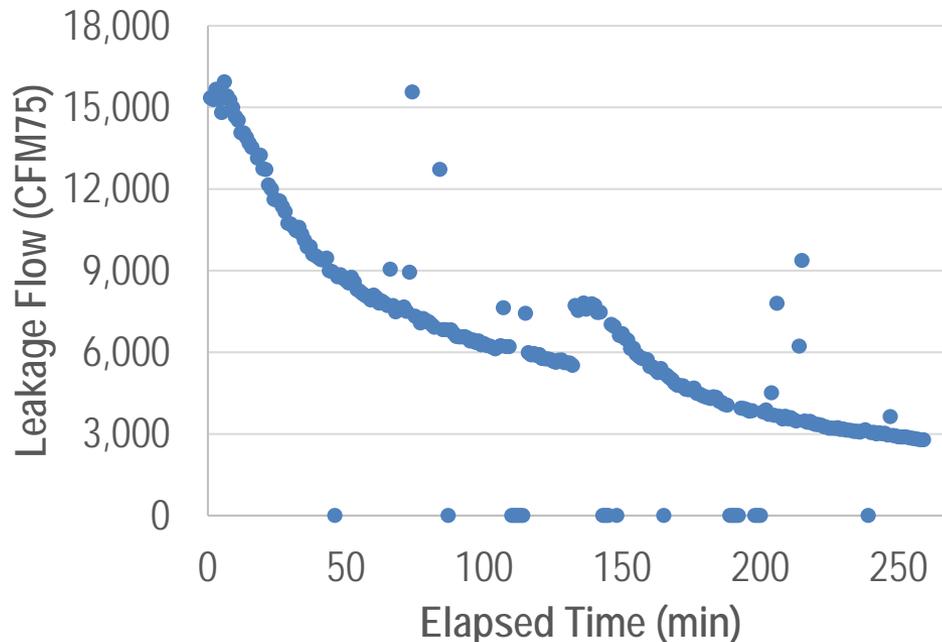
# Demonstrations

- Average leakage reduced by half
- Up to 80% reduction in leakage
- Three buildings brought within USACE specifications
- Many buildings in poor condition



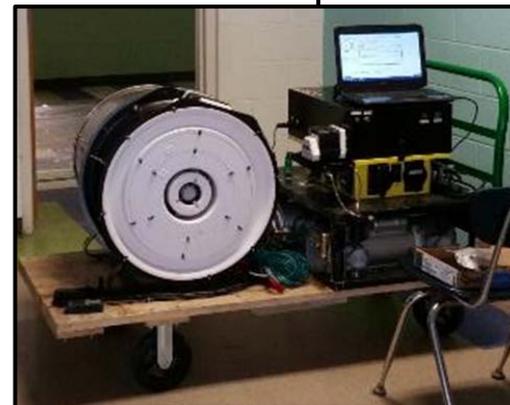
# Mechanicsburg Industrial Facility

- 8,400 ft<sup>2</sup> building
- Two sealing events
- 65% sealed of total leakage after ~4 h of injection
- Sealed 82% of sealable leakage (leakage after prep)
- Brought to within USACE spec (0.672 to 0.241 CFM75/ft<sup>2</sup>)



# Quantico Ashurst Elementary

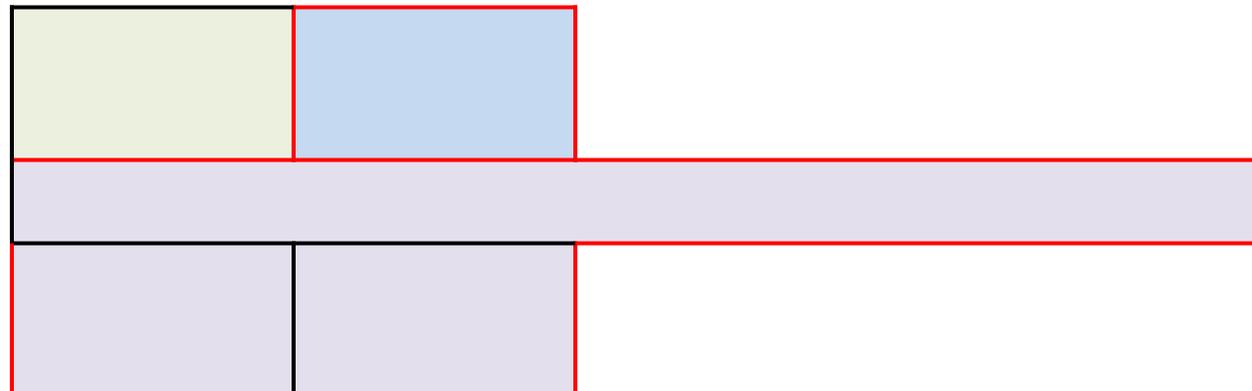
- ~6,000 ft<sup>2</sup>
- Four classrooms and hallway sealed
- Large gaps discovered during initial demo
- Manual sealing of large gaps prior to aerosol sealing was necessary



# Quantico Ashurst Elementary

Leakage [cfm@75 Pa]

		Start	Finish	Sealed
7/19	Manual sealing and mobilization			
7/20	Perimeter previously sealed manually	6130	1286	4844
7/21	Inside perimeter sealed manually (injection stopped - compressor failure)	8093	7321	772
8/29	Manual sealing and mobilization			
8/30	Inside perimeter previously sealed manually (injection stopped - hour of the day)	8109	4086	4023
8/31	machine and building prep for next day			
9/1	Sealing with two machines and 4 fans (Aeroseal software on both)	11566	5783	5783
			TOTAL	15422



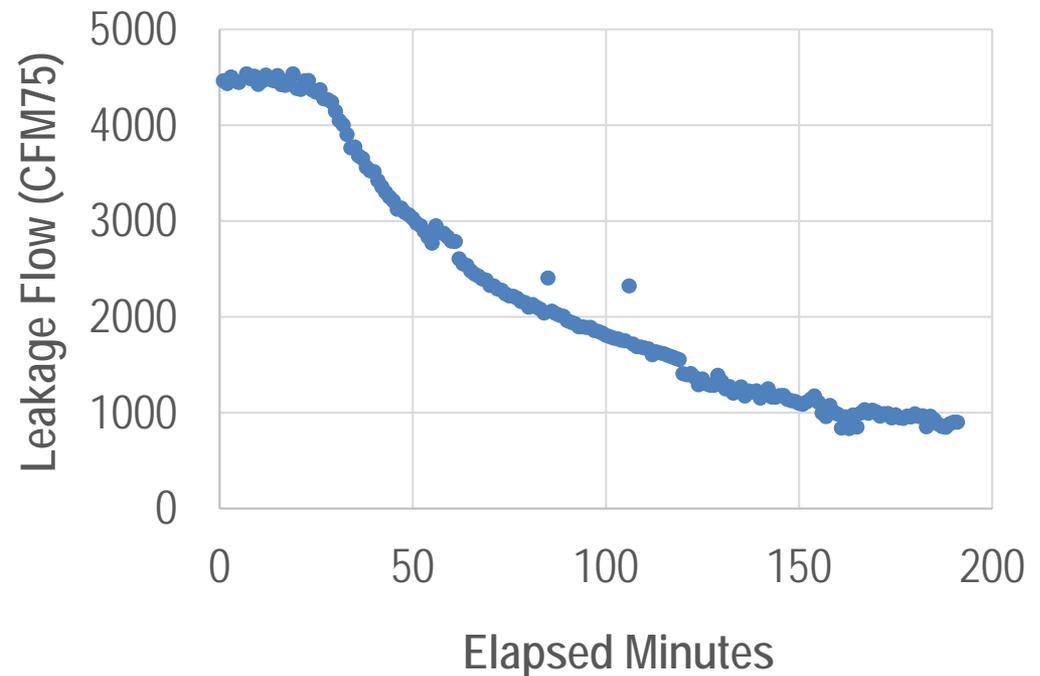
# Quantico Office Building

- 3,000 ft<sup>2</sup>
- During tenant change
  - Horizontal surfaces needed to be protected
  - 16 person-hours to prepare building



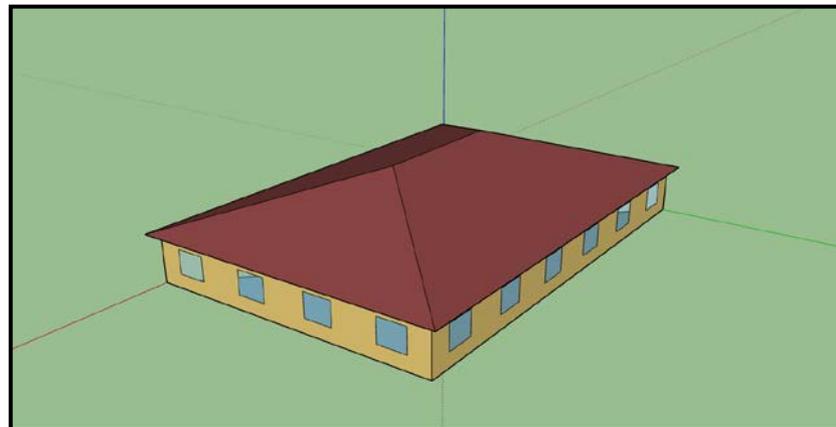
# Quantico Office Building

- Sealed 80% of the building leakage
- Brought to within USACE spec (0.493 to 0.158 CFM75/ft<sup>2</sup>)
- Three hours of injection
- Building operator seeking LEED credits



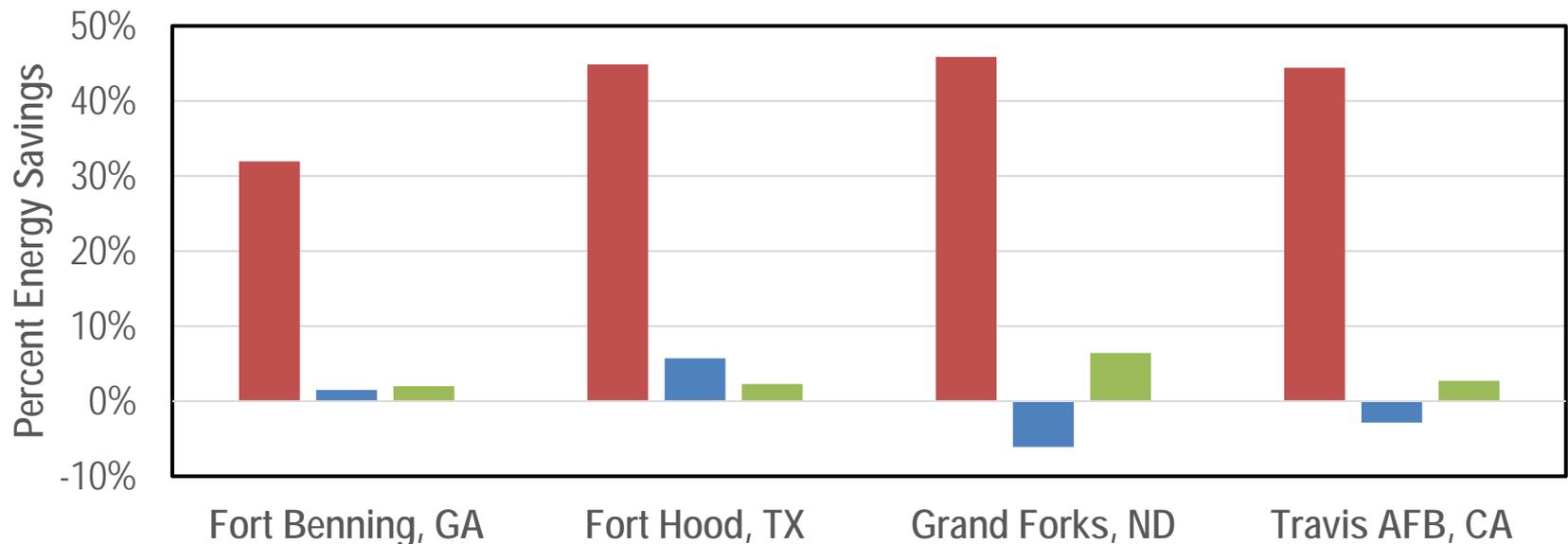
# Performance Modeling

- Modified DOE reference models in EnergyPlus
- Infiltration modeled based on PNNL infiltration guidelines and ASHRAE 62.1 ventilation guidelines
- Variables investigated
  - Climate Zone – simulated 4 climate zones (CA, GA, ND, TX)
  - Leakage – simulated two leakage levels (baseline and USACE)



# Performance Modeling Results

- Pre-1980 5,500 ft<sup>2</sup> Office Building
- Does not include additional outside air for pressurization
  - More air for pressurization than required for ventilation
  - Tightening shell from baseline to USACE levels eliminates this load



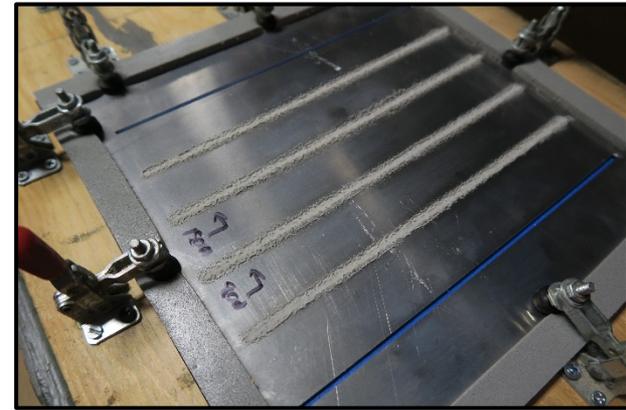
# Durability Test Protocol

- Seals created in lab under different application temperatures and %RH
- Performed four tests on seals
  - “Accelerated” Pressure Loading: 1000 pressure cycles between 0-800 Pa
  - “Hurricane Test”: 1500 Pa maintained for one hour
  - Temperature Cycling: 1000 temperature cycles between 80oF and 120oF at constant 800 Pa

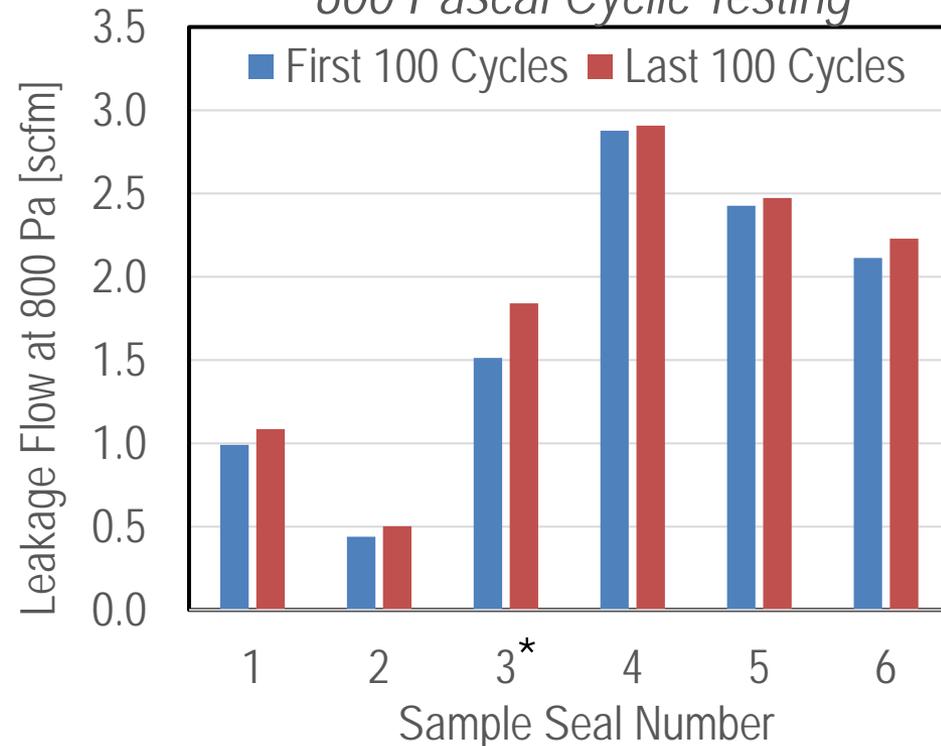


# Durability Test Results

- “Accelerated” Pressure Loading
  - No significant change in seal tightness
  - Change in leakage was gradual
  - Did not establish final leakage plateau
  - Simulated seal failure showed an abrupt change



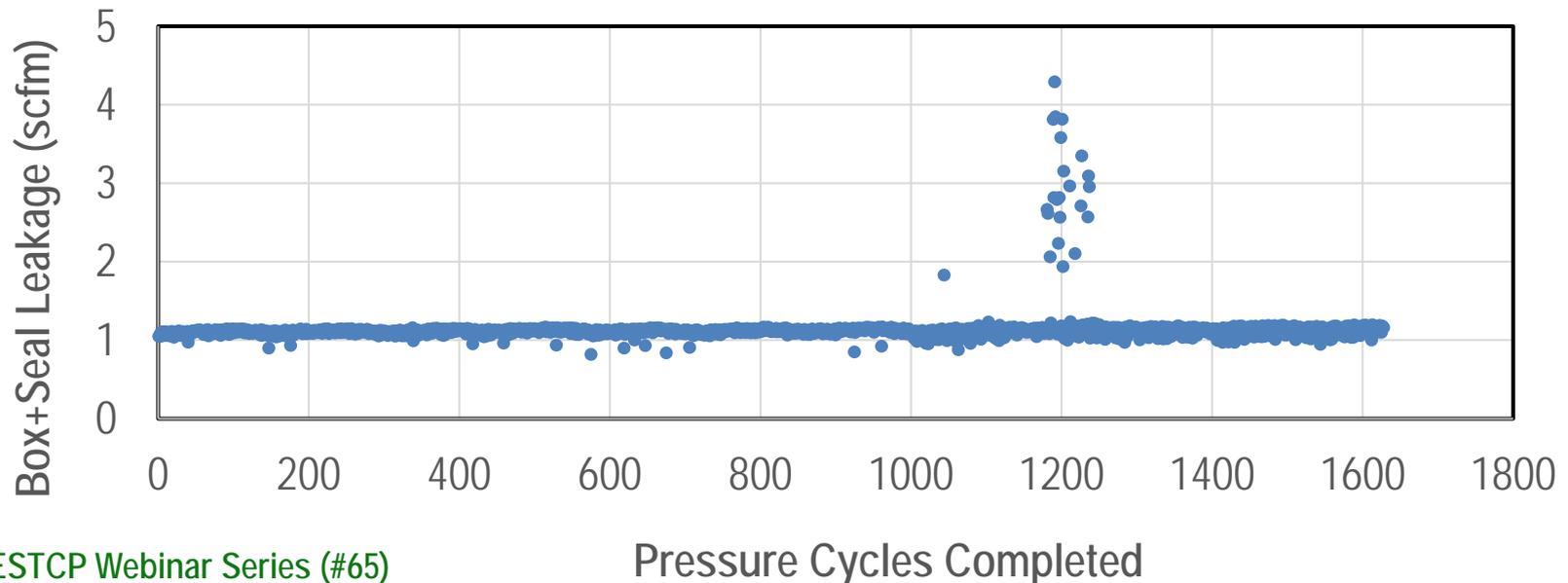
*800 Pascal Cyclic Testing*



\* Control system malfunction caused over-pressurization (~4,000 Pa)

# Durability Test Results

- Additional cycling tests performed at lower pressure
  - 100 Pa cycling for more realistic building pressures
  - >1,600 cycles completed
  - Observed no significant drift in leakage rates



# Conclusions

- Aerosol sealing is an effective method for sealing buildings
- Appears to be most appropriate during tenant change
- USACE tightness level can minimize infiltration and reduce operational costs
- Seals can withstand pressures beyond what a building would experience

# *SERDP & ESTCP Webinar Series*

For additional information, please visit  
<https://www.serdp-estcp.org/Program-Areas/Energy-and-Water/Energy/Conservation-and-Efficiency/EW-201511>

## **Speaker Contact Information**

csharrington@ucdavis.edu; 530-754-7670



## Q&A Session 2



The next webinar is on  
December 7, 2017

*Management of Novel Hawaiian  
Ecosystems*



## Survey Reminder

*Please take a moment to complete the survey that will pop up on your screen when the webinar ends*

