



Hype vs. Reality: Benefits of Underfloor Air Distribution (UFAD) Systems

Rebuild America

June 18, 2004

Presented by:

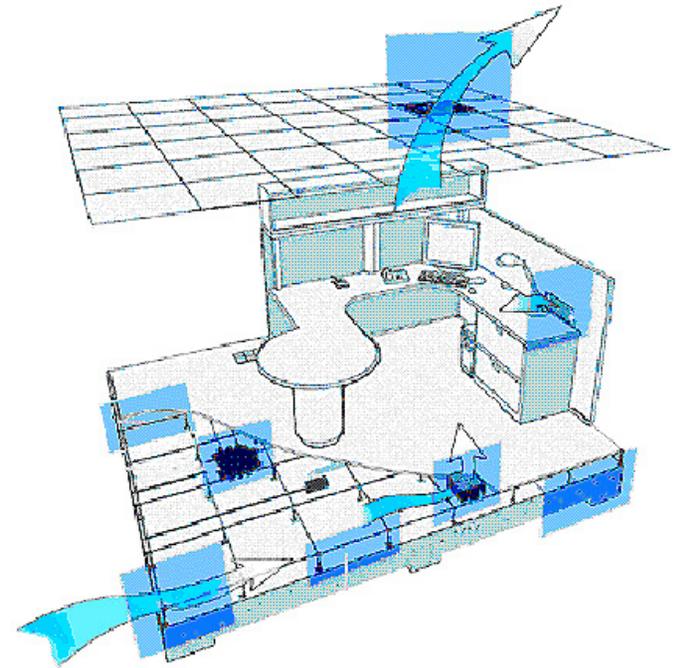
Mark C. Murray &
Patrick Jackson





Outline for today's talk

- Introduction
- Overview of UFAD benefits
- Six UFAD benefits:
hype vs. reality





UFAD research areas

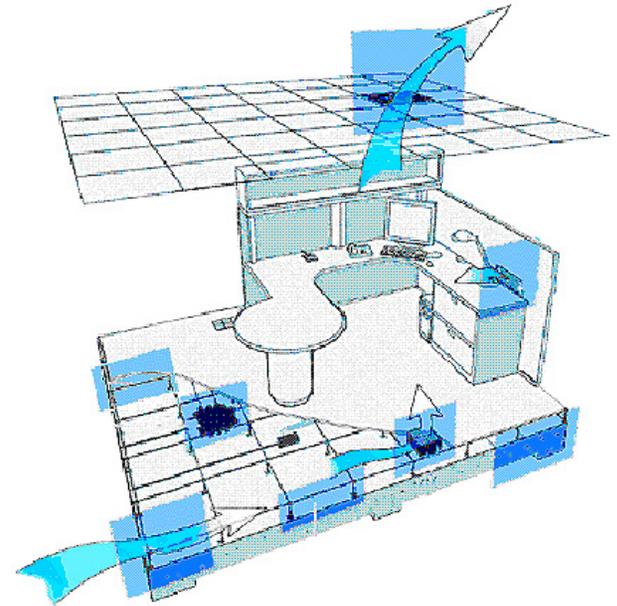
- Fundamental science
 - UFAD plenum performance
 - Room air stratification
- Building industry practice
 - Case studies
 - Cost comparison study
- Resource development
 - EnergyPlus
 - Design guide
 - UFAD technology website





Potential UFAD benefits

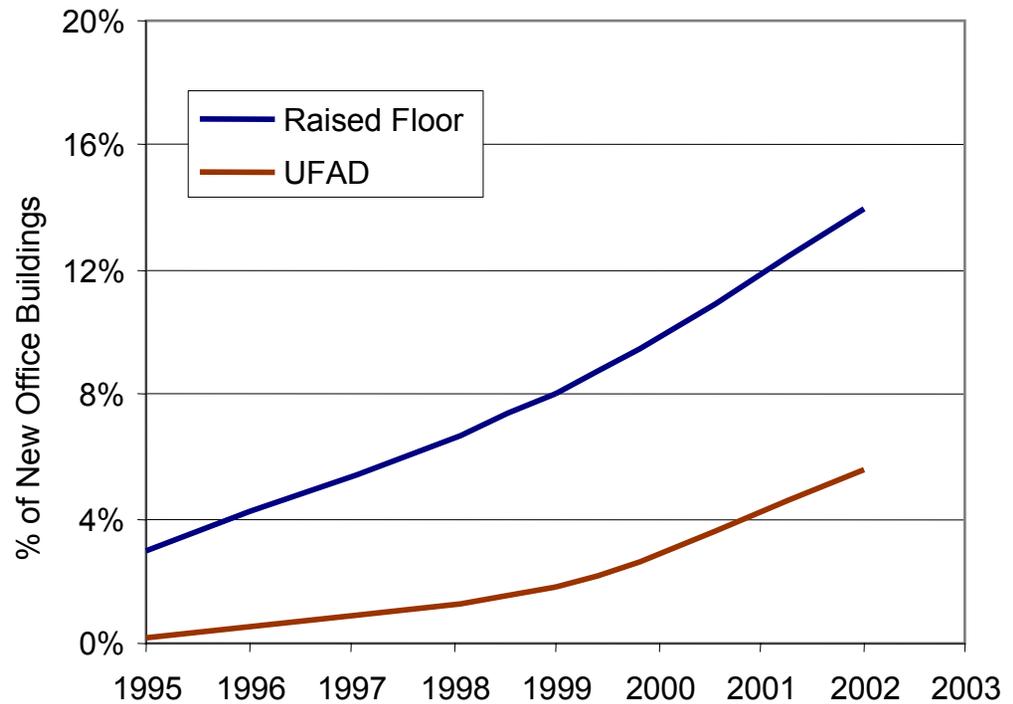
- Improved flexibility for building services
- Improved ventilation efficiency and indoor air quality
- Improved occupant comfort, productivity and health
- Reduced energy use
- Reduced life-cycle building costs





Raised floor and UFAD adoption

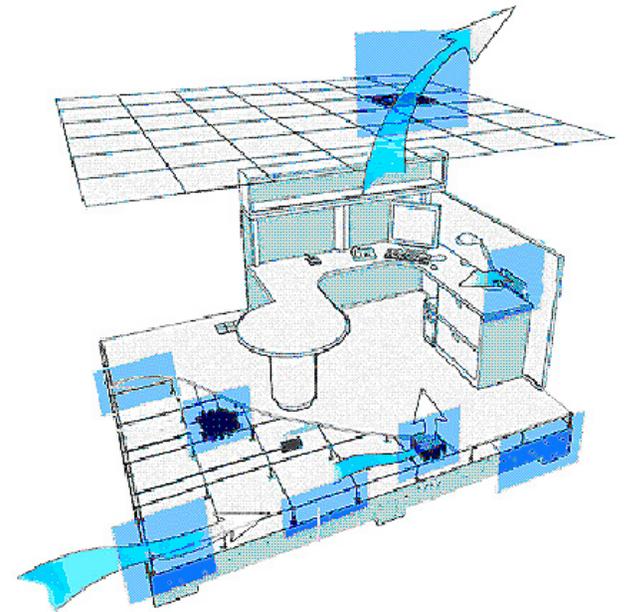
- **1995:** Less than 3% of new office buildings had raised floors, UFAD a “fringe” element
- **1999:** 8% of new offices used raised floors, 20-25% of these with UFAD systems.
- **2002:** 12% -15% have raised floors, +/- 40% of these with UFAD systems.





Hype vs. reality

“UFAD systems provide improved flexibility for building services, allowing for fast and inexpensive reconfigurations, and accommodating the high churn rates of the modern workplace.”



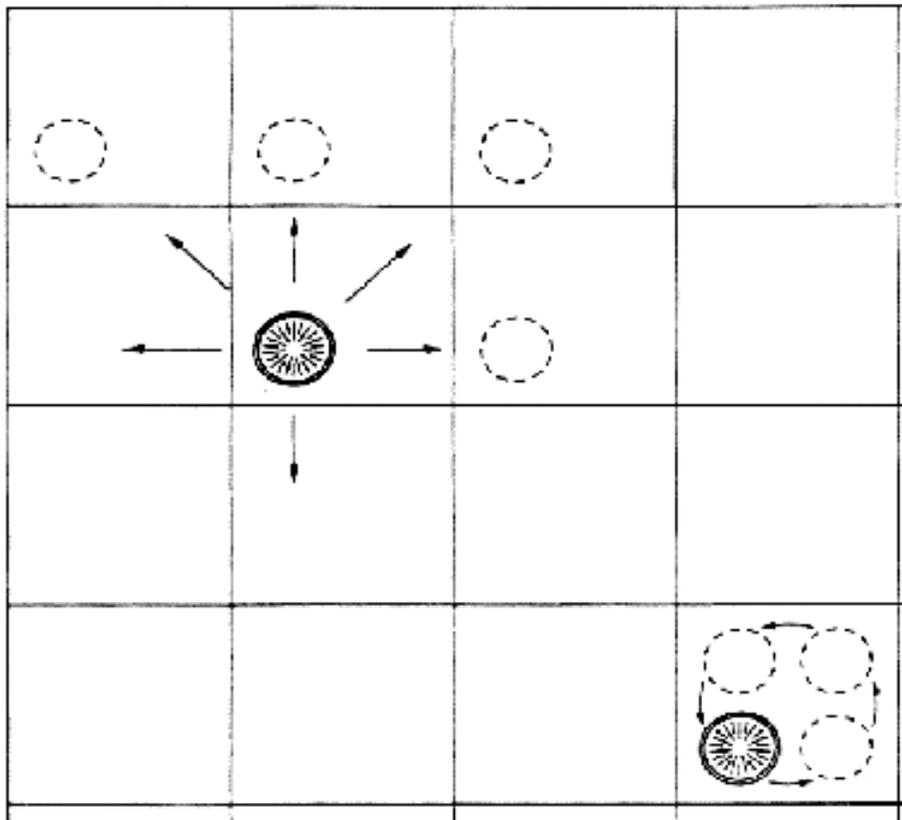


Flexibility: raised floor installation





Flexibility: ease of layout changes



- Diffuser layout in quadrant of tile for maximum flexibility
- Similar location strategy for data/electrical boxes





Flexibility: cable management

- Modular wiring systems eliminate the need for electrified furniture
- “Plug and play” capability
- Easy to accommodate freestanding furniture

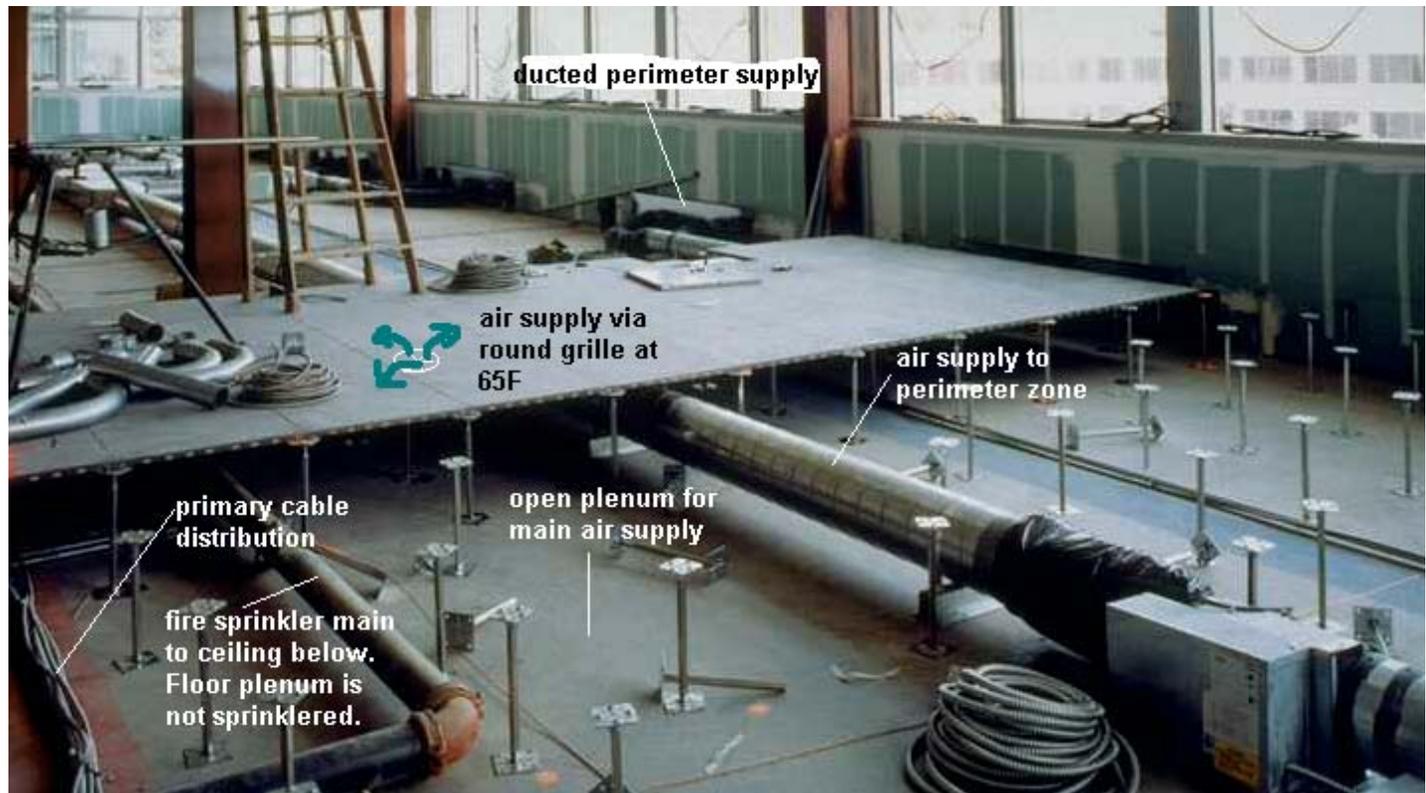


Images: Tate
Access Floor



Flexibility: equipment issues

- Locations of equipment should be coordinated with space plan for maintenance access





Flexibility: flooring issues

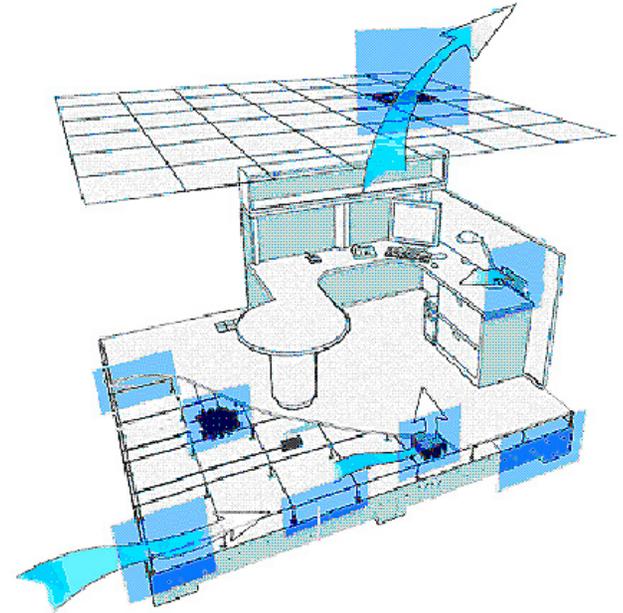
- Carpet tile, glue-down or laid in place
- Aligned (24") or offset (usually 18")
- Other flooring finishes possible





Hype vs. reality

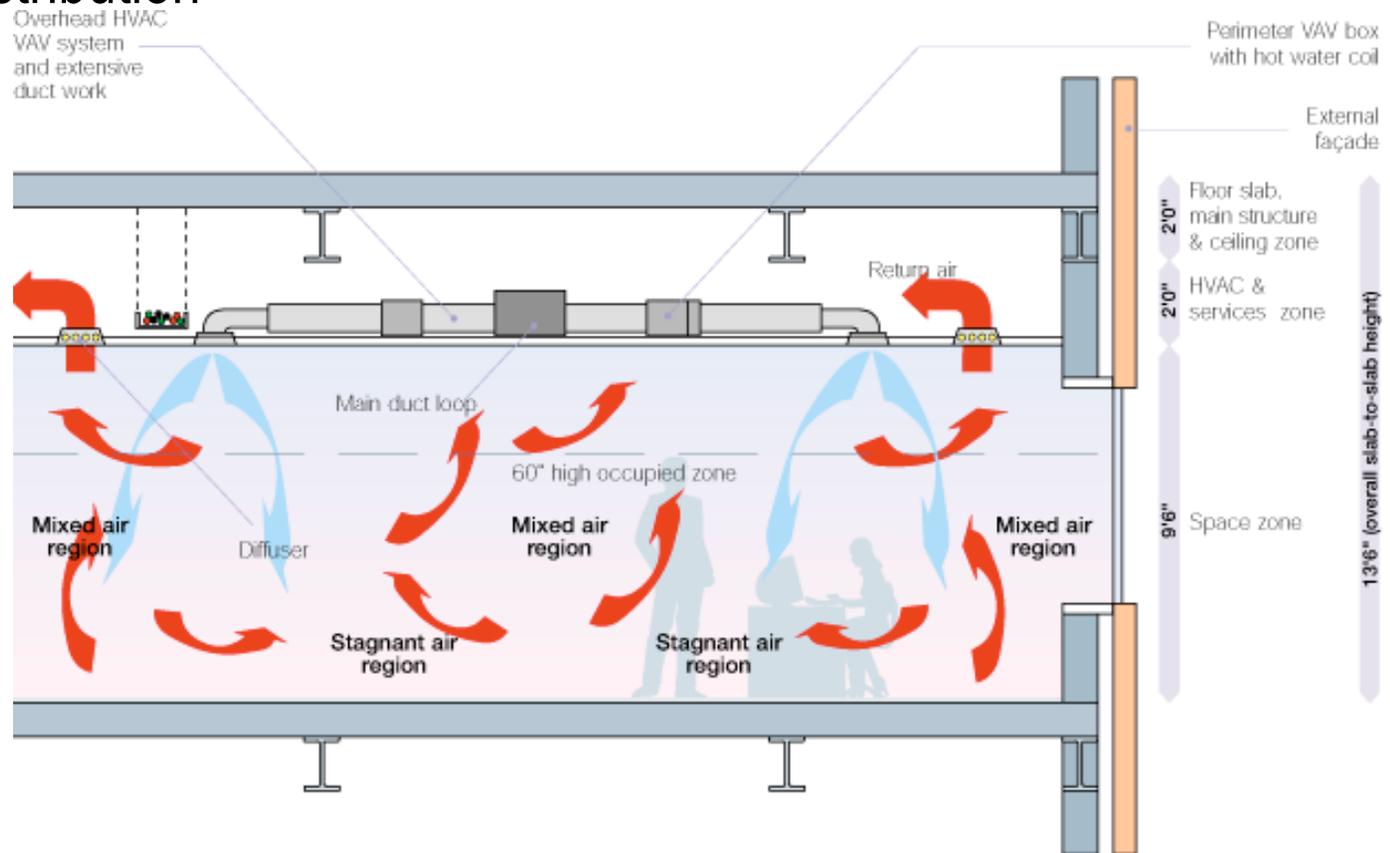
“UFAD systems provide improved ventilation efficiency and indoor air quality (IAQ).”





Ventilation: overhead system

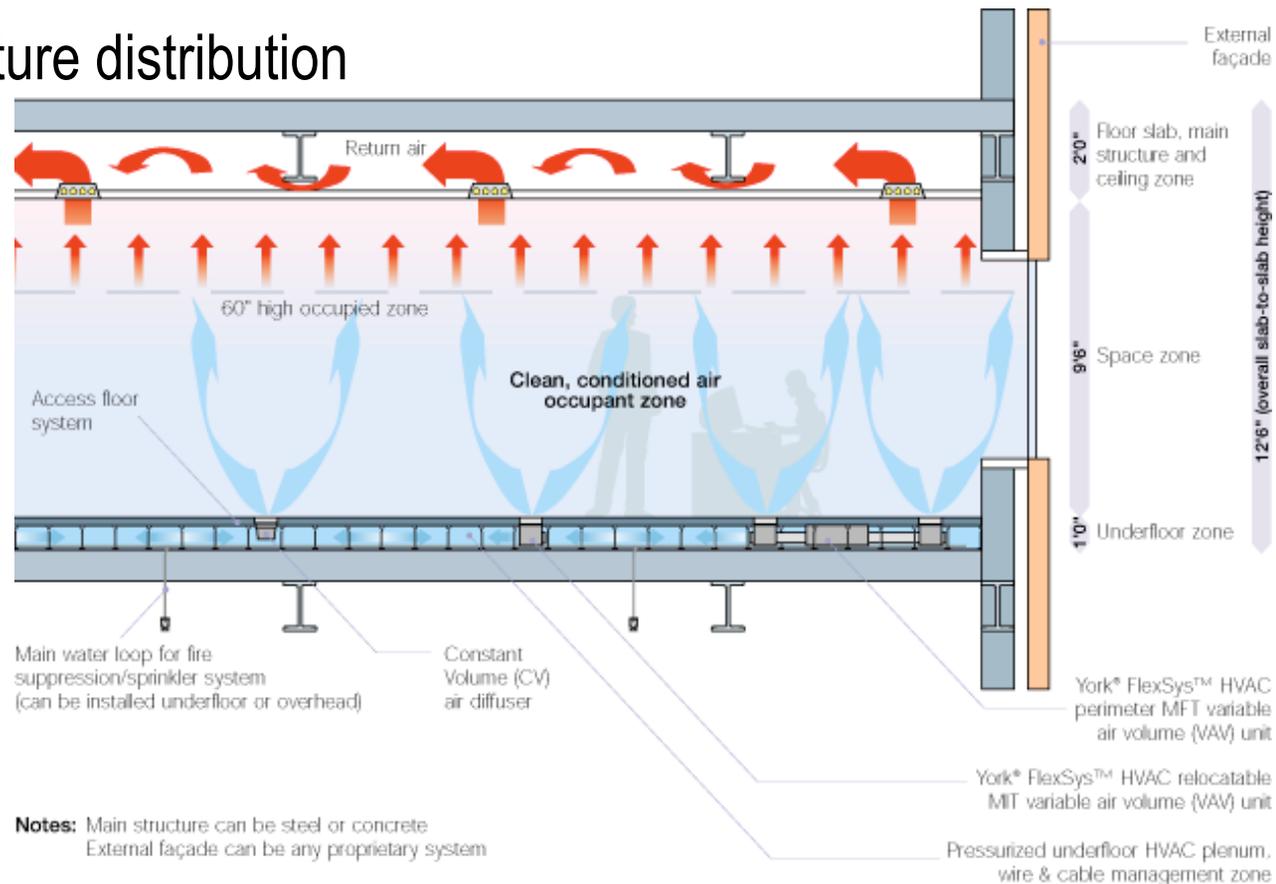
- Air supply at 55° F
- Uniform mixing of supply air within space, uniform temperature and pollutant distribution





Ventilation: UFAD system

- Air supply at 60° - 63° F
- Bottom to top air movement
- Stratified temperature distribution



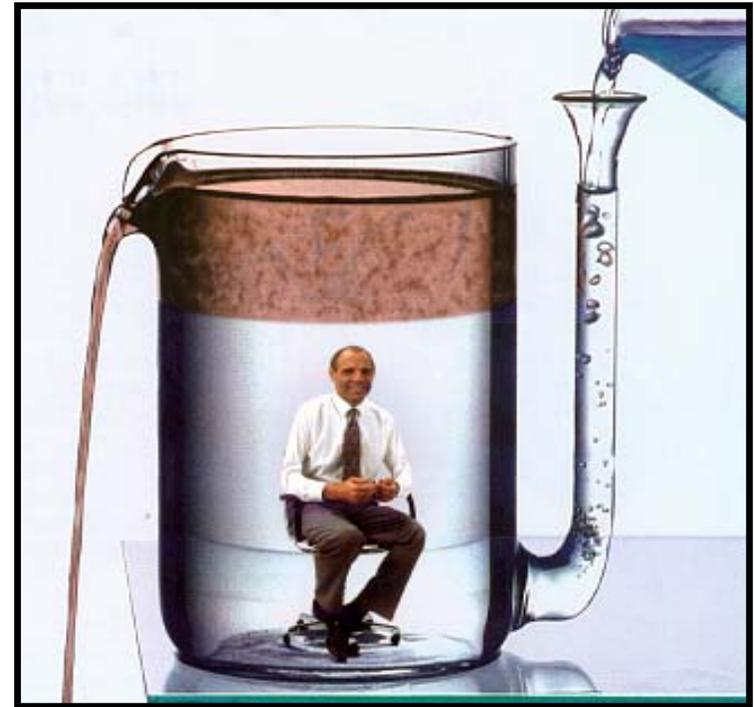


Comparison

Overhead VAV



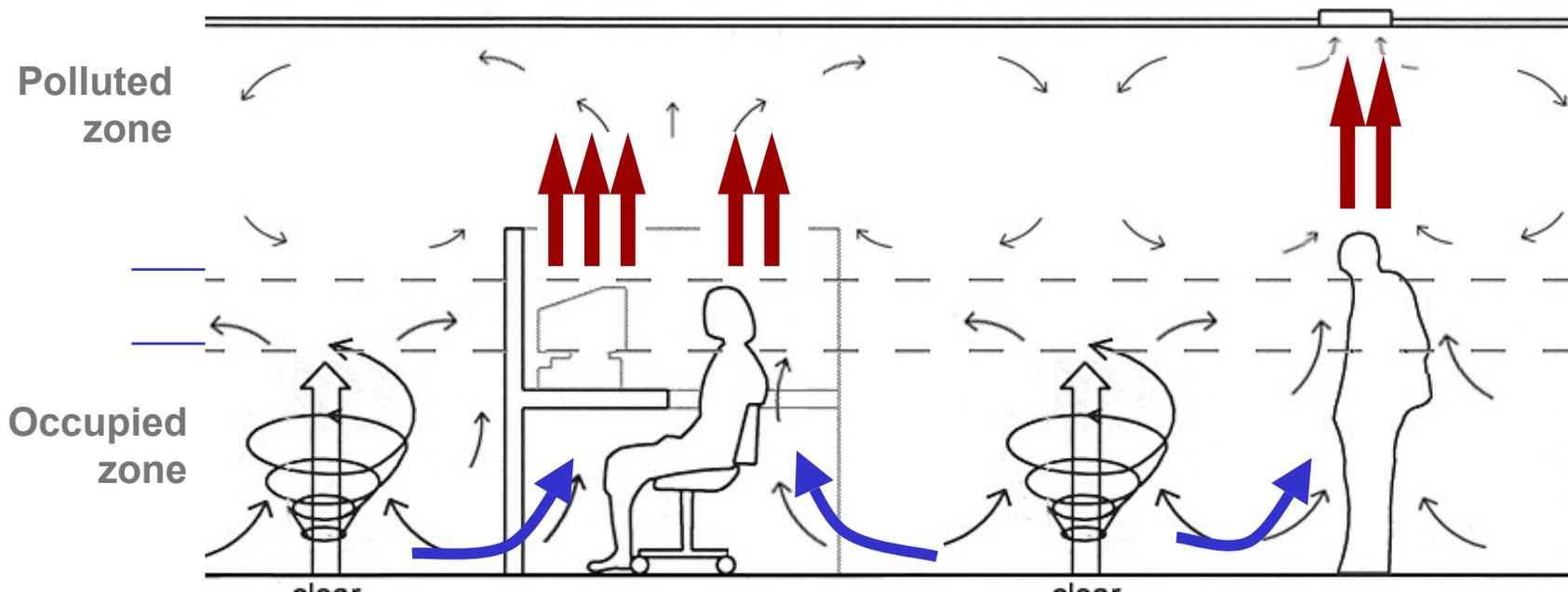
Under floor FlexSys





UFAD ventilation efficiency

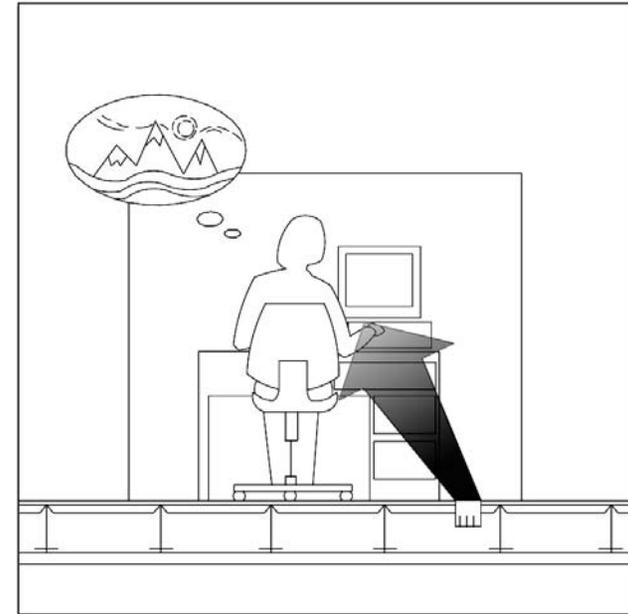
- Heat “plumes” from people and equipment rise above occupied zone
- Plumes draw supply air where needed





UFAD ventilation efficiency

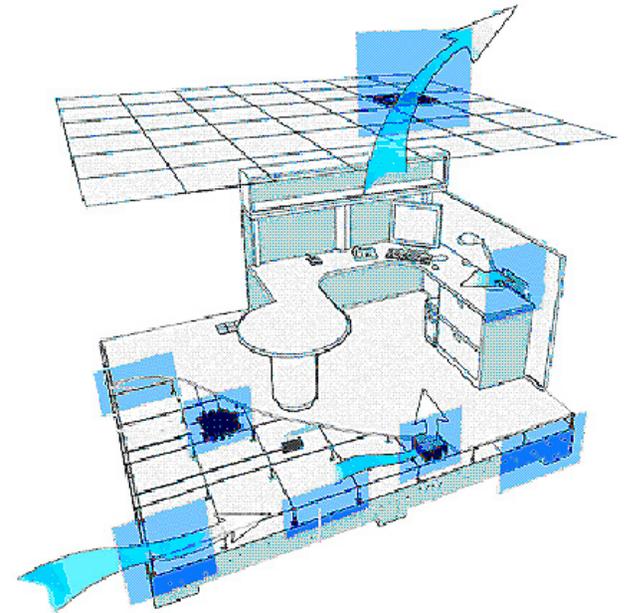
- Field research found that UFAD system had lower airborne particle concentrations than OH system (Japan, 1995)
- Sensation of air movement gives perception of better IAQ, important for occupant satisfaction
- Additional field research continues





Hype vs. reality

“UFAD systems provide improved thermal comfort, productivity, and health.”





Thermal comfort: standards

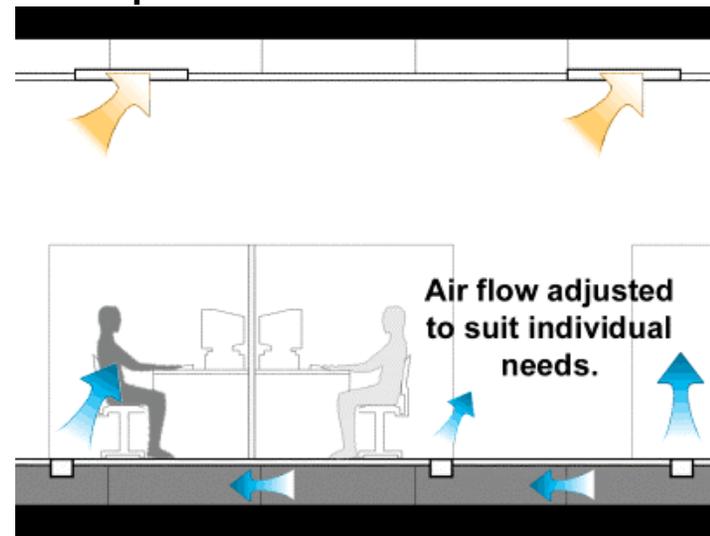
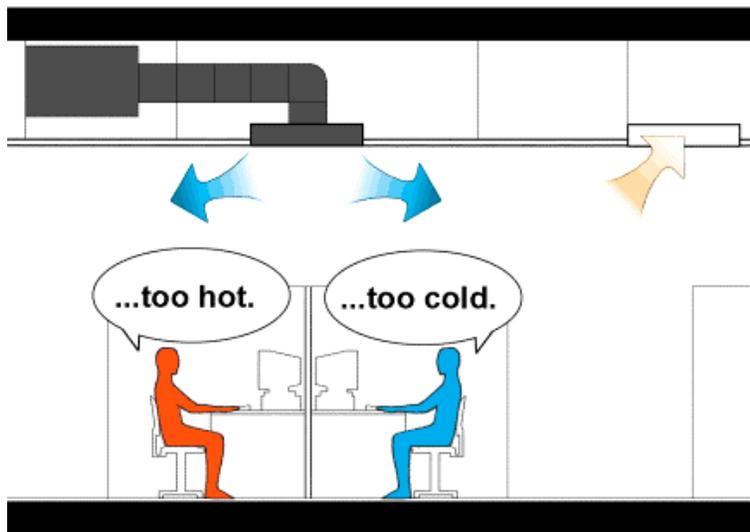
- ASHRAE comfort standards based on laboratory research
- Subjects had little or no control of environment
- Comfort standard only provides satisfaction to 80% of occupants
- Conventional standards with no occupant control leave 20% too hot or too cold





Thermal comfort: individual control

- Two CBE field research studies found that **occupants with no control are twice as sensitive to temperature changes.**
- More control = fewer hot/cold complaints





Thermal comfort: UFAD diffuser types

- Passive swirl diffusers, pressurized plenum
- Occupant may control airflow volume
(images: Price and Trox)





Thermal comfort: UFAD diffuser types

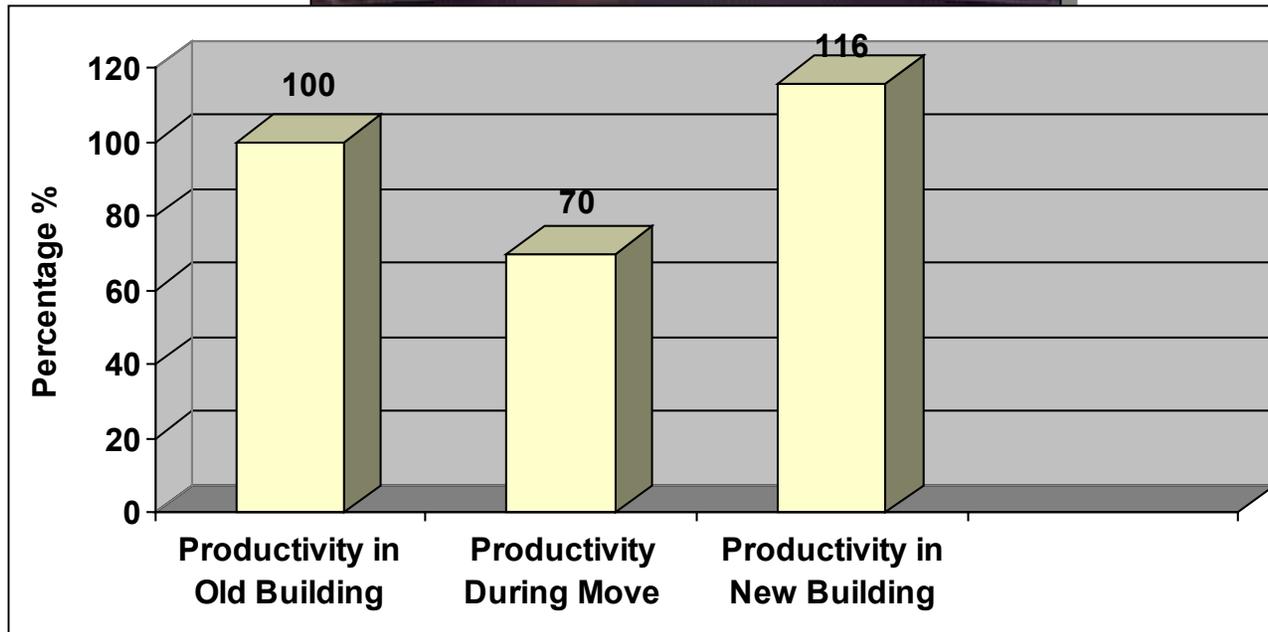
- Passive variable area diffusers, pressurized plenum in VAV operation
- Occupant may control airflow direction
(images: YORK)





Increased Productivity

**West Bend Mutual
Insurance
Company**
(West Bend, WI)





Healthier for Employees

- Building completed 1996
- Recent 5-year study shows employee absenteeism reduced by 30%.
- Employees state the “air quality just feels healthier”

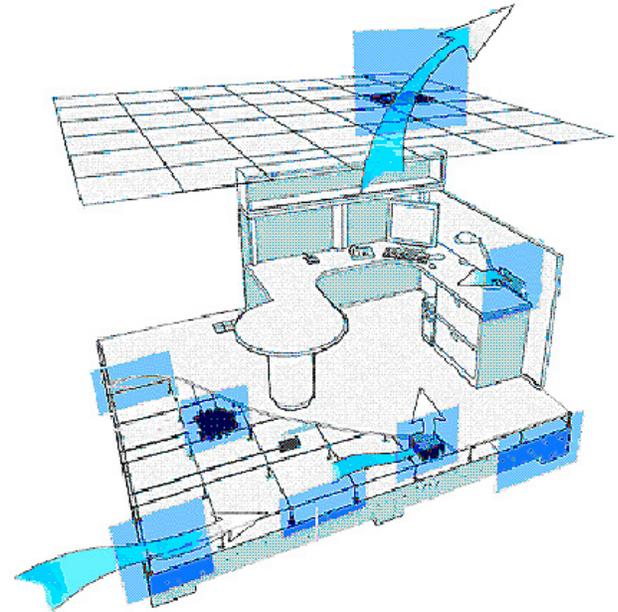


SMUD (Sacramento Municipal Utility Department)
Sacramento, California



Hype vs. reality

“UFAD systems use less energy than conventional overhead systems.”





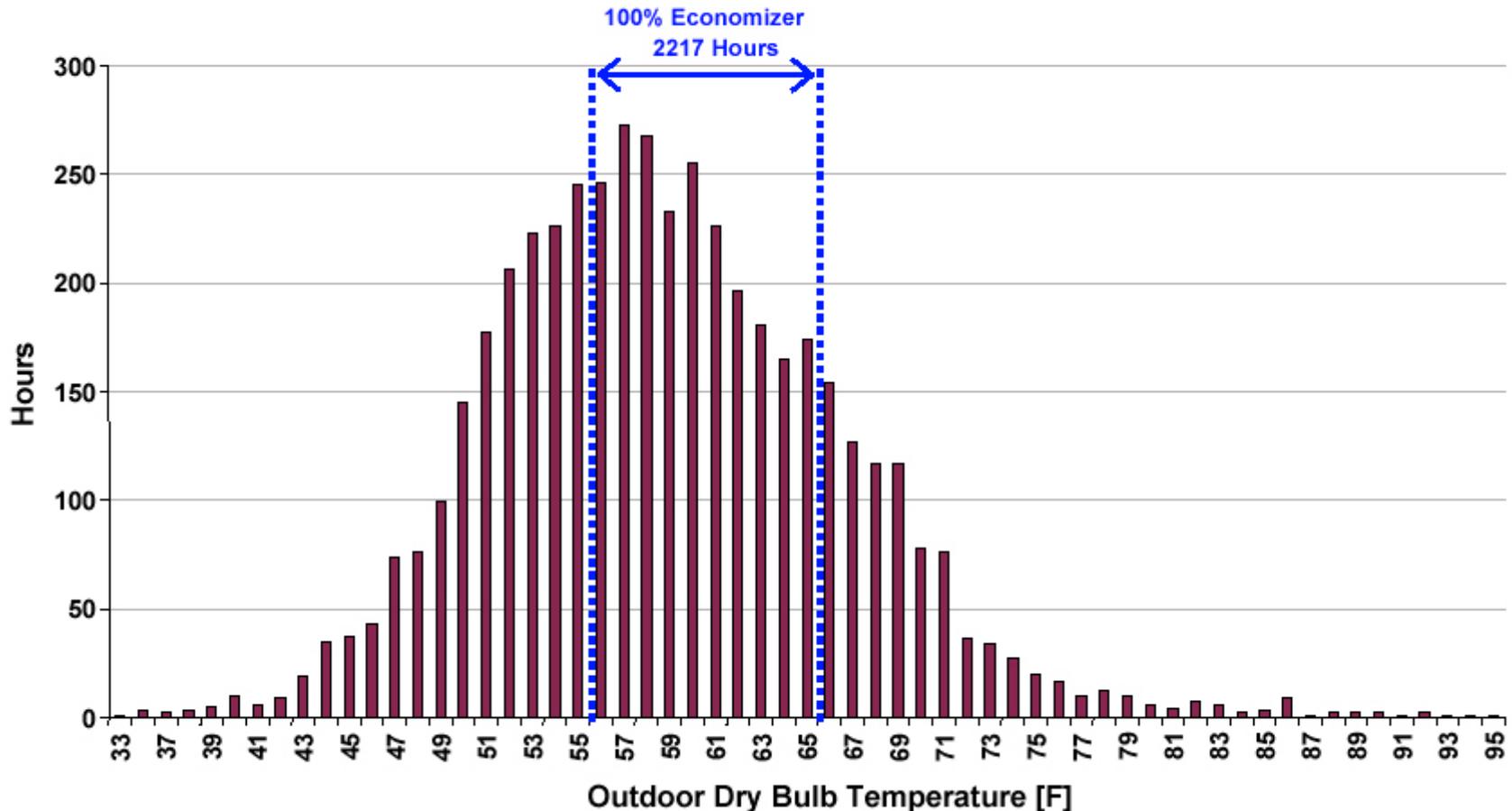
Energy: extended economizer use

- Supply air temperature of 60° – 63° F
- Return air temperature of 80° – 83° F
- More economizer hours compared to traditional 55° – 75° F supply and return air temperatures
- Savings are ultimately dependant on the ambient conditions



Energy: extended economizer use

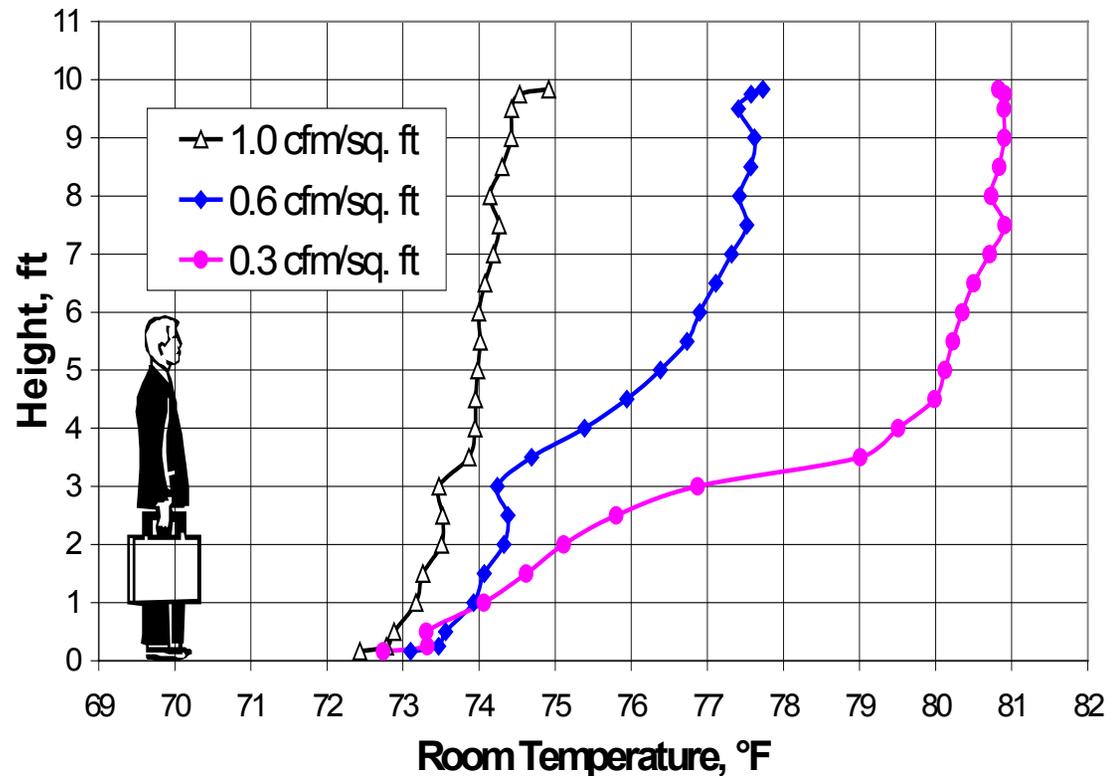
San Francisco Outdoor Temperature Distribution
(Dry Bulb temperatures between 8am and 8pm)





Energy: optimizing stratification

- Possible to reduce airflow and maintain comfort
- Some case studies found stratification
 - Many examples are “over-aired” and not stratified



Air temperature profiles with constant load



Energy: reduced fan power

- Reduced fan power due to low static pressure requirements
 - Static pressure of 0.05" in supply plenum
 - At recommended supply air volume, at 70% of system capacity, fan power savings of 45%
 - Fan power is approximately 40% of HVAC system power requirement



Energy: thermal mass storage

- Supply air in contact with thermal mass of concrete
- Night ventilation strategies possible
- Energy savings have been modeled
- Control strategies difficult to implement in practice





Case Study: MIT Stata Center - Cambridge





M.I.T.'s Ray and Maria Stata Center, a 730,000-square-foot complex devoted to computer science.



Copyright 2004 The New York Times Company

The meandering main corridor, with its bright red, blue and yellow walls, is known as "student street."



Copyright 2004 The New York Times Company

An interior view of the sprawling Stata Center, designed to encourage colleagues to mingle.



Copyright 2004 The New York Times Company

The lack of an interior grid is part of Frank Gehry's plan to spark creative combustion by encouraging the building's occupants to bump into one another.



**Natural light pours
through the skylights
and huge windows
inside the building.**



Case Study: Des Moines Area Comm. College



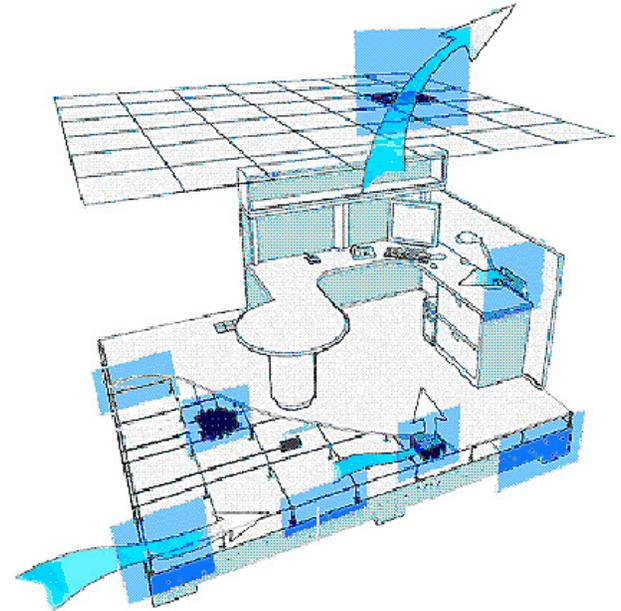
This system, combined with other energy saving features, resulted in a tremendous reduction of energy costs compared to those of a typical building. The HVAC system reduced energy costs associated with operating the facility by **43 percent**.

1st Place ASHRAE Technology Award 2004 for IAQ, Comfort & Energy Conservation



Hype vs. reality

“UFAD systems may reduce building life-cycle costs, and in some cases may reduce first costs, in comparison to overhead systems.”





Costs: Initial added costs

- Raised floor system - \$5.00/ ft² (Nashville, recent project)
- Raised core (\$0.54-\$0.80/GSF)
(based on \$18-\$20/ ft², however only comprises 4-5% of building floor area)
- Plenum sealing and cleaning (\$0-\$1.00/ ft²)



Costs: Initial saved costs

- Cable management systems (\$0.22 to \$3.10/ ft² savings possible compared to electrified furniture)
- Floor to floor heights (up to \$2.00/ ft² potential savings estimated)
- Elimination of complete acoustical ceilings (up to \$2.50/ ft²)
- Leveling of uneven floor slabs in renovations (up to \$2.00/ ft²)



Life-cycle costs: Churn factors

Churn percentage (% of people that move per year)

IFMA 1997 average was 41%

Area per person (typically 100-350 ft² per person)

Cost savings per workstation move (estimates vary)

Equation for savings:

$$\begin{aligned} & [\% \text{ churn} / (\text{ft}^2 \text{ per person})] \times [\text{savings} / \text{workstation}] \\ & = \text{Annual Churn Savings} / \text{ft}^2 \end{aligned}$$



Life-cycle costs: Churn

- BOMA 2001 estimates:
 - Simple move with existing workspaces- \$322 per move
 - Relocating workstations and/or furniture- \$993 per move
 - Move with construction- \$2031 per move
- CBE estimates UFAD annual savings of \$0.26-\$1.82/ ft²
 - (using IFMA 41% churn, range represents 150-350 ft² /person)
- Owens Corning Headquarters study, savings of \$300 per employee move, \$0.45/ ft² annually (CMU 1997)



Hype vs. reality?

- Reality: UFAD systems offer the potential for greater flexibility, energy efficiency, and occupant comfort while creating savings in building life-cycle costs.
- Factors to UFAD project success include system design, climate, design integration, and building management practices.
- Technology has moved beyond early adopters, and is becoming better understood, however challenges still exist for teams doing their first implementation.

Additional documentation and research ongoing...



Resources and contact information

UFAD technology website

www.cbe.berkeley.edu/underfloorair/

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