Underfloor Air Distribution in a Commercial High Rise: The New York Times Headquarters

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Background

- New headquarters facility in New York City.
- Building Stats:
  - 1.6 million sf
  - Dimmable ballasts
  - Automatic shade control
  - Underfloor Air Distribution System (UFAD)

Research Begins

- Flack + Kurtz brought on as MEP designer due to their expertise in UFAD and CFD.
- Visited/researched locations that had system.
  - Alcoa Corporate Center, Pittsburgh, PA
  - European type, similar to displacement ventilation system
  - Modeled work after the UFAD at the Berlin Chancellery

Facts

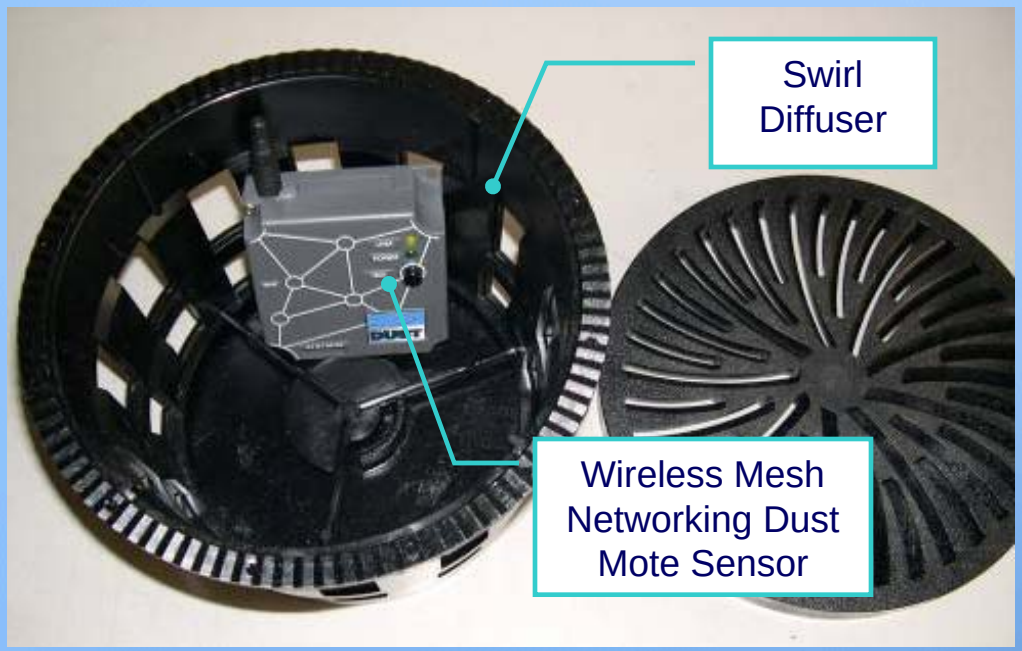
- NYTC needed facts to ensure the implementation of a UFAD was cost effective and to eliminate occupant comfort complaints.
  - Cost analysis included everything from the raised floor, sheet metal work and power to data and voice cabling and furniture wiring.

Benefits of UFAD System

- Flexibility of Space
  - Needed open space to capture as much daylight and outdoor views as possible.
  - Adaptability due to constantly changing departments and shuffling of desks.
  - Reposition floor tiles when needed - conventional overhead system does not allow for this.

Benefits of UFAD System

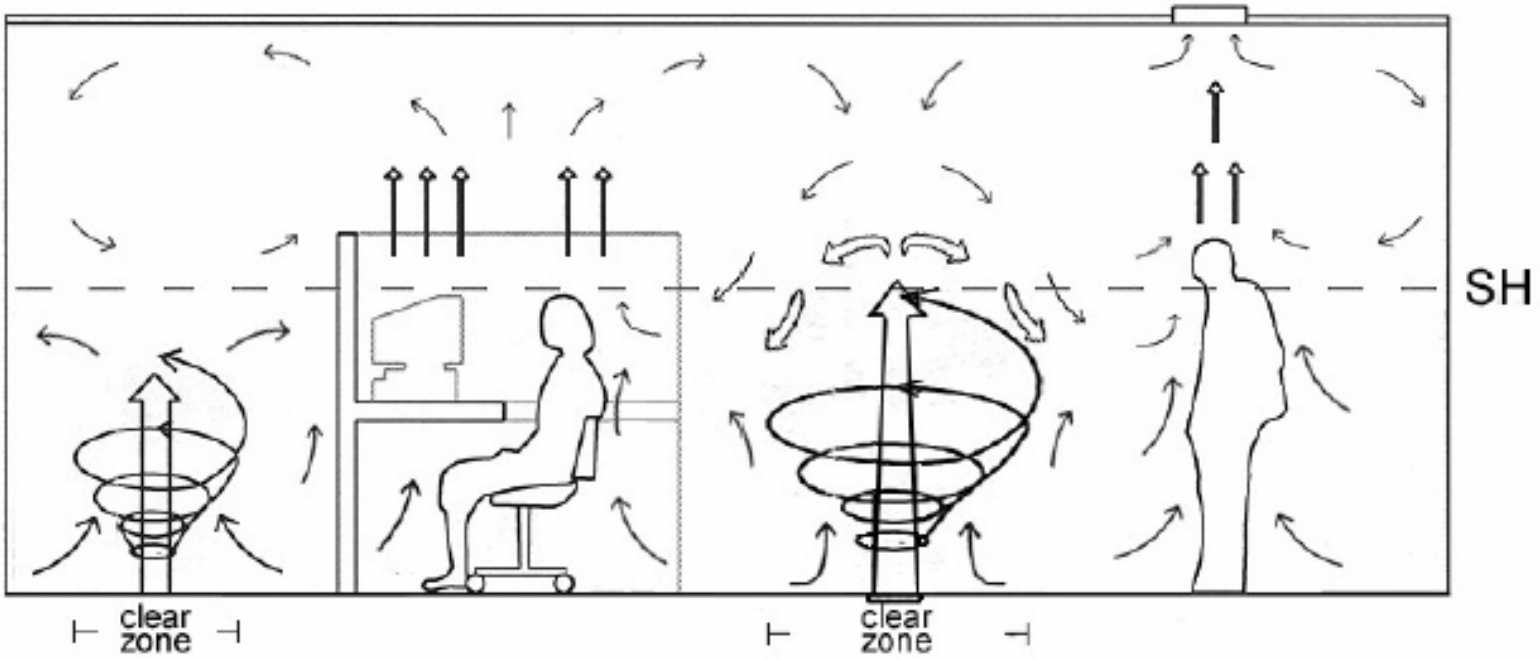
- More Occupant & Comfort Control
  - Each desk has a swirl diffuser for air delivery that can be adjusted.



Benefits of UFAD System

- Energy Consumption Reduction
  - Occupied zone is 4 – 67 inches above finished floor.
  - Cooling of occupied zone is performed with a low air velocity discharge from the swirl diffusers.
  - Air slowly absorbs heat and allows hot air to rise.
  - Four degree rise in temperature is achieved creating a stratification of the air/temperature barrier.
  - Air discharged from diffusers should be within a 7 degree band, i.e. 63 – 70 degrees F for maximum user comfort.

Underfloor Air Distribution System

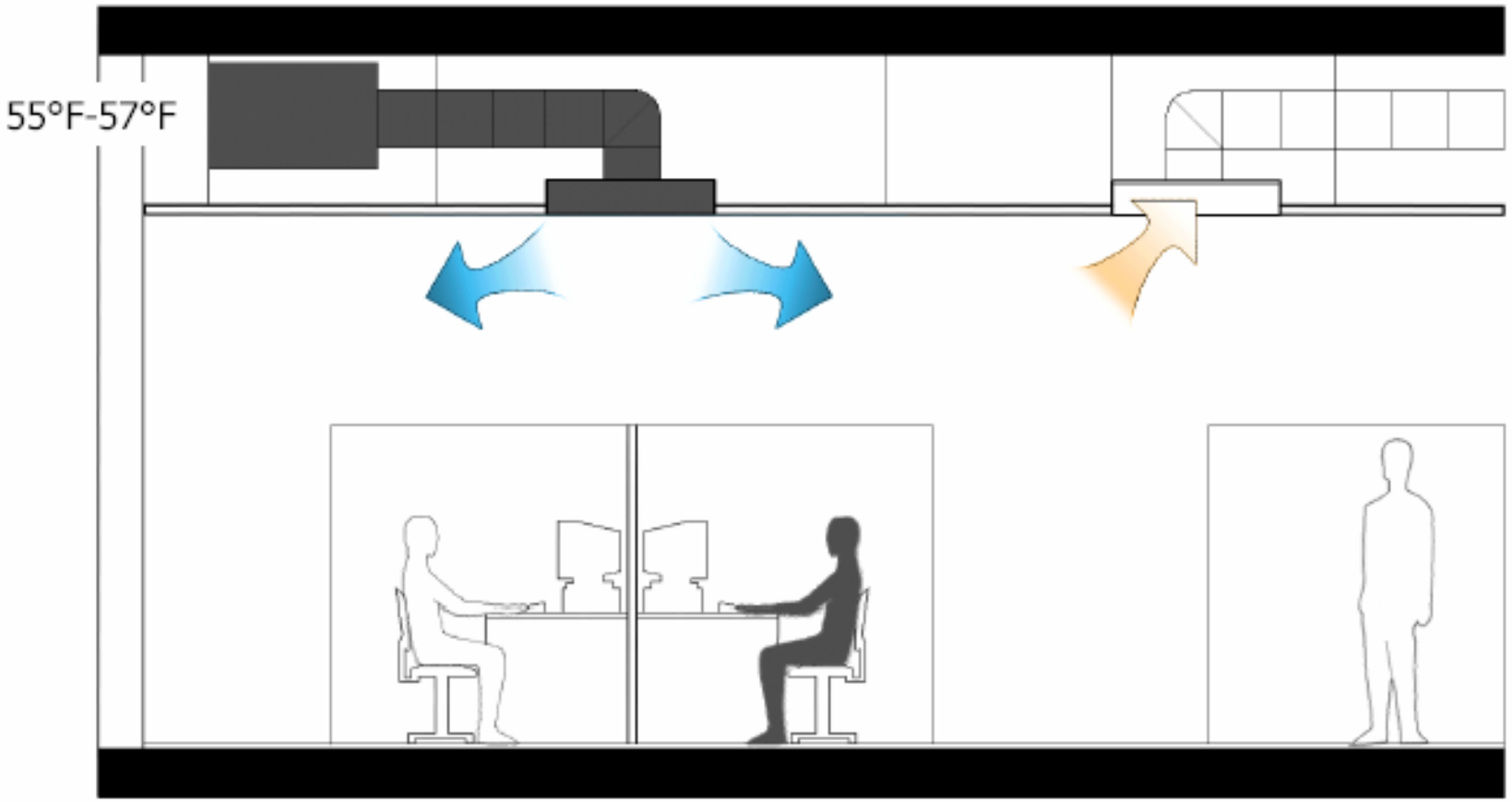


Diffuser throw above stratification level (SH)

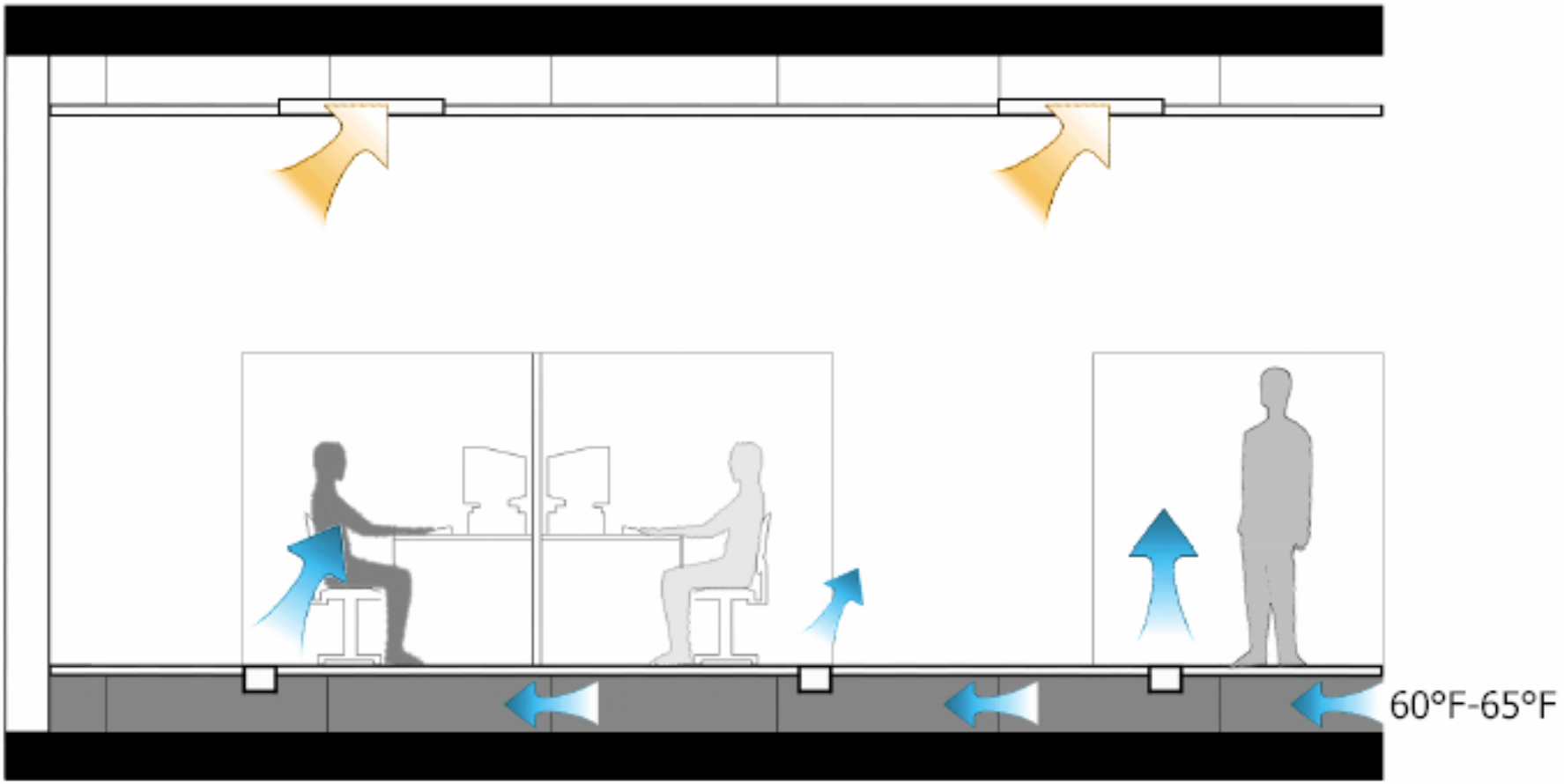
Benefits of UFAD System

- Airborne Illness Decrease
  - Overhead forces air down, then air distributed laterally, therefore spreading germs throughout space.
  - UFAD system carries germs up and out through natural ventilation of hot air rising.
  - Dust is carried upward gently instead of being stirred up, as often occurs with an overhead system.

Overhead System

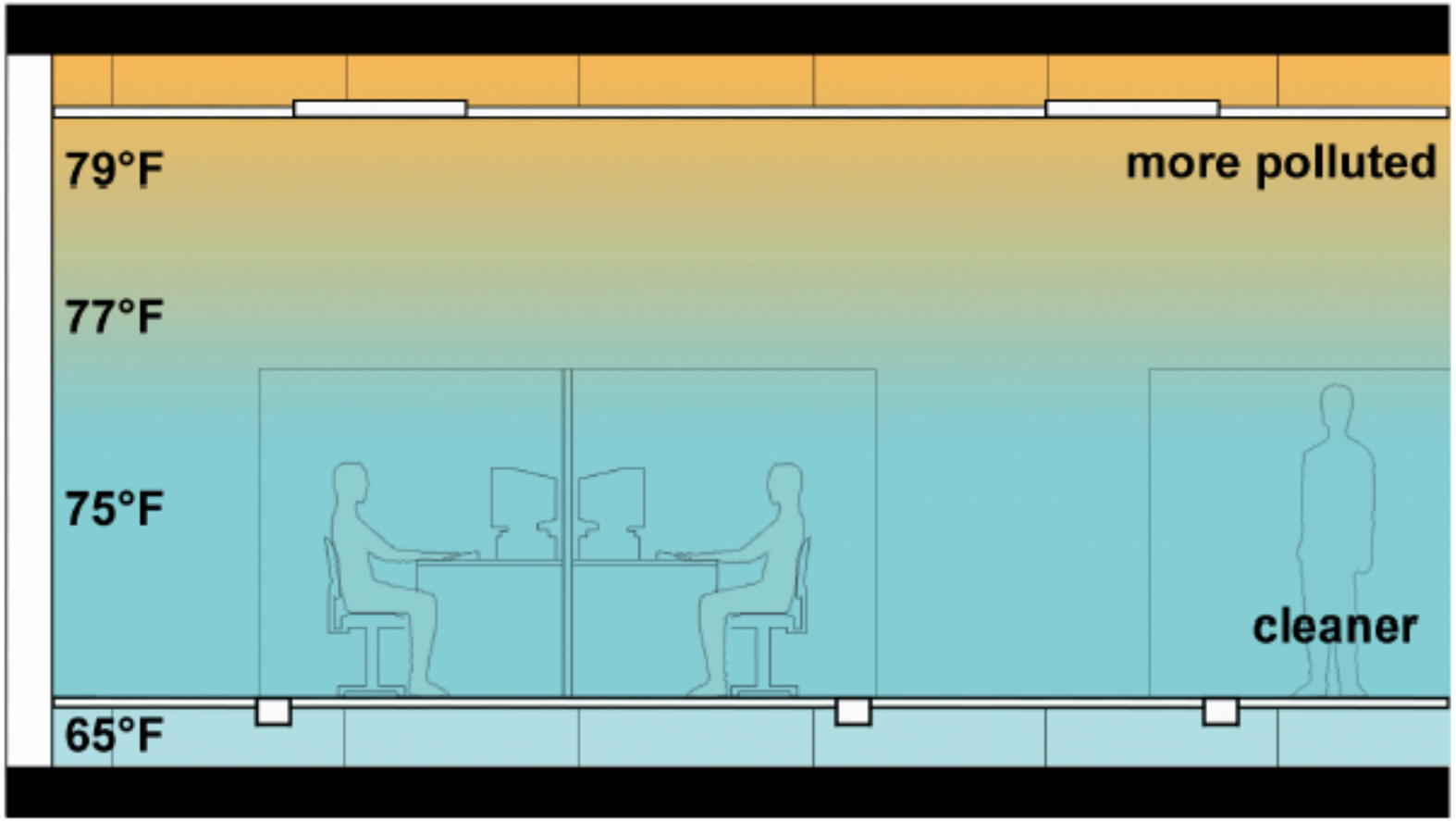


Underfloor air distribution system



Room air stratification

(cooling operation)



UFAD Design at The Times

- Air highway delivery system.
- Air delivered from air handler on the floor via a loop of ductwork.
- Modulating dampers control the pressure in 6 zoned off underfloor low pressure zones.
- Series of fan powered boxes control the temperature at the window wall. (Provide heat in the winter and cooling in the summer.)

UFAD Design at The Times

- Temperature at the window wall is controlled via thermostats, strategically located in the perimeter zone.
- Temperature for the interior space is controlled via thermostats located on the core walls at 84 inches above finished floor.
- Return air passes through grills in the ceiling mounted lighting fixtures and is returned back to the air handler through the return air plenum above the ceiling.
- Fresh air supplied by two air handling units on the 28th floor.

Educating the Team

- Sponsored a one day UFAD summit with all team members and key experts.
- Discuss design, construction and possible pitfalls.
- Decided to write the specification for commissioning the UFAD system.
  - Paul Linden, Natural Works
  - Flack + Kurtz
  - Larry Dumpert/Glenn Hughes, NYTC

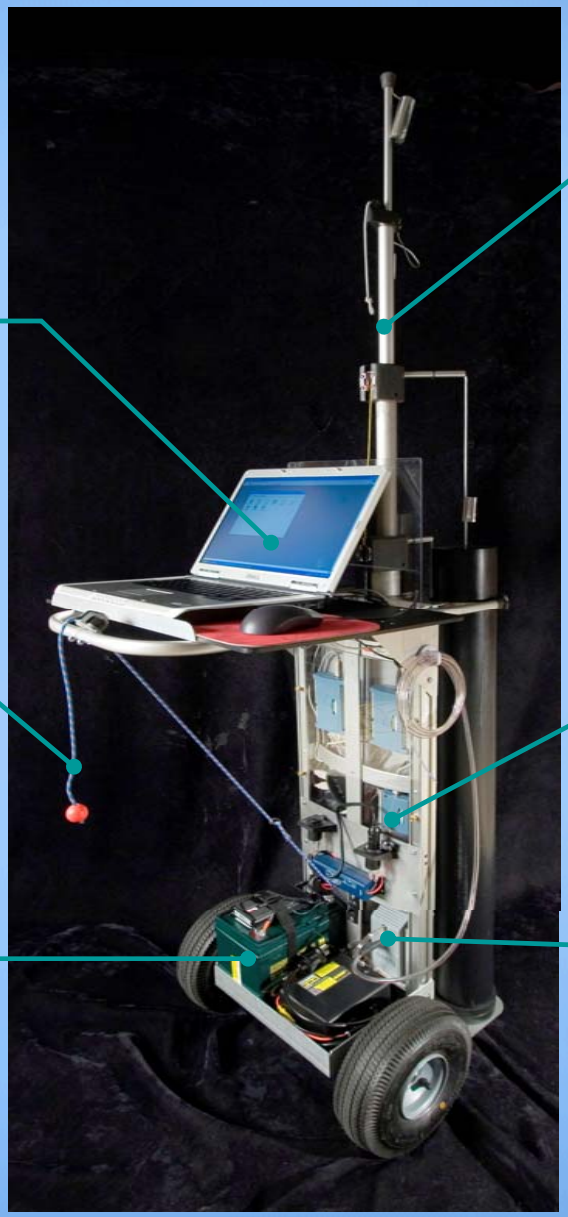
CBE – Center for the Built Environment

- Team of Tom Webster and Fred Bauman from the University of California, Berkeley campus retained to develop tools and protocols.
  - Mobile UFAD commissioning cart for measuring space temperatures
  - Temperature motes mesh network for measuring underfloor supply air temperatures
  - Data collection and evaluation software system mounted on the mobile cart

Testing Tools and Protocols

- Challenges
  - Simulating live conditions and measuring them before staff moved into the space.
  - Capturing data in a useable format.
- Two critical items that needed to be recorded were occupied average temperature and stratification within the space.

UFAD Commissioning Cart



Cart laptop computer

Lanyard for raising tree

12 VDC Battery power system

Telescoping stratification measurement tree

Data acquisition boards

Pressure sensor, with plastic tubing tether (with internal thermocouple)

Commissioning Cart

- Telescoping arm for temperature sensors at various heights.
  - Determines average occupied zone temperature.
  - Determines stratification within the occupied zone.
- Anemometer was installed to measure underfloor pressure in the air highway and low pressure plenum.

Modeling

- CBE modeled thermal heat load for a human body.
- Thermal plume generators were created and tested in CBE's lab in Berkeley, California.
- Used a 120 VAC electrical outlet and simulated heat plumes that would typically come off of humans and computers.
- Over 200 of these devices were scattered at desks and chairs to simulate the occupants.
  - Simulated 30 – 60 percent of heat load of an entire floor.

Testing Time

- First sessions of tests were for the air highway.
  - Each had precut tiles installed where air was pumped in to generate a pressure in the floor of .5” wc.
- Upon passing test, fan powered boxes that serve the perimeter were tested.
- Next the raised floor was finished and a low pressure zone test occurred.

Contractors Role

- Due to initial education, contractors understood what was required from them.
- Contractors fully met expectations.
- Willing participants in process, as they understood the methodology.
- A fully functional system also guaranteed that they would be released from their contract responsibilities on time.

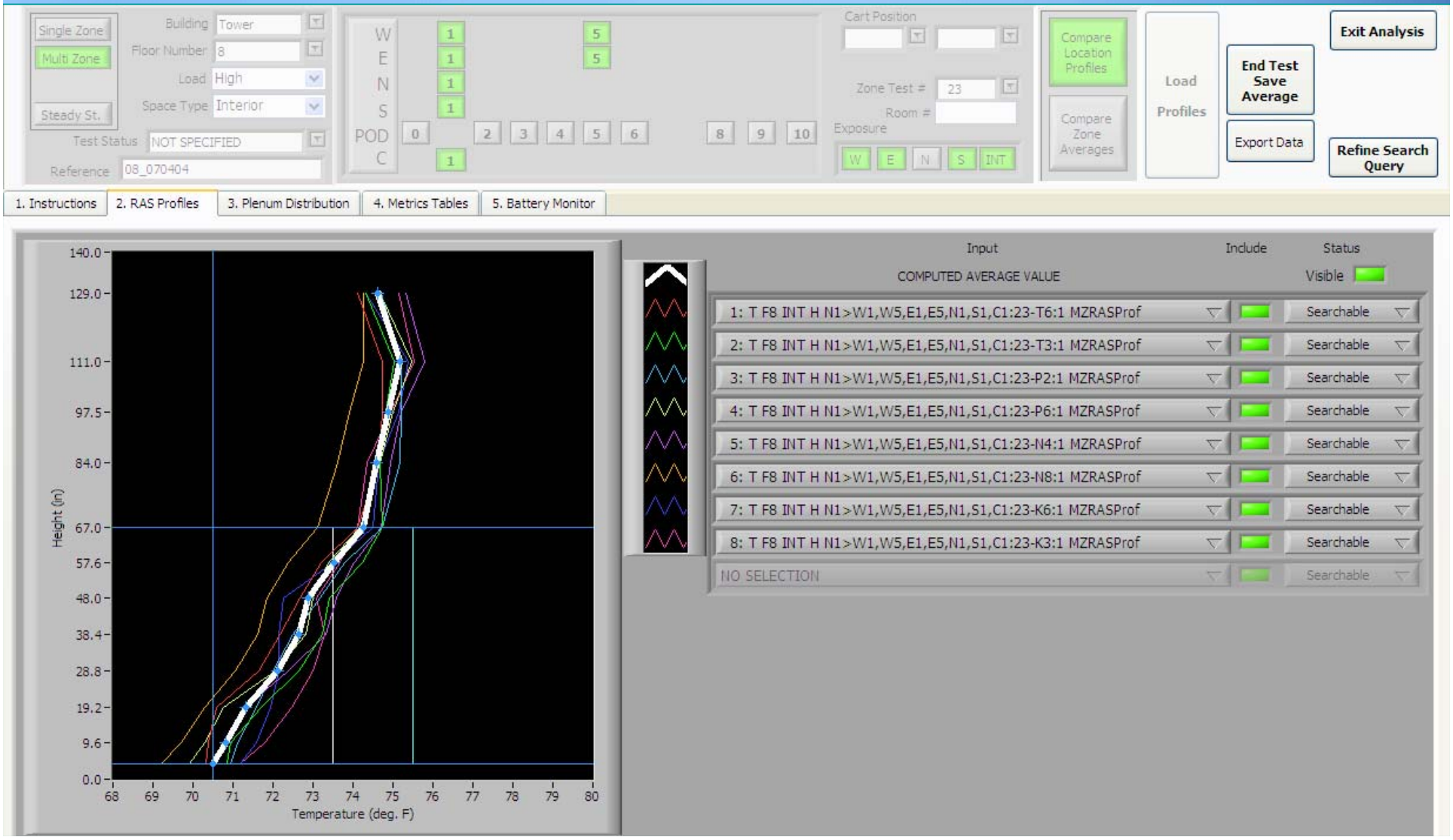
Functional Testing

- NYTC and commissioning authority tested each floor with the commissioning UFAD cart.
- Contractors supported tests by correcting various problems identified by the data collection and evaluation system on the cart.
  - Swirl diffuser locations
  - Air highway pressure
  - FPB airflow
- Thermal plume generators were plugged in throughout a typical floor.
- Temperature motes were distributed throughout the floor being commissioned.

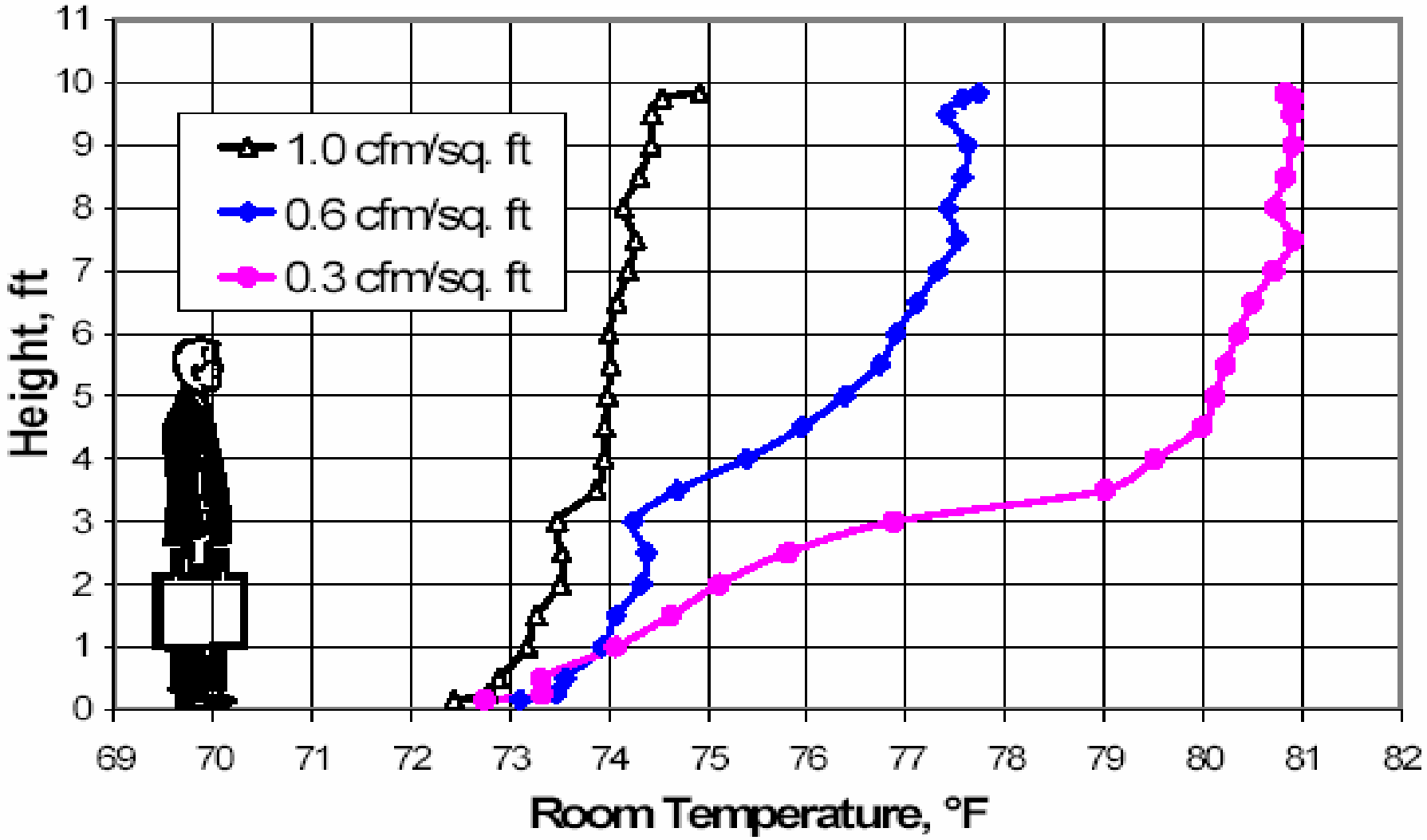
Functional Testing

- Each floor above and below had to maintain steady conditions as if they were occupied to achieve accurate results.
- Optimal supply air temperature was determined on a multi-zone floor wide basis.
  - Set the supply air temperature and used the cart to determine average occupied zone temperature and stratification in the occupied zone.

Air Stratification Profile

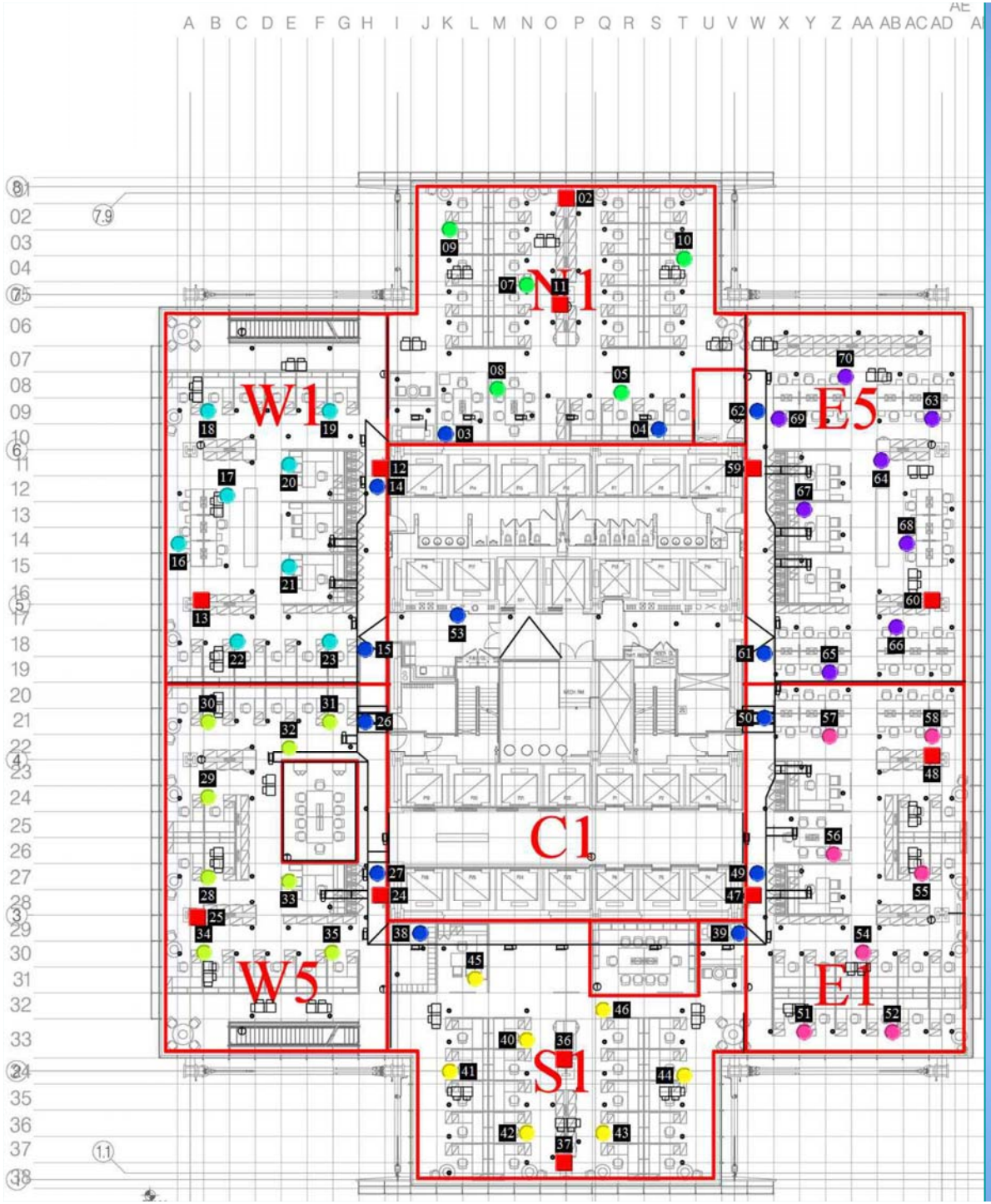


Stratification



Motes

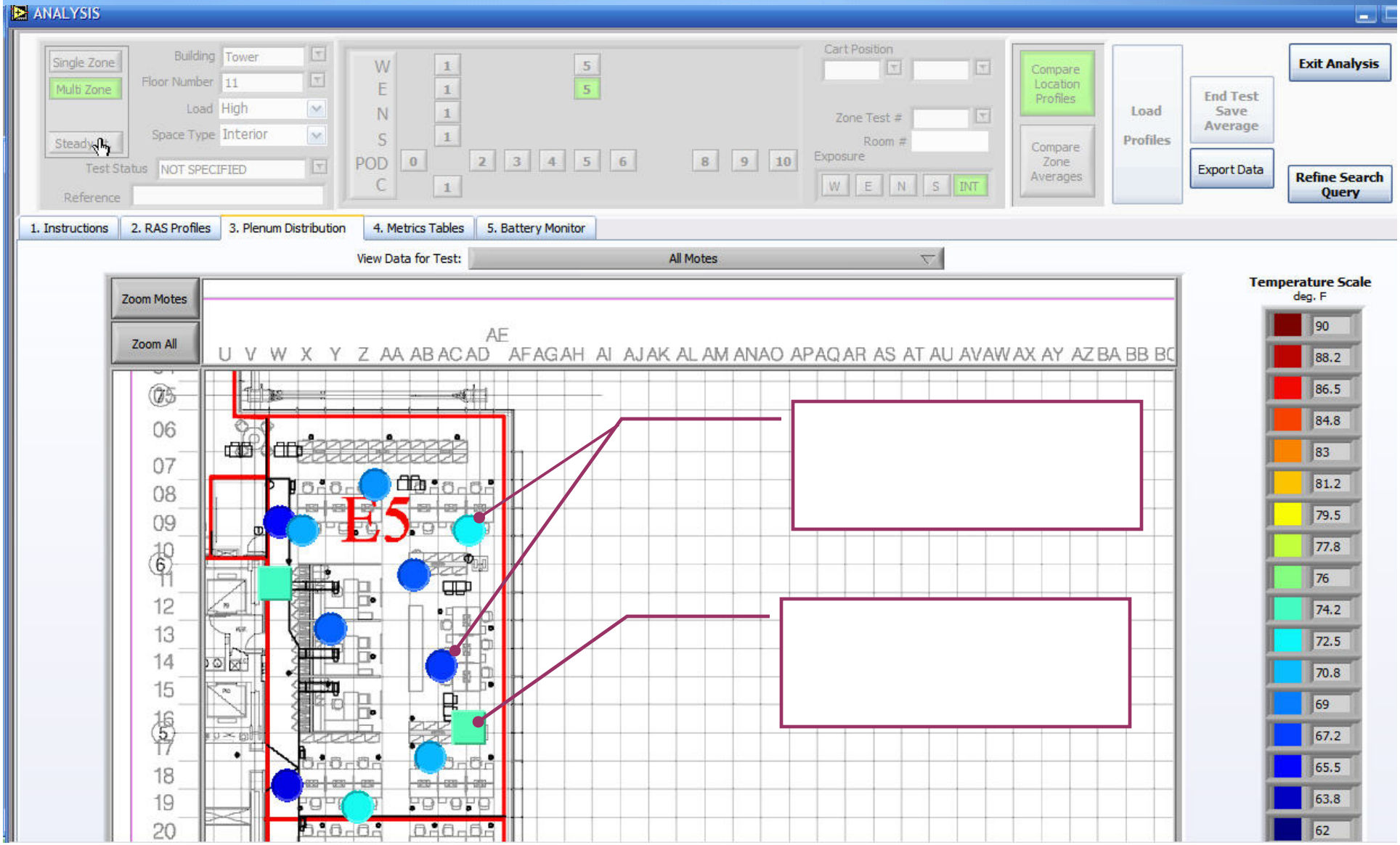
- Mesh network wireless temperature sensors.
- Placed in each swirl diffuser to determine the temperature discharge at each diffuser.
- Map of location of the motes was developed and data fed to laptop on the commissioning cart.



11th Floor Tower

7 Zone Mote Map

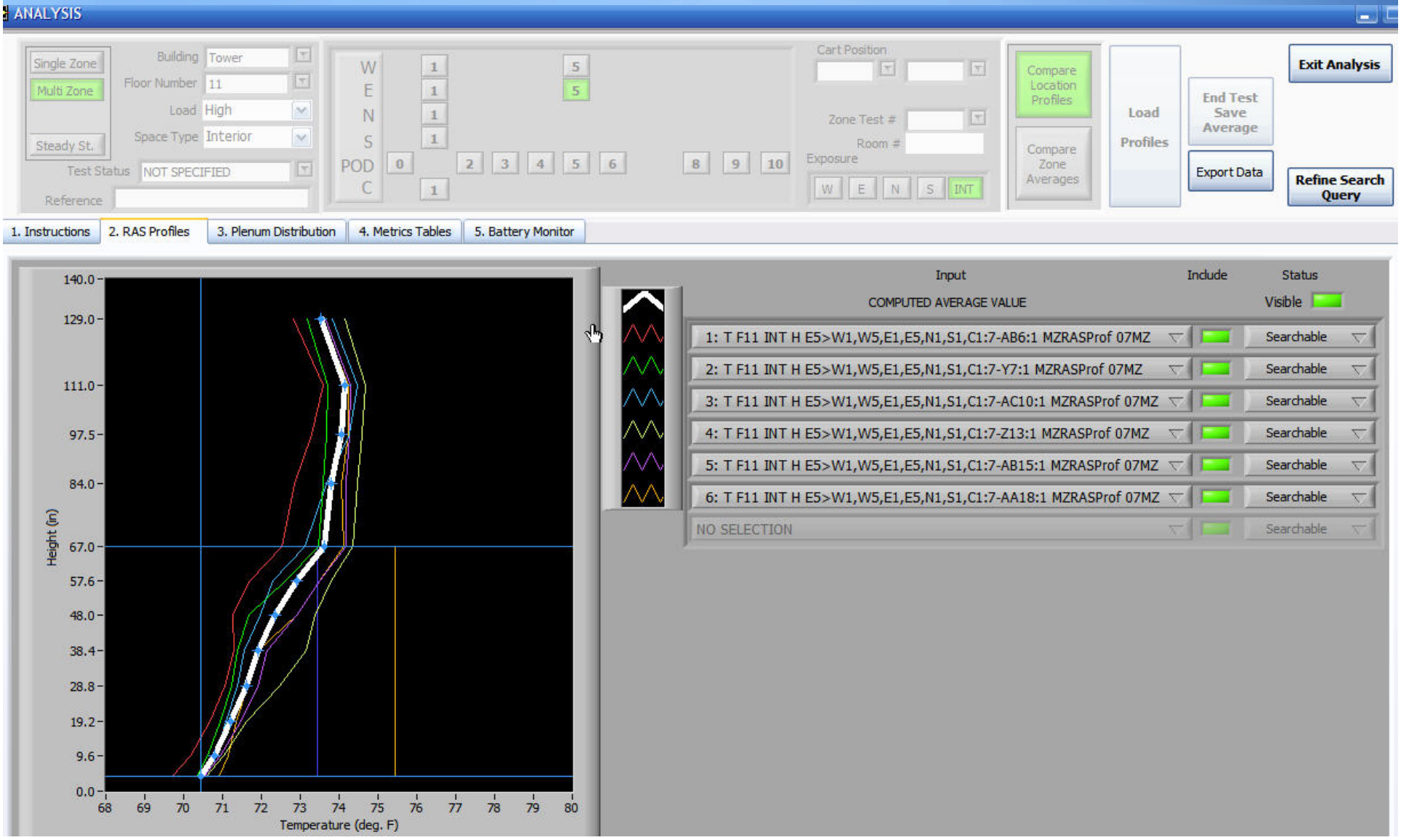
11th Floor - Zone “E5”
One of Seven Zones in a Multi-zone Test



11th Floor - Zone "E5"
Room Air Stratification (RAS) in Occupied Zone (4" to 67" above FF)
Statistical Data Collected

Swirl diffusers Mixed but most open full / some 1/2 open / swirls with motes at full open.	% max of Zebras set by TAB.					
SAT of 63	T=75	T=75	T=75	T=81	T=81 + T=72	T=81+ T=72
UFAD Zone	E5			still too cool		
CW Mullion Grid	AA, 18	AB, 15	Z, 13	AC, 10	Y, 7	AB, 6
Pressure in LLP	0.013	0.013	0.01 (006>011)	0.011	0.007	0.012
SAT at Diff	72.7	70.7	66.5	71.2	67.9	72.6
Tree Sensor Ht	Temps Per RAS Profile					
67"	74	74.2	74.4	73.3	73.3	72.5
57.6"	73.4	73.5	73.7	72.4	72.4	71.6
48"	72.9	72.9	73.4	72.2	71.7	71.3
38.4"	72.2	72.1	73.2	71.6	71.4	71.3
28.8"	71.7	71.8	72.6	71.5	71.2	71.1
19.2"	71.5	71.5	71.7	71.2	71.1	70.7
9.6"	71.3	71	71	70.8	70.7	70.3
4"	71	70.5	70.7	70.5	70.3	69.8
RAS Cart Loc - Ave. Temps	72.25	72.1875	72.5875	71.6875	71.5125	71.08
RAS Temp Zone Ave.	71.88					
Toz	3	3.7	3.7	2.8	3	2.7
Toz Zone Ave.	3.15					
RAS Position Start Time	1720	1727	1731	1737	1744	1754

11th Floor - Zone “E5”
Room Air Stratification (RAS) in Occupied Zone (4” to 67” above FF)
Ave. Space Temp = 71.88 // OZ Differential = 3.15 (2.7 – 3.7)



Functional Testing

- Discovered base building system sequences needed to be adjusted, specifically in winter mode.
- Hot water system needed two revisions:
  - Outdoor reset changes to maintain high hot water temperatures to avoid subcooling of space.
  - Additionally, in a more typical design the hot water system is turned off at some predetermined outdoor temperature such as 50 degrees. That had to be modified to meet the buildings demands.

Lessons Learned

- Detailed research.
- Proactive education and training.
- Commitment of all parties involved