IBACOS®

| i n n o v a t i o n |

Evaluating Small-Diameter Ductwork in High-Performance Homes

Pennsylvania Housing Research Center

Residential Building Design & Construction Conference

March 2016

Andrew Poerschke

Agenda

Townhouse Small-Diameter Case Study

- Overview
- Comfort
- System Run

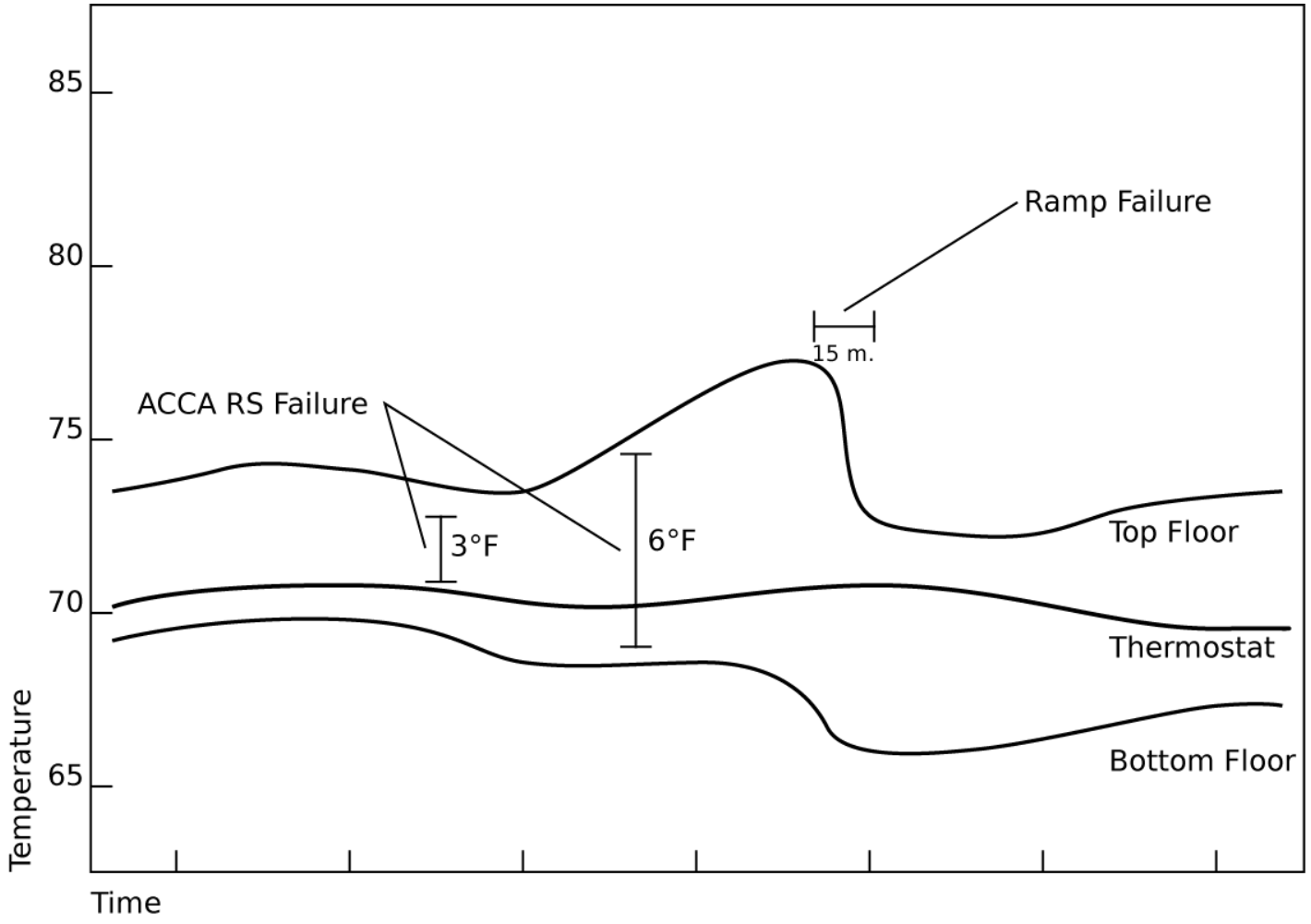
Home-Run Manifold System

- Design Approach
- Lab Results
- Field Results

How We Think About Comfort

ACCA Manual RS

ASHRAE Standard 55



IBACOS
innovation

Case Study

NEW TOWN BUILDERS

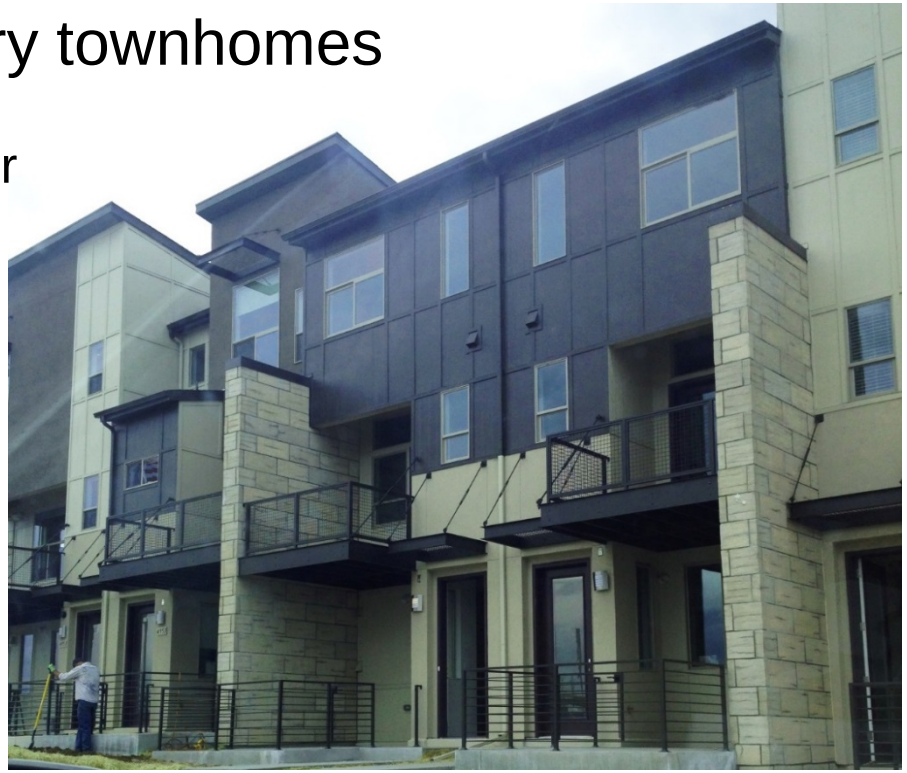
thrive HOME BUILDERS

Walls – R-23
Ceiling – R-38
Ducts – R-4
Slab Edge – R-10
Exposed Floor – R-50

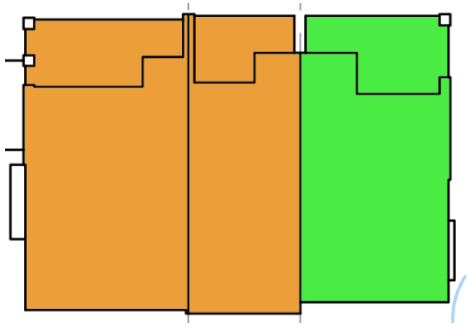
Ductwork in conditioned space

Denver, CO homebuilder:
Testing a small-diameter duct system for 3-story townhomes

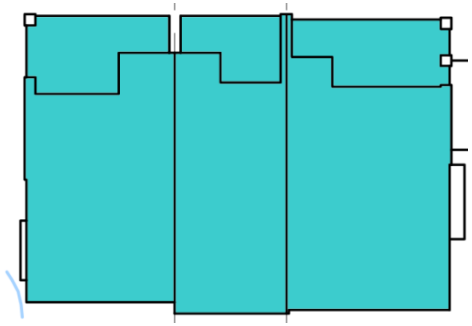
- Reduce floor-to-floor stratification
- Improve comfort
- Improve energy efficiency
- Ductwork in conditioned space



Experiment



Control

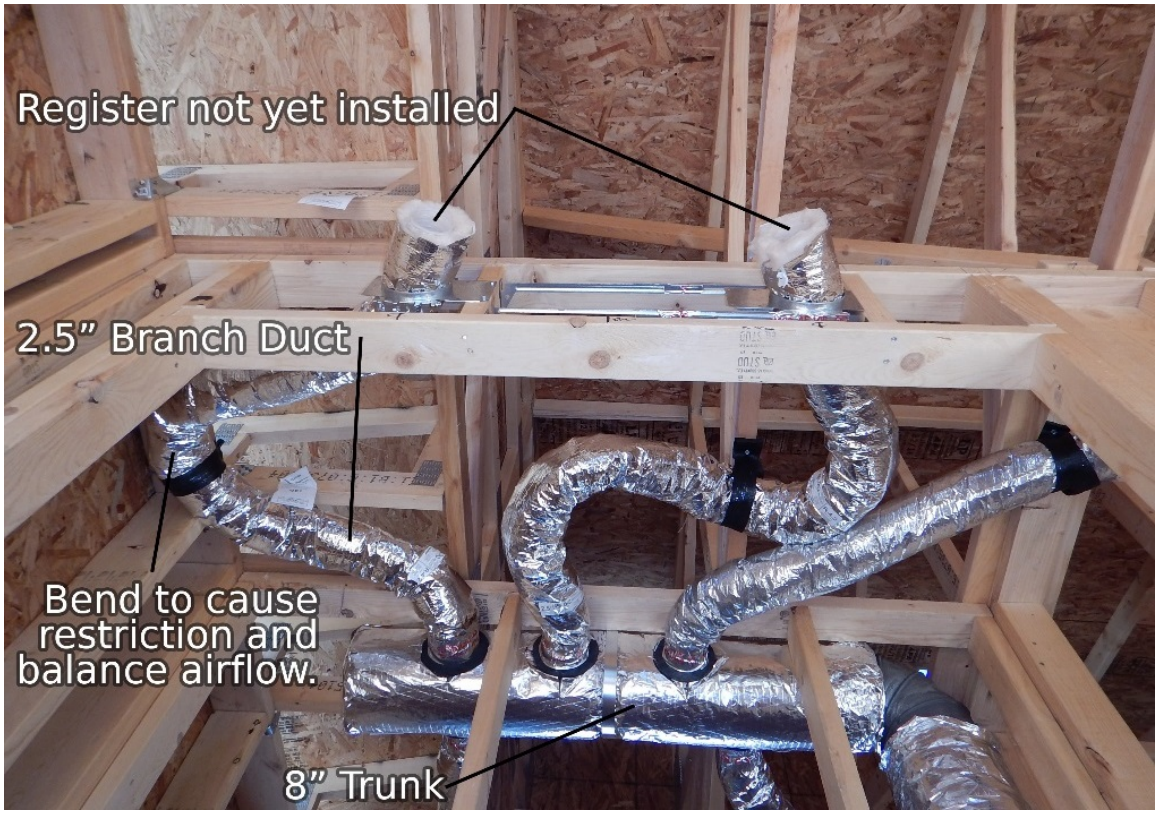


	A1	A2	A3	B1	B2	B3
Design Cooling Load (kBtu/h)	**16**	**13**	**18**	**16**	**13**	**18**
Air Conditioner Rated Capacity (kBtu/h)	**24**	**24**	**36**	**24**	**18**	**24**
Outdoor Unit Model	IS24G065	IS24G065	IS36G110	CA13NA24	CA13NA18	CA13NA24
Air Handling Unit Model	M2430BL1-EA2	M2430BL1-EA2	IS12MPA	59SC2C040S17	59SC2C040S17	59SC2C040S17
Ductwork Location	Conditioned space	Conditioned space	Conditioned space	Conditioned space	Conditioned space	Conditioned space
Air Handling Unit Location	Second floor	Second floor	High wall fan coil	First floor	First floor	First floor
Building Measured Air Leakage (ACH 50)	2.97	3.49	3.98	2.15	2.73	3.18
Ductwork Measured Air Leakage (CFM @ 25 Pa)	54	47	N/A	5	5	-
Floor Area	**1,300 ft^2**	**1,100 ft^2**	**1,600 ft^2**	**1,300 ft^2**	**1,100 ft^2**	**1,600 ft^2**

Small-Diameter Duct System

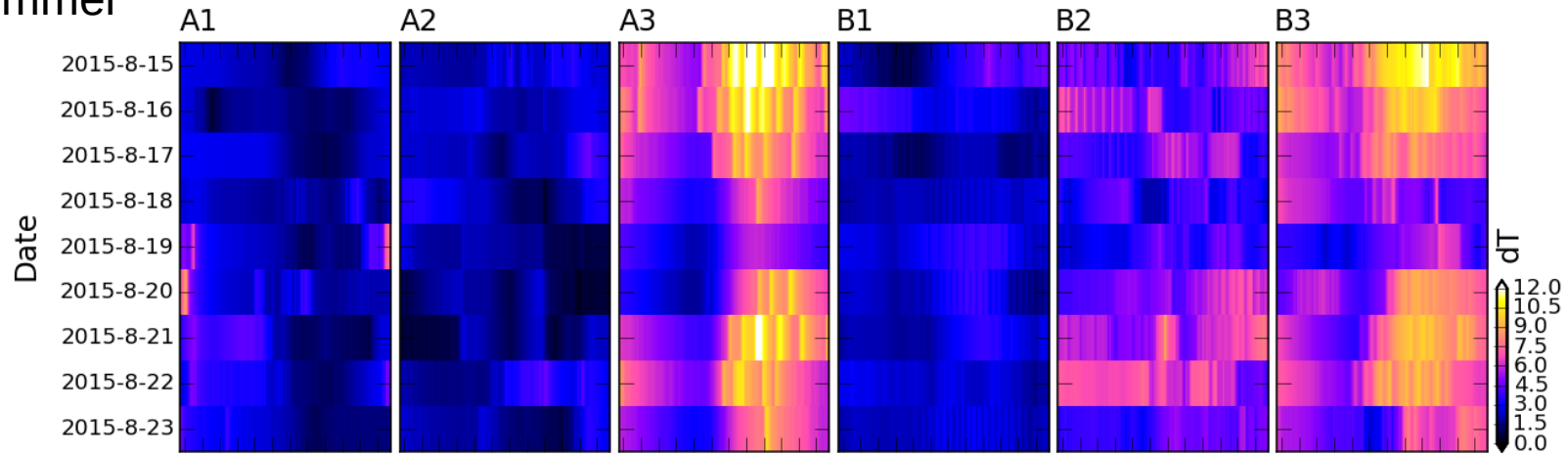
Small-Diameter Duct System

Small Bulkhead

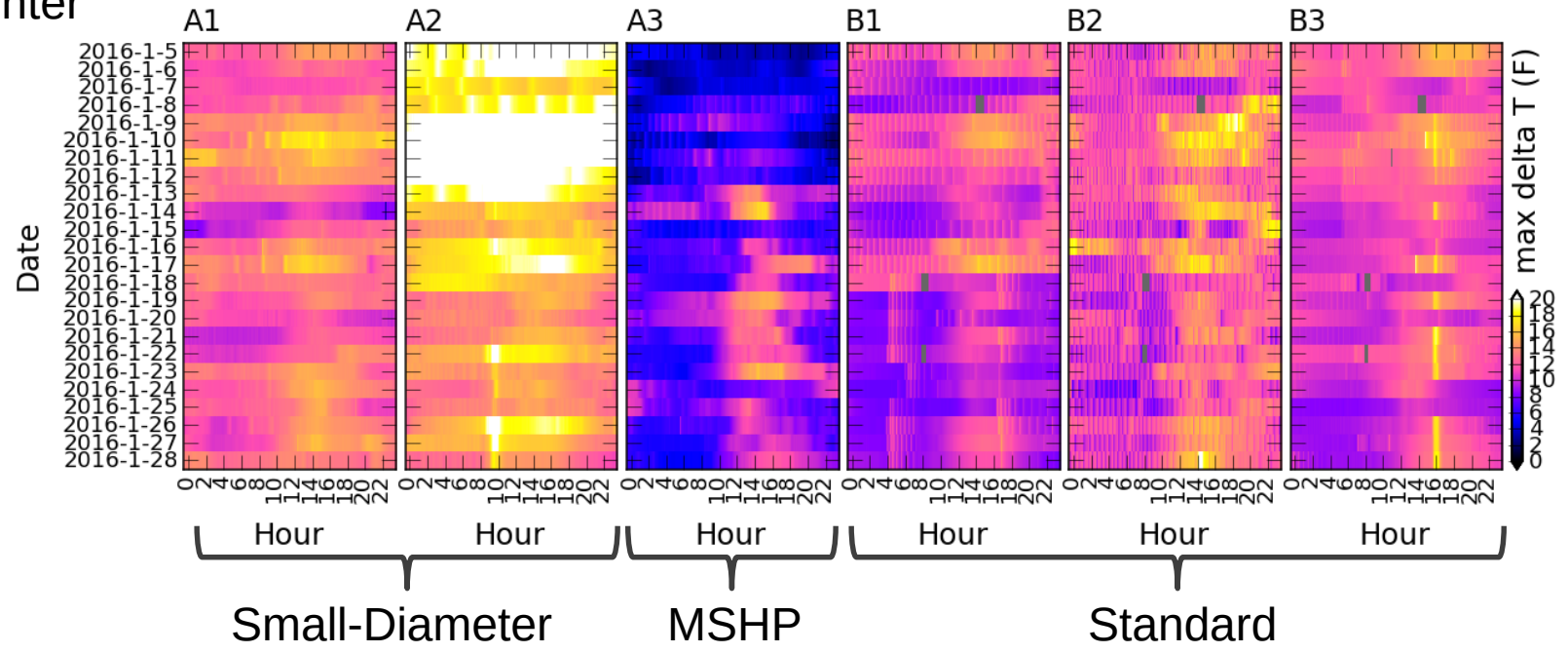


Room-to-Room Uniformity

Summer

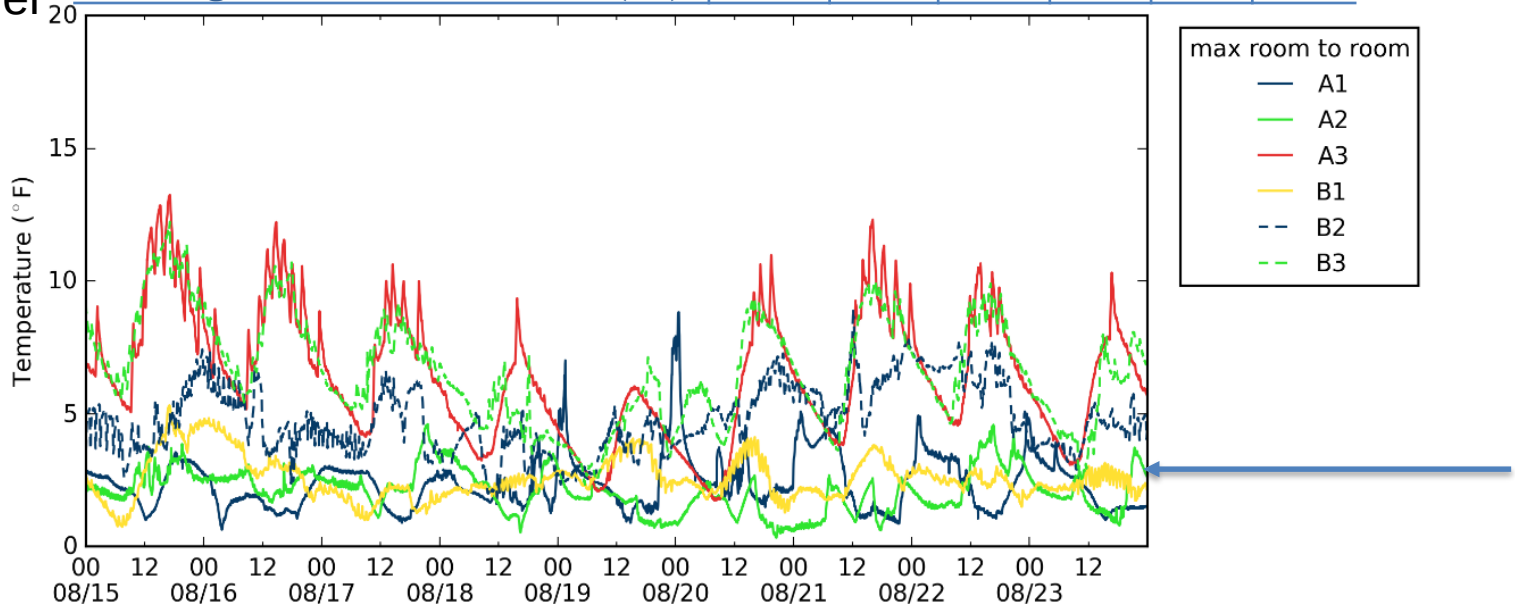


Winter

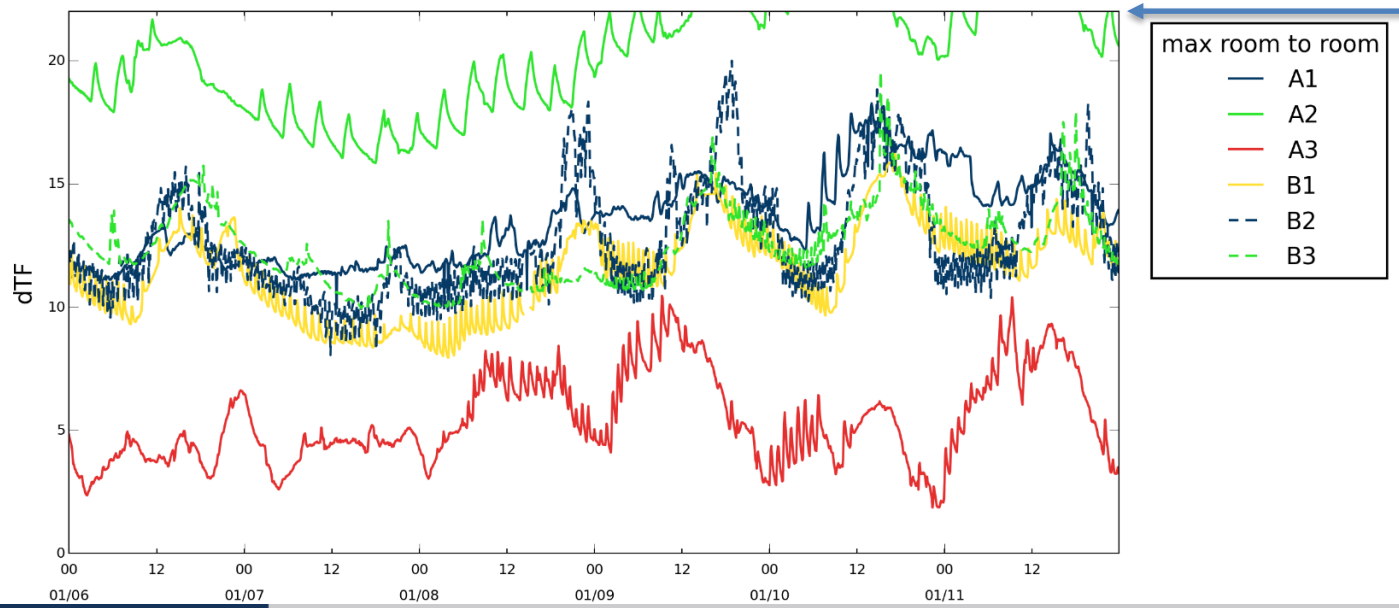


	A1	A2	A3	B1	B2	B3
Average Room-to-Room ΔT (°F)	2.4	2.1	6.4	2.6	4.8	6.6

Summer

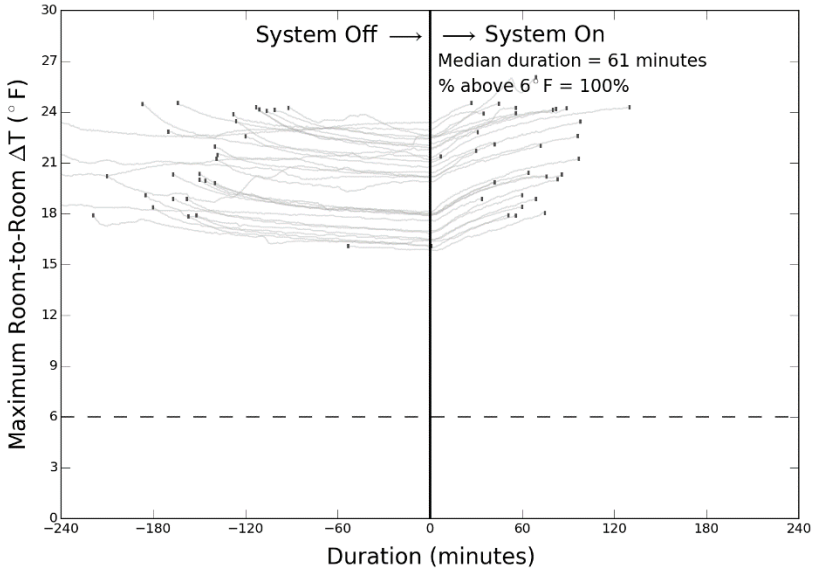


Winter

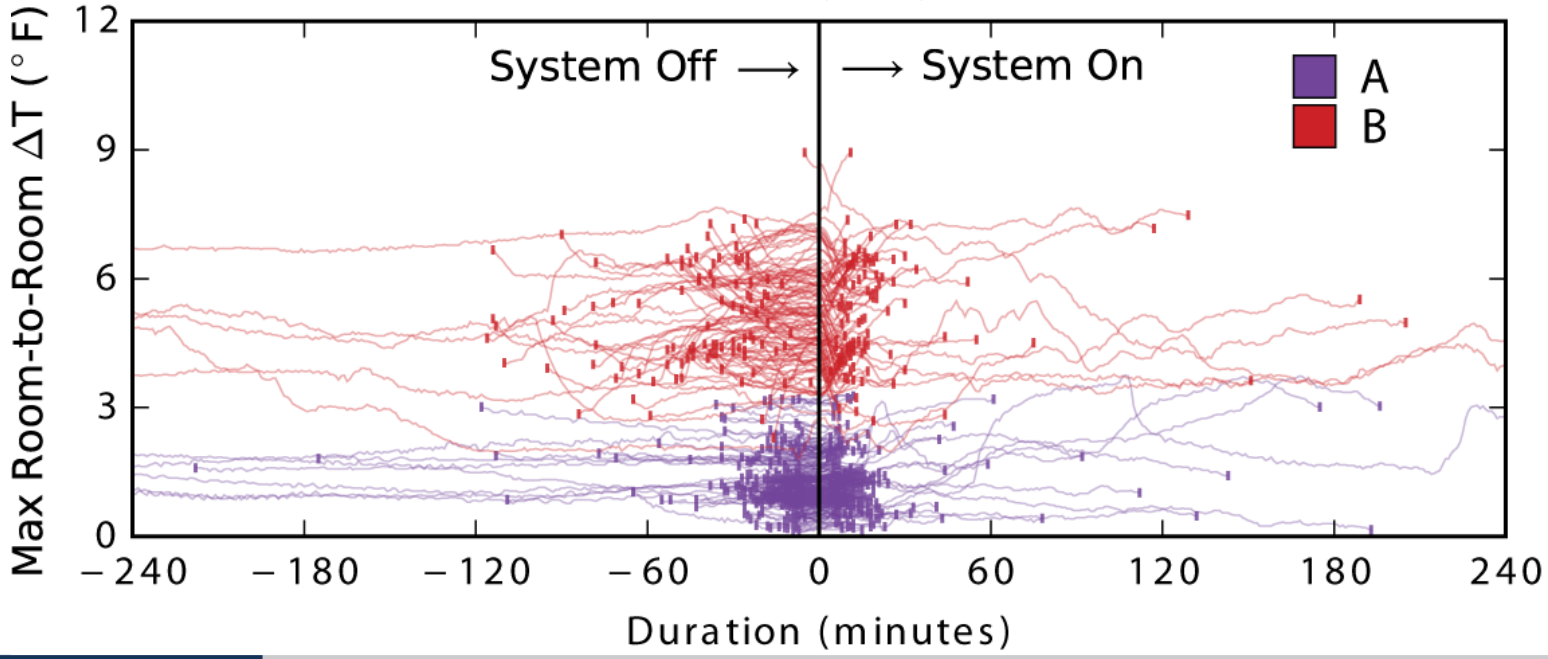


System Runtime

Summer

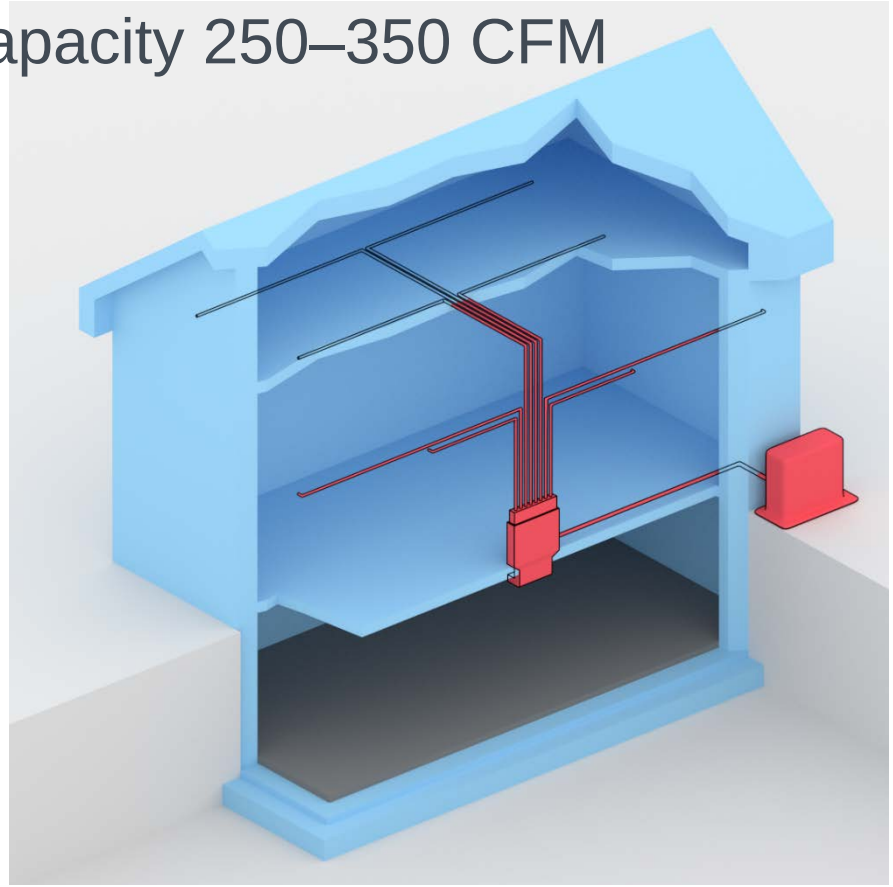


Winter



Plug-n-Play Duct System

- Home-run duct design method
- Each runout ~20 CFM
- Total system capacity 250–350 CFM

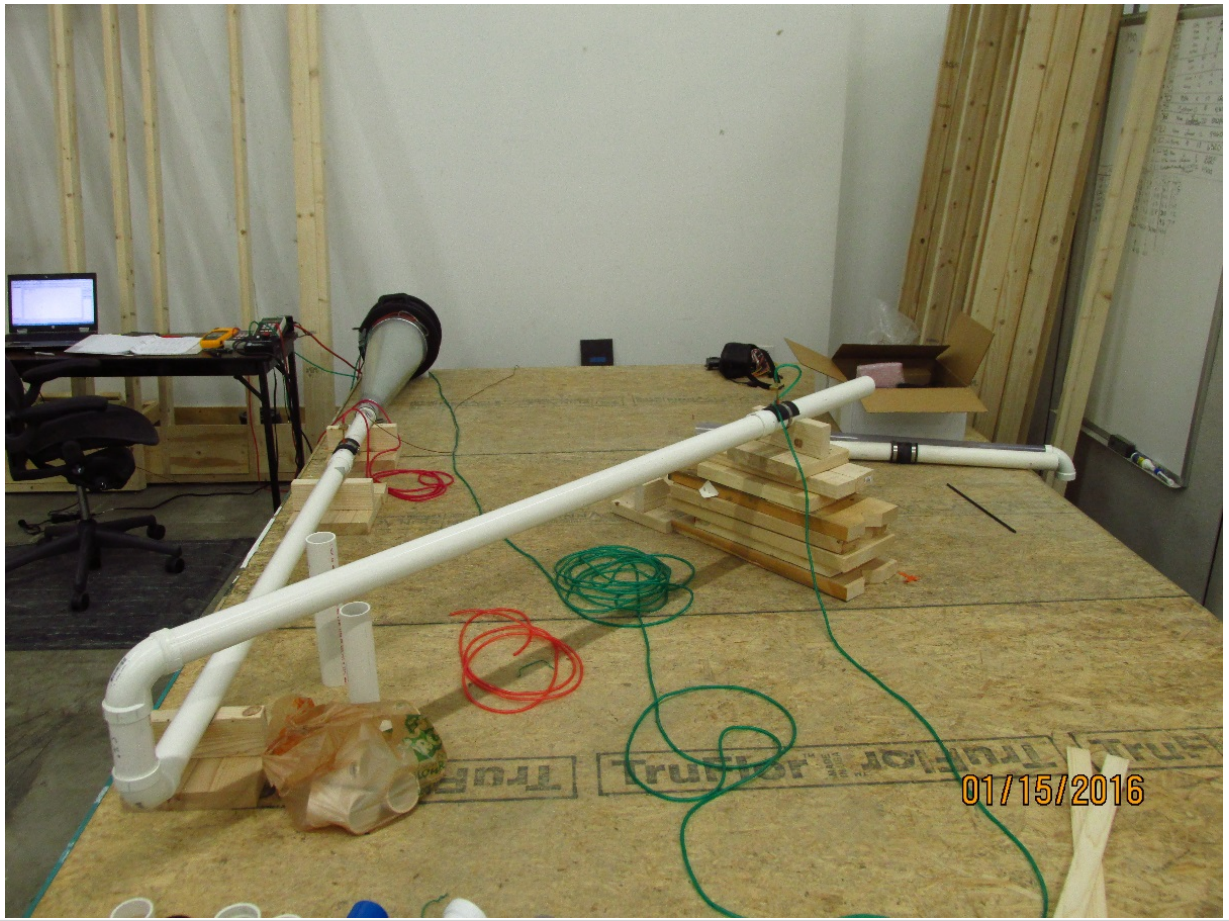


Lab Data

Verify predictability of airflow

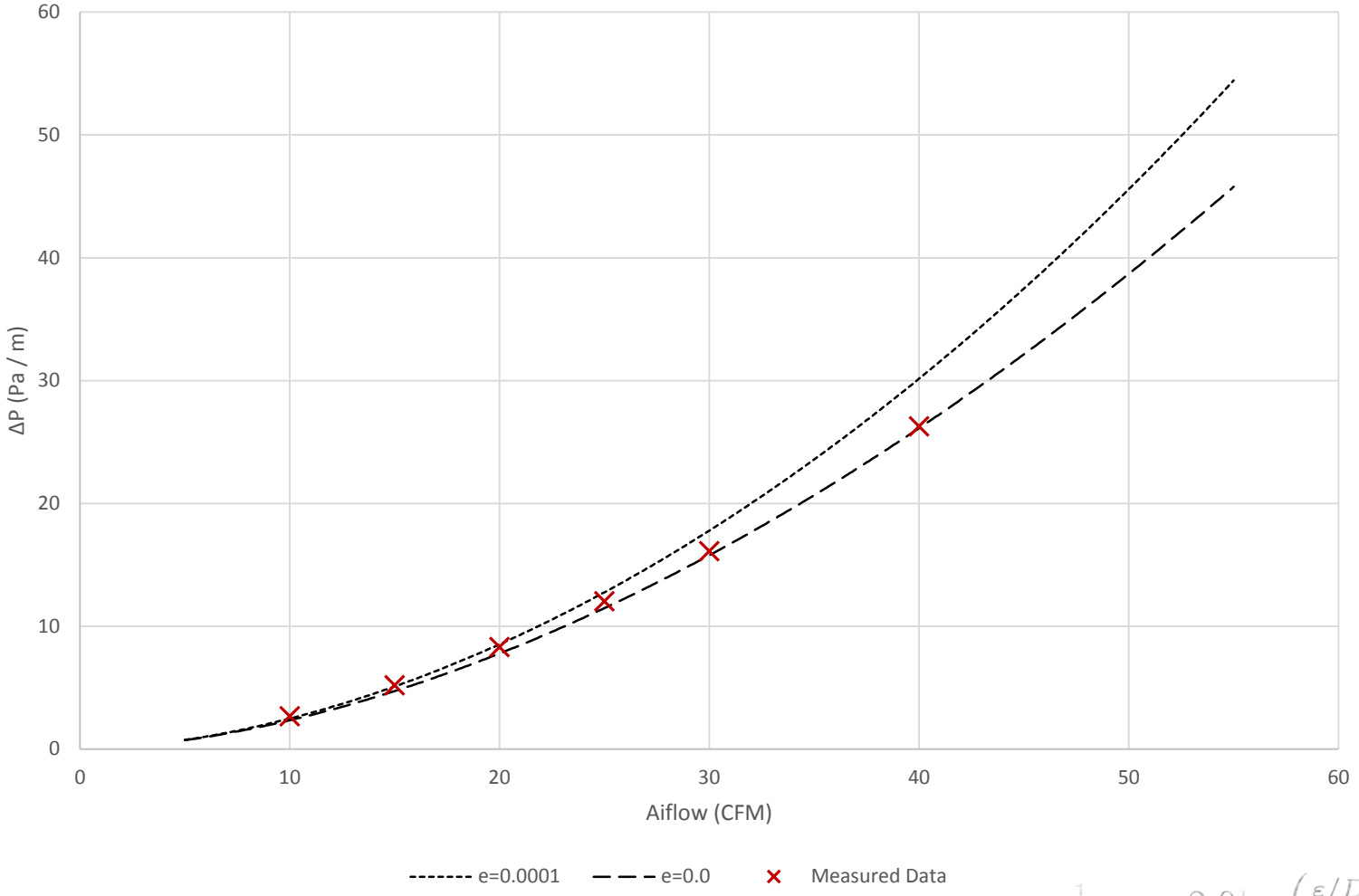
Input curves for simulations

Straight Duct
Single Elbow
Two Elbows



Lab Data

Darcy–Weisbach vs. Measurements



$$Re = \frac{\rho * V * D}{\mu}$$

$$\Delta p = f \frac{\ell}{D} \frac{\rho V^2}{2}$$

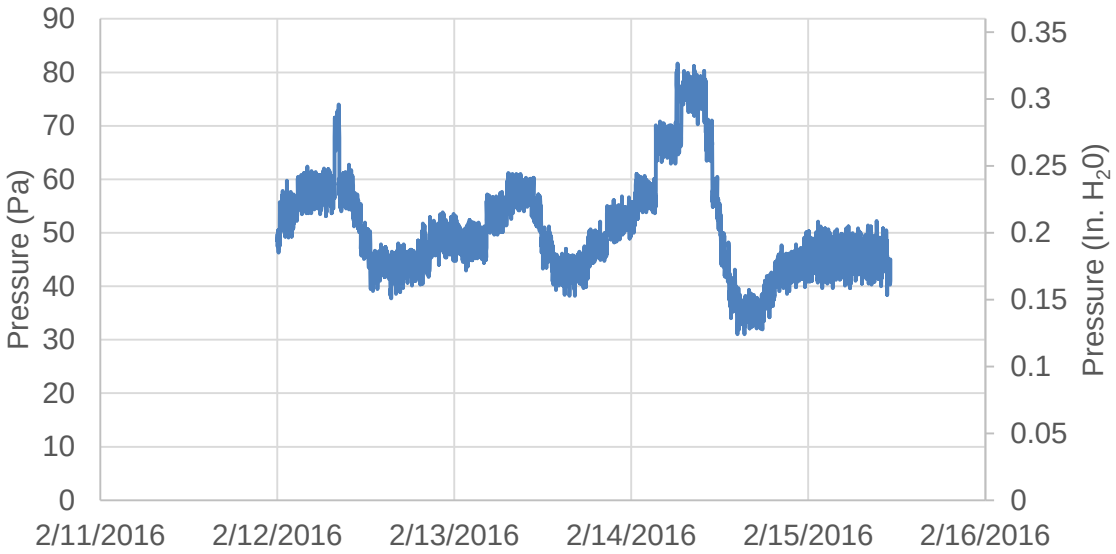
$$\frac{1}{\sqrt{f}} = -2.0 log\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{Re\sqrt{f}}\right)$$

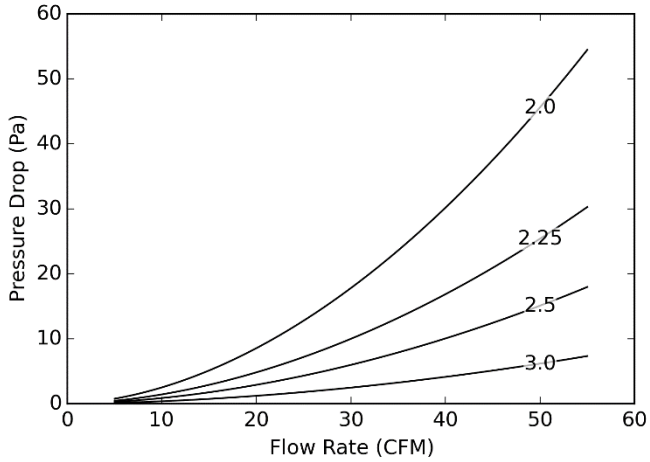
Field Data

Walls – R40
Attic – R60
Slab – R10

0.7 ACH50

Plenum Static Pressure



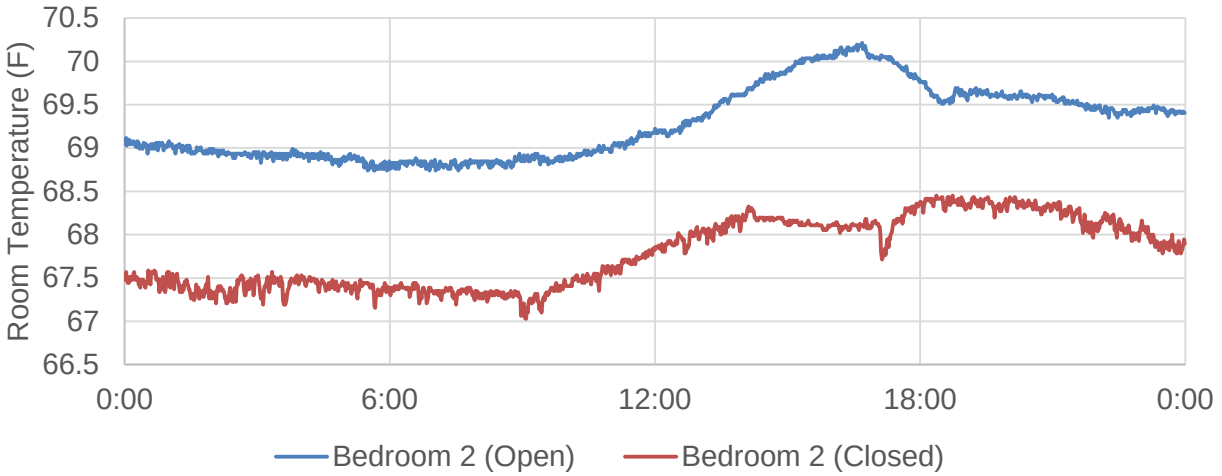


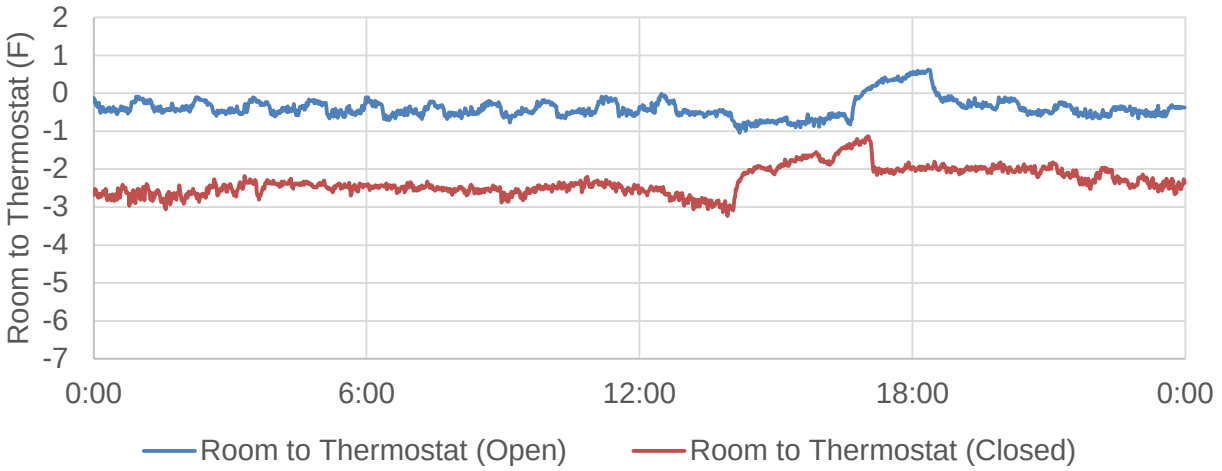
$$\Delta p = f \frac{\ell \rho (Q)^2}{4\pi^2 \boldsymbol{r^5}}$$

25 Pa = 0.1 in. H20

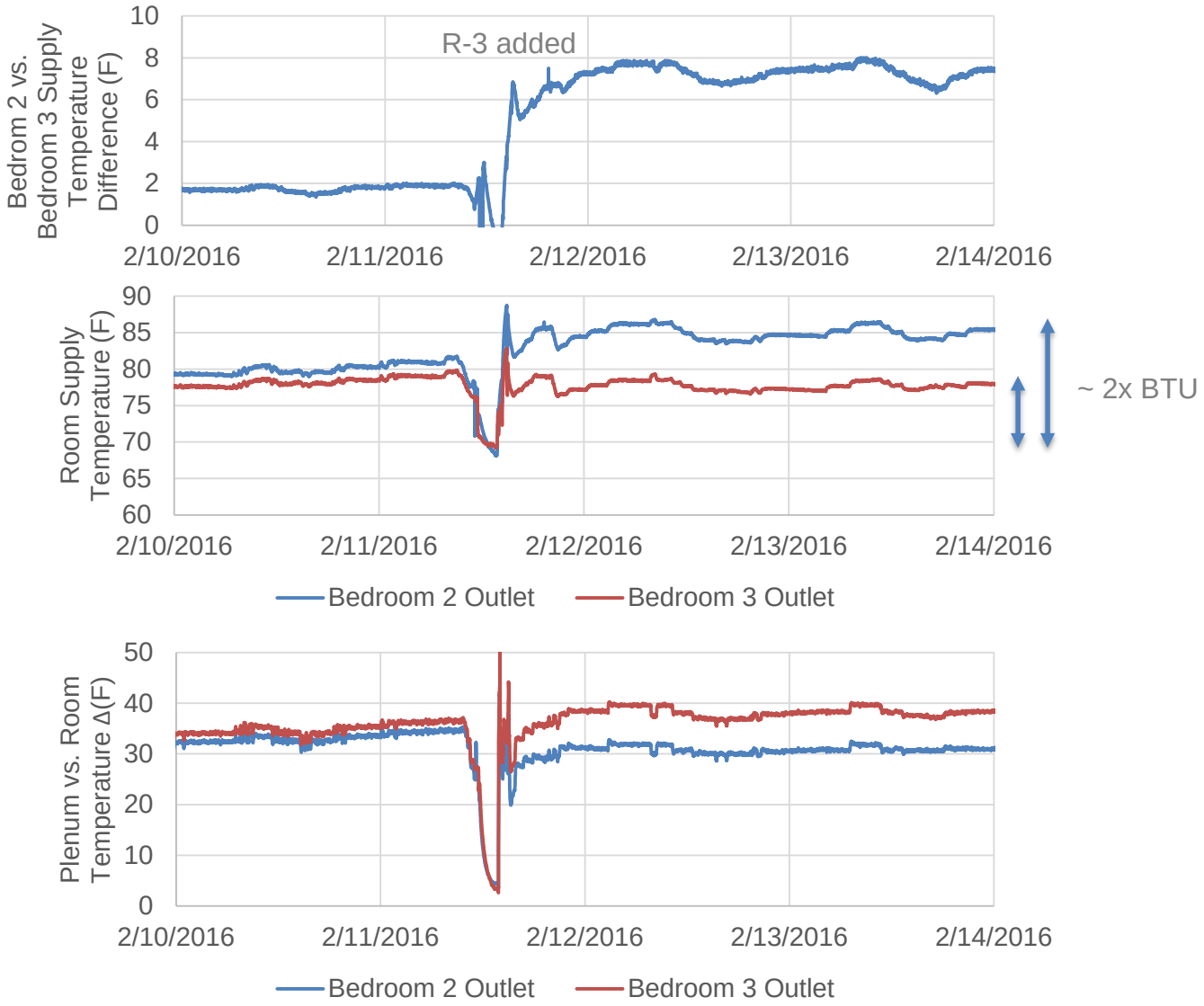
IBACOS
innovation

Bedroom Temperature

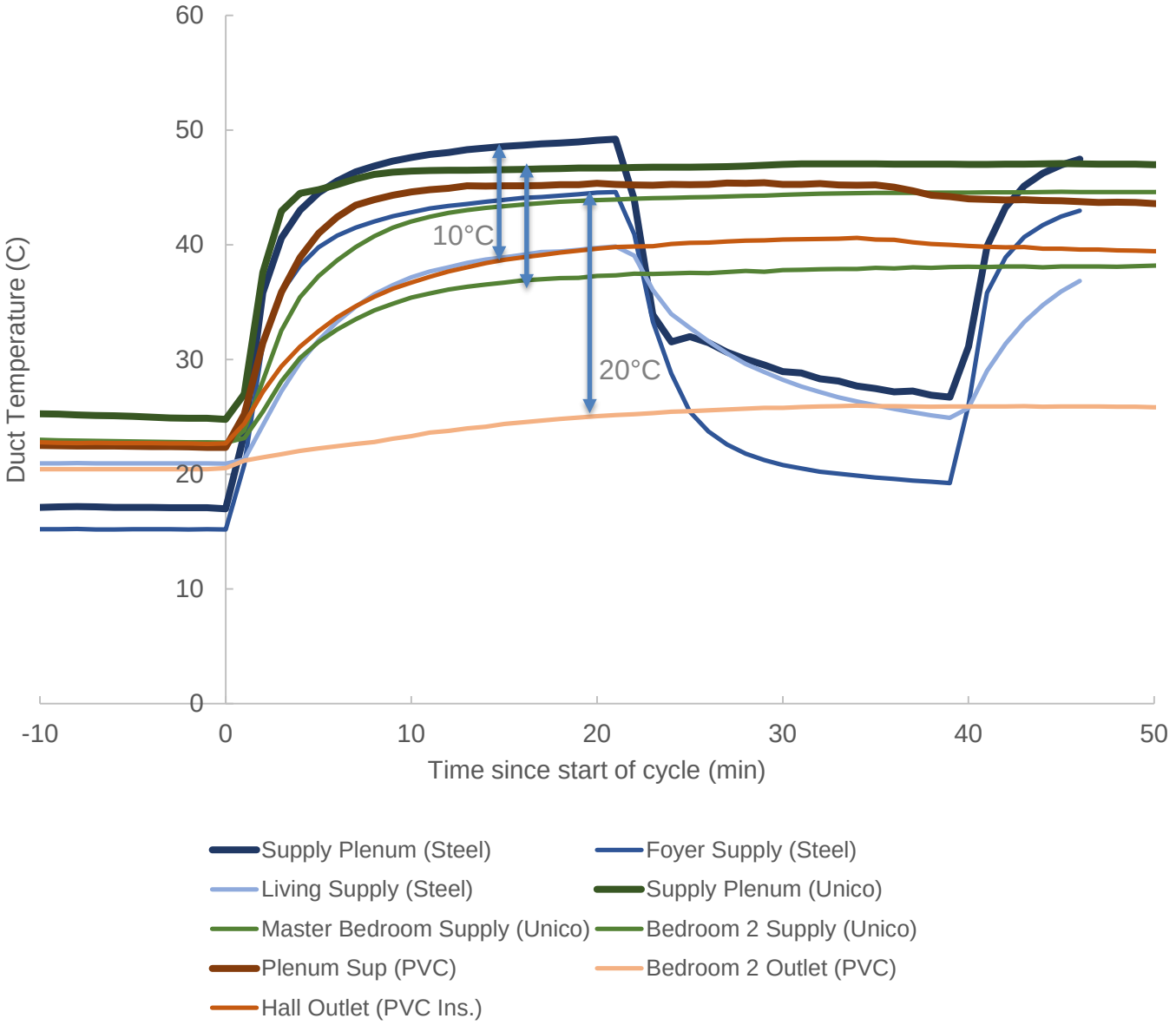




Duct Supply Temperature



Duct Supply Temperature



Compared to town house with similar duct lengths Δ10°C = Δ 18°F

IBACOS
innovation

Where Are We Going?

Current effort runs through mid-2016

- Design Methodology
- Cost and Labor
- Simulations
- Cooling Field Data

IBACOS
innovation

Questions and Discussion