



# Underfloor Air Distribution Systems

## David Stenftenagel

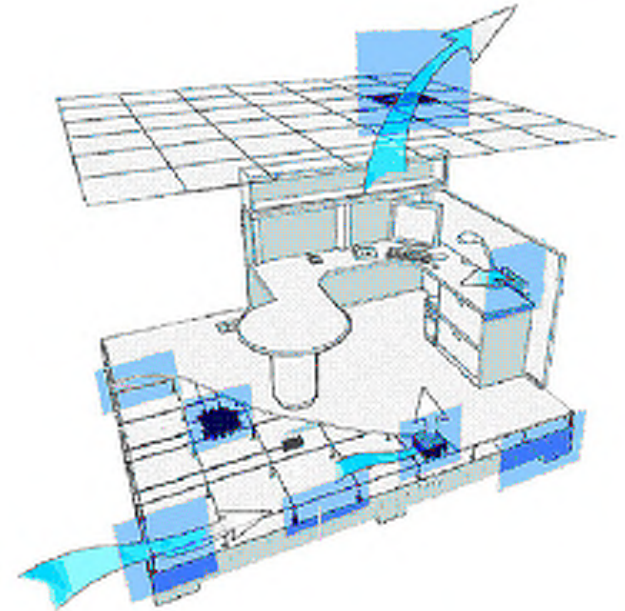
York International

- Why use Underfloor Air?
- What is Underfloor Air Distribution (UFAD)?
- How Does it Work?
- Features and Benefits
- Lessons Learned



# Potential UFAD Benefits

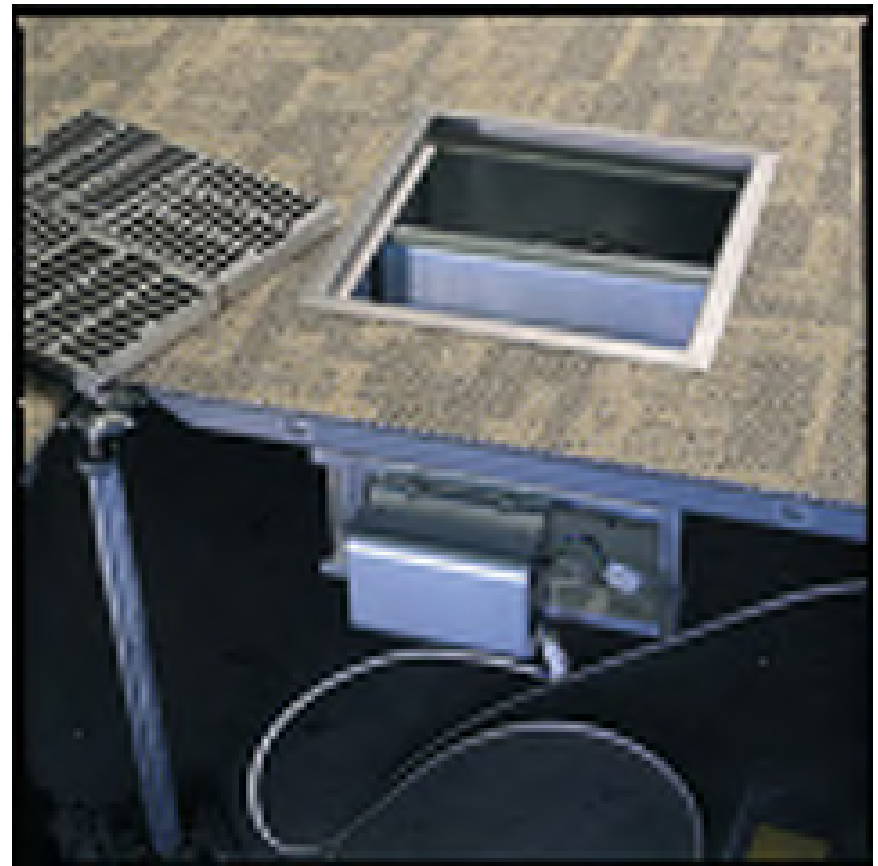
- Improved occupant comfort, productivity and health
- Improved ventilation efficiency and indoor air quality
- Reduced energy use
- Reduced life-cycle building costs
- Improved flexibility for building services
- Reduced floor-to-floor height in new construction





# What is Underfloor Air Distribution?

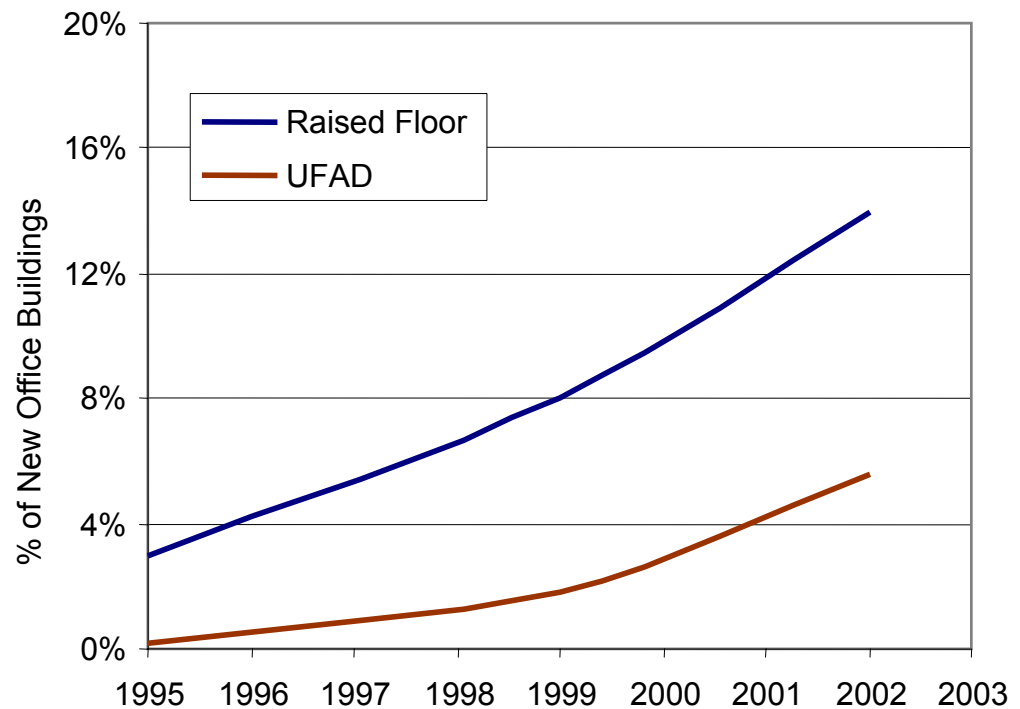
*“Instead of air being introduced through a ducted overhead system, air is distributed via the plenum space under a raised access floor system and introduced through a series of diffusers which are installed in the raised floor panels.”*





# 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.





# Underfloor vs. Conventional Air Distribution System Design Issues

- Underfloor air supply plenum
- Air supplied into occupied zone near floor level
- Higher supply air temperatures (for cooling)
- Allows for occupant control
- Properly controlled stratification leads to reduced energy use while maintaining comfort
- Reduced space sensible heat load
- Perimeter zone solutions are critical
- Access floor improves flexibility and re-configurability

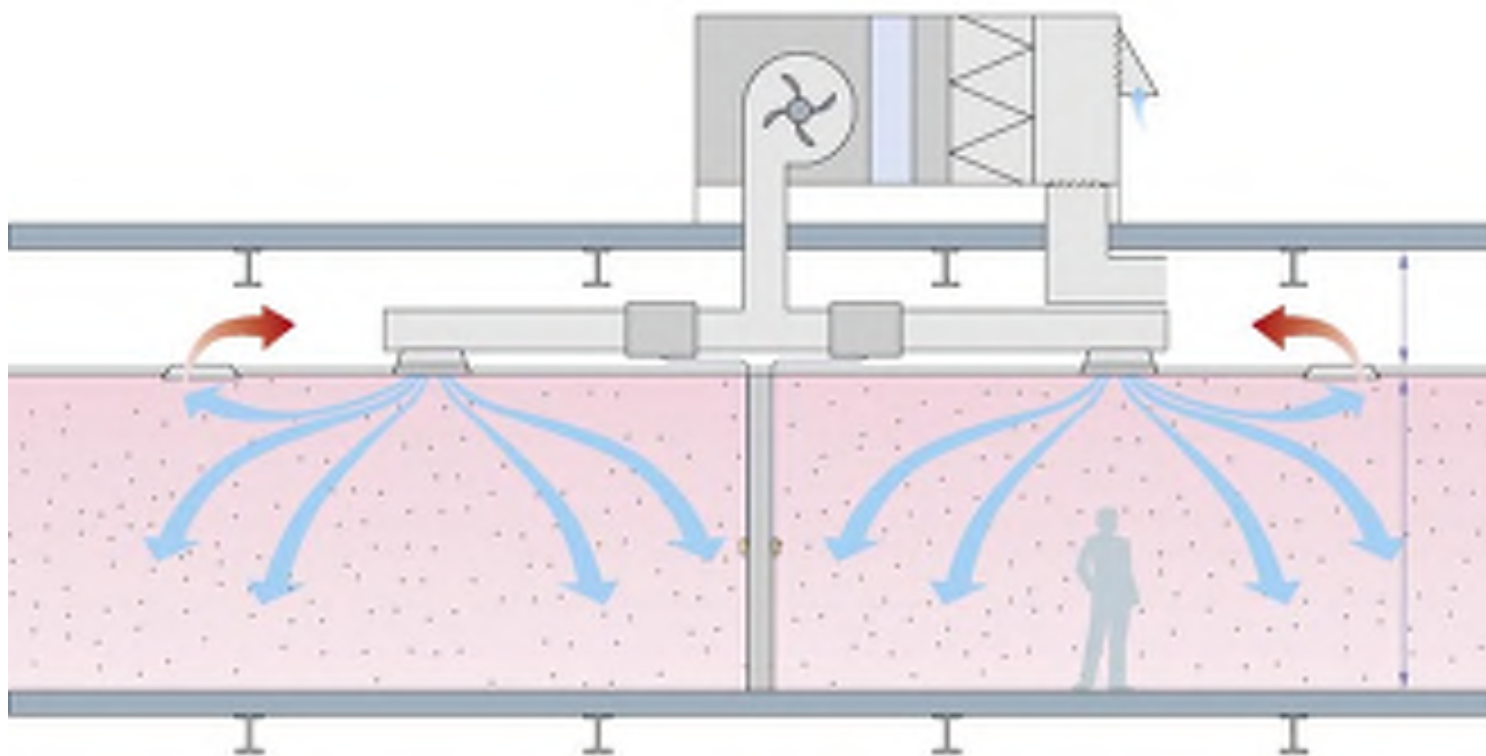


# How Does it Work?



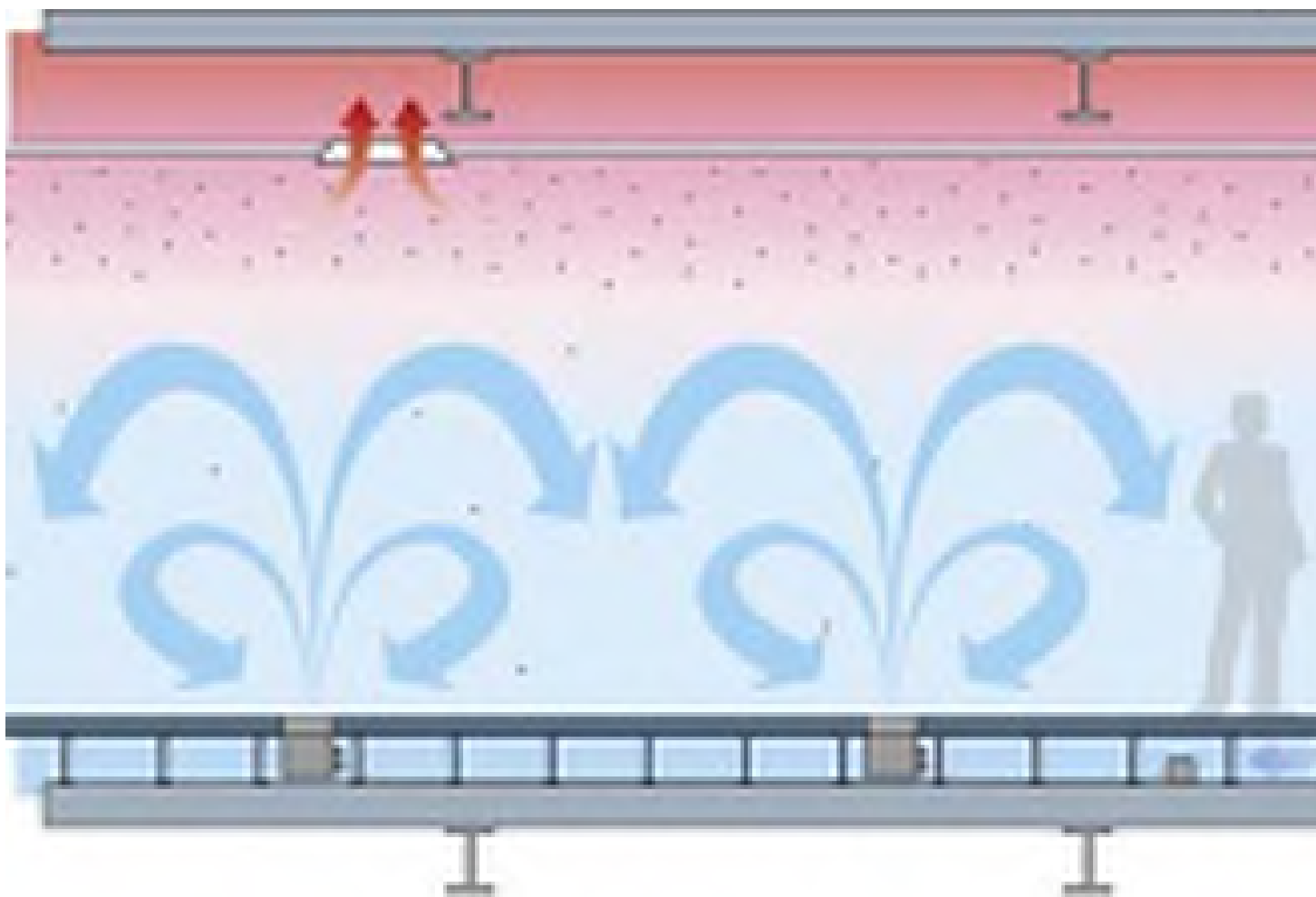


# Overhead Air Distribution System





# Underfloor Air Distribution System





# Types of Diffusers

## Motorized Diffusers

- Operates a damper via thermostatic controls



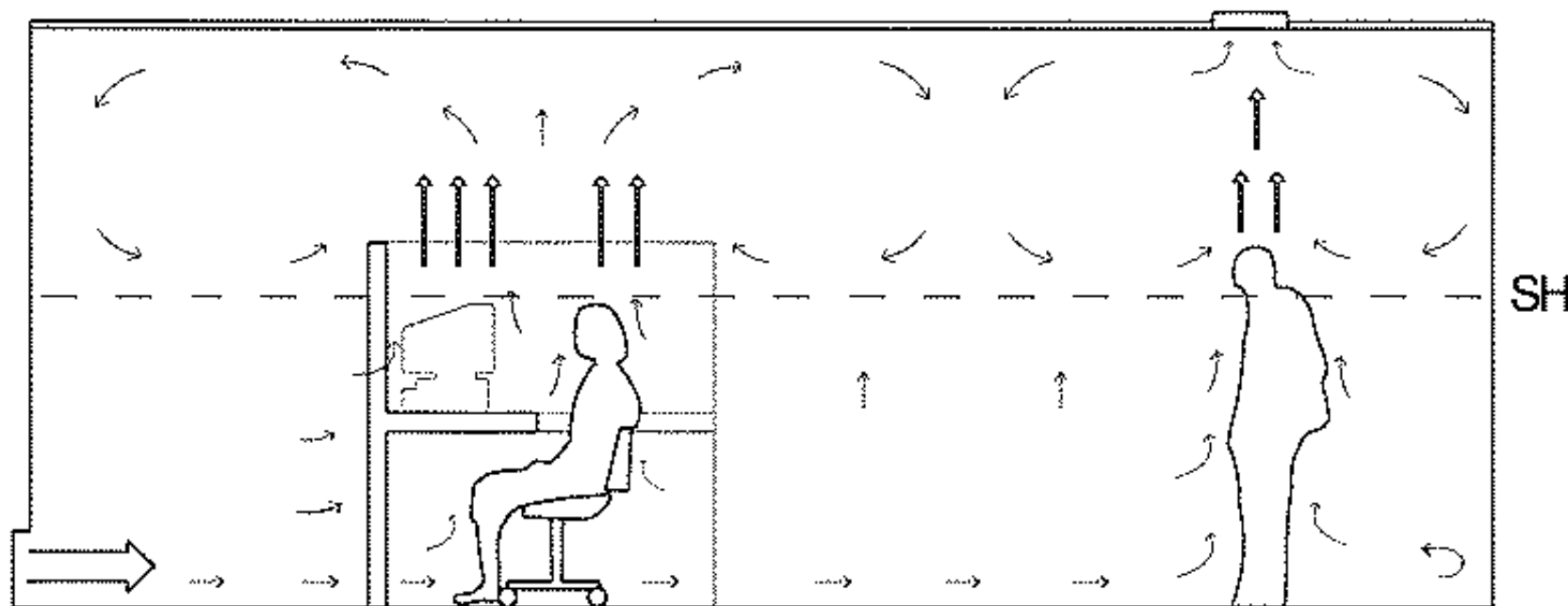
## Swirls Diffusers

- Air Flow is manually controlled at each diffuser





# Displacement Ventilation System



Minimize mixing in occupied zone



# Cost Issues-Raised Access Floor and Diffusers

In most cases the additional cost the raised access floor and diffusers will be offset by the realized saving related to other trades such as HVAC, Power, Voice, and Cabling.





# HVAC Cost Savings

## Duct Work Cost

- Sheet Metal
- Fabrication
- Installation
- Majority Eliminated

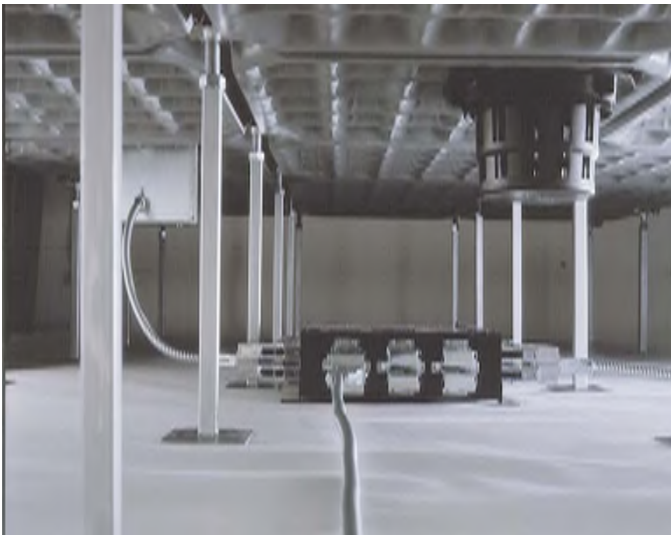
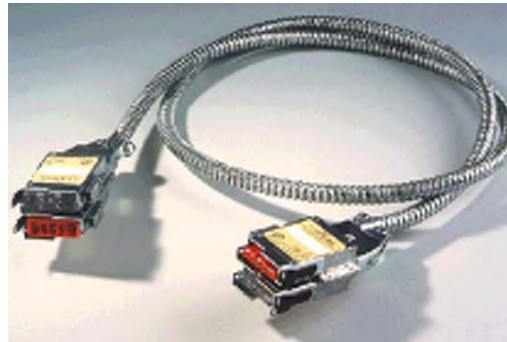


Overhead HVAC Ductwork



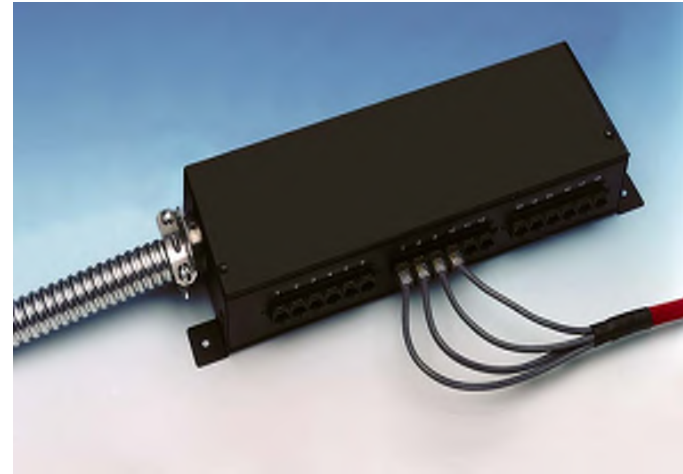
# Power Savings

- Power supplies are placed under the raised floor.
- "Plug & Play Power Controls make for faster installation.

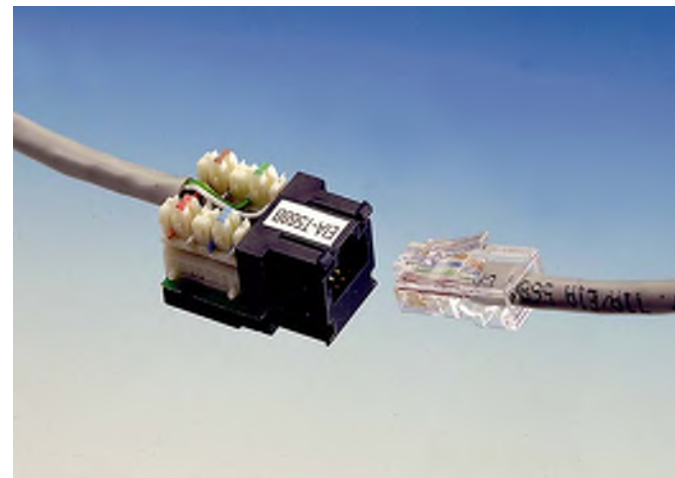




# Voice and Cabling Savings



"Plug & Play" Voice  
and Cabling Systems  
are easily installed  
under the raised floor.





# Voice and Cabling Savings



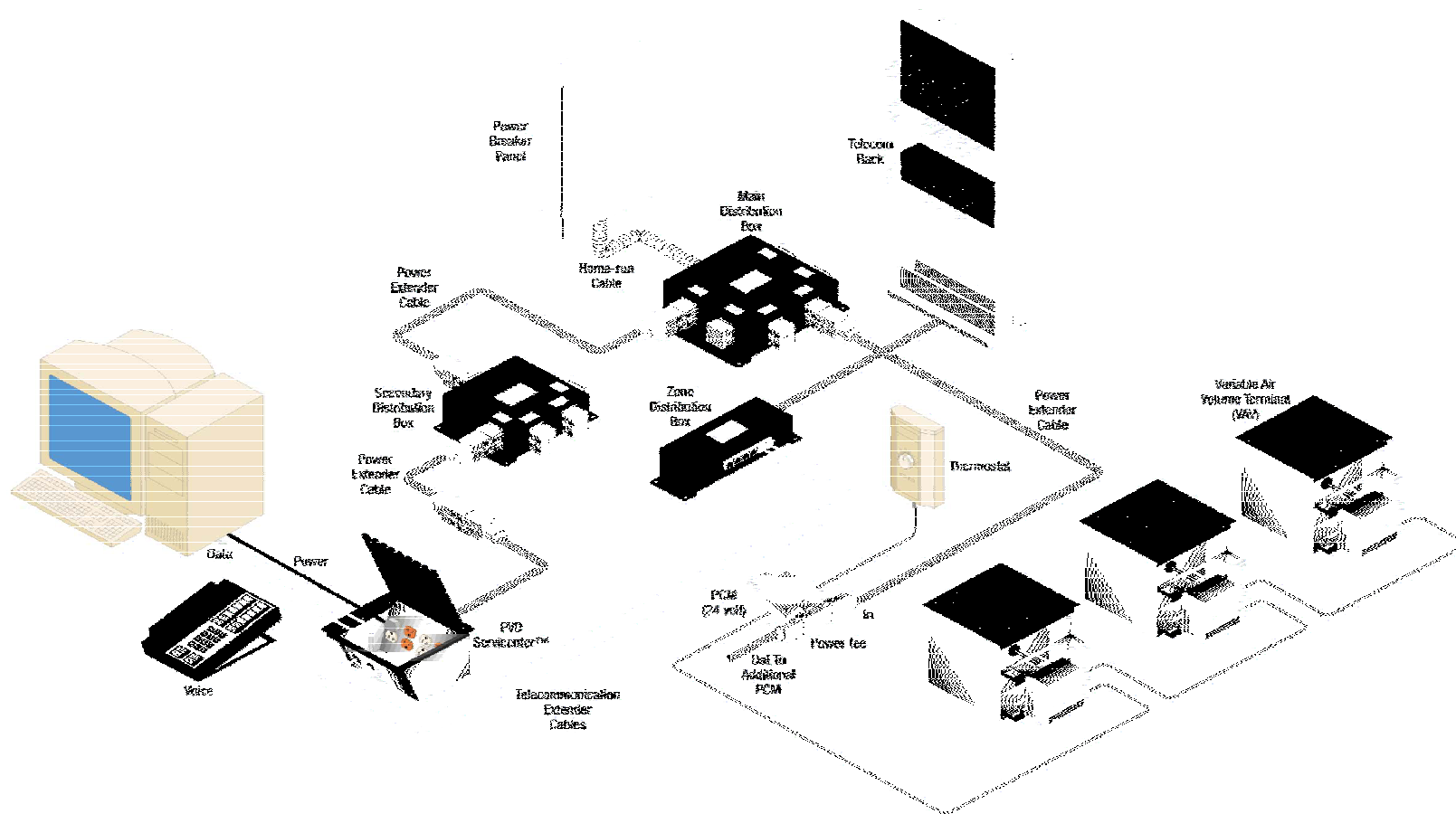
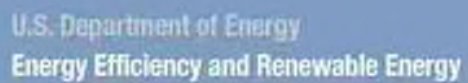
Difficult and costly  
overhead installations  
are eliminated.





# State of the Art Integrated System







# Underfloor Air Distribution Benefits

- Flexibility to make changes
- Improved indoor environmental quality
- Energy savings
- Reduced lifecycle cost of building



# Flexibility

- \*The entire under floor space is a plenum
- \*Conditioned air available *anywhere*
- \*Add terminals in minutes
- \*"Plug & Play" power and controls
- \*Re-zone & add zones in minutes
- \*Reconfigure HVAC easier than furniture

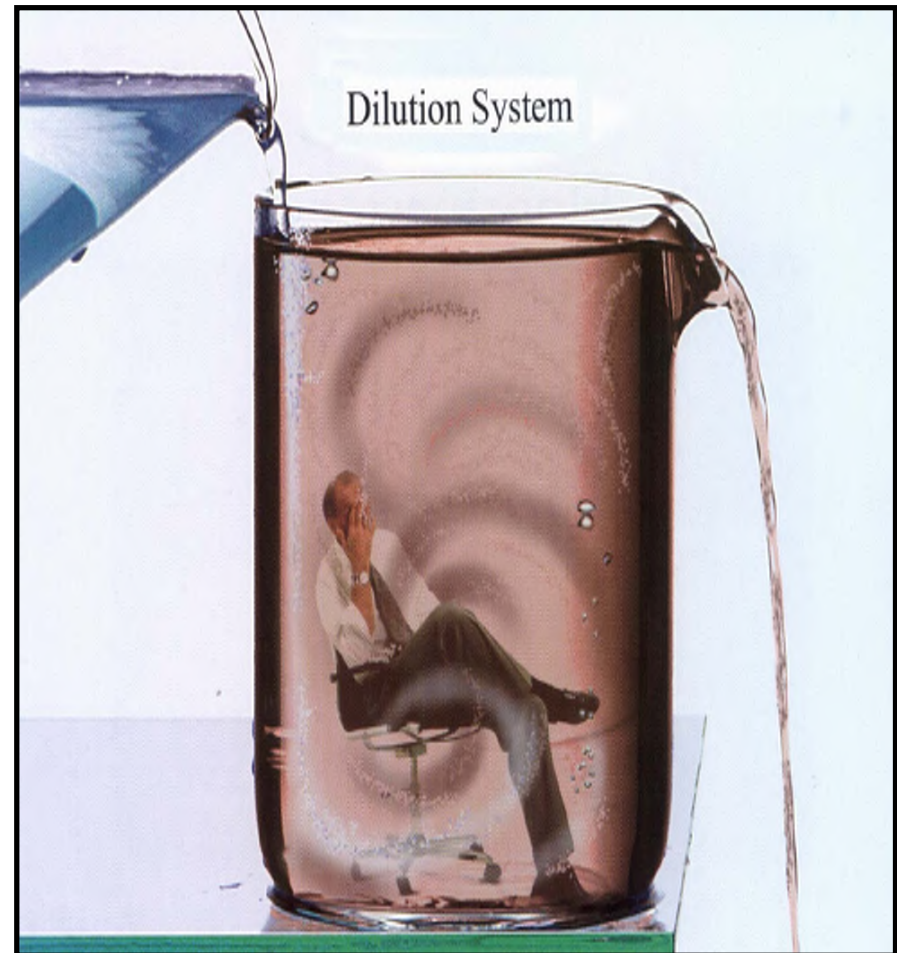




# IAQ with Conventional Overhead Air Distribution

All the supply air is injected, high in the space, at a velocity designed to create mixing within the room. Then some of the mixed air is drawn off, usually at ceiling level, as return or exhaust air.

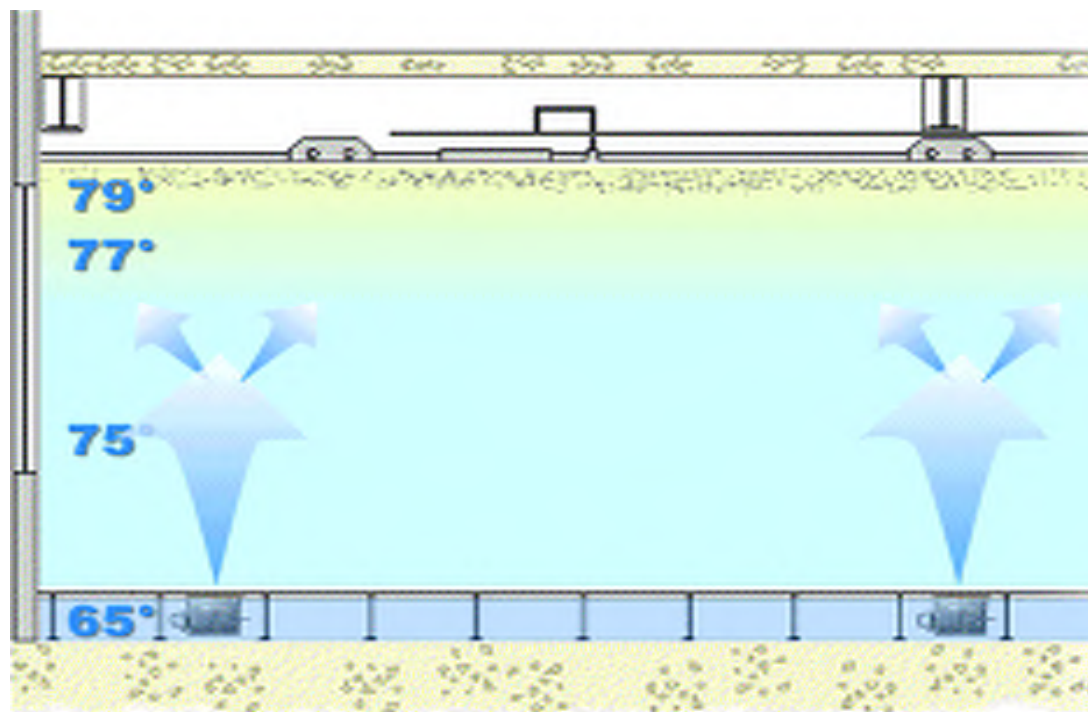
Thus pollutants and germs must be disseminated throughout the room, they are actively spread and shared between all room occupants.





# Improved Indoor Air Quality

- \*Occupant gets first use of conditioned air
- \*Convection enhanced ventilation (CEV) cools and ventilates people first
- \*Single pass of air pushes pollutants up to ceiling





# IAQ with Underfloor Air Distribution

UFAD stratifies the air and prevents mixing. Pollutants are carried upwards, in thermal plumes, out of reach of occupants. Concentrated pollutants are removed via exhaust at highest points in room. Occupants located in clean zone constantly breathe uncontaminated air. No sharing of pollutants and germs between room occupants.





# Indoor Air Quality

- Traditional approach
  - Provide uniform ventilation throughout space
- Underfloor approach
  - Fresh air is delivered closer to the occupants
  - Floor-to-ceiling air flow pattern provides improved IAQ in occupied zone (up to 6 ft [1.8 m])
  - Local air supply improves air motion, preventing sensation of stagnant air (associated w/ poor IAQ)



# Thermal Comfort

## Variations in Individual Preferences

- Clothing
- Activity level
- Body weight & size
- Personal preferences





# Thermal Comfort

- Traditional approach
  - Satisfy up to 80% of building occupants
- Underfloor approach
  - Allow personal control of the local thermal environment – satisfy up to 100% of occupants – reduce occupant complaints



# Energy Savings

**20% - 30% total energy savings vs. overhead HVAC system**

\*Reduced fan horsepower and energy consumption due to very low differential static pressure (0.05" vs. 1.5-2.0" typical for overhead supply air systems)

\*More hours of free cooling since air is delivered at 63<sup>0</sup>F- 65<sup>0</sup>F vs. 55<sup>0</sup>F for overhead systems



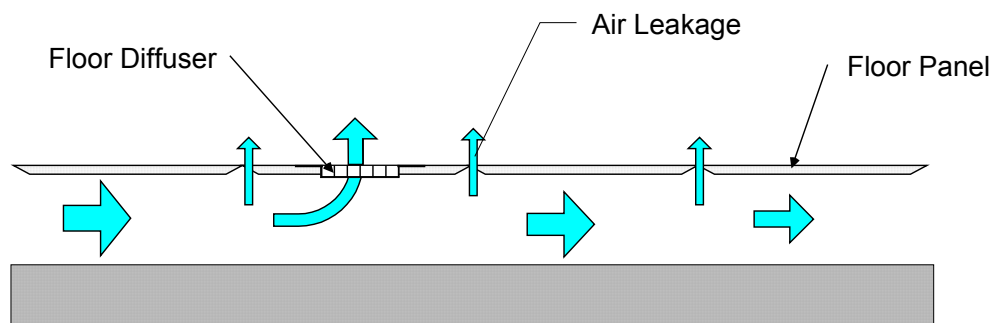
# Reduced Fan Power

- Underfloor plenum is the primary air distribution route
- UFAD systems use less ductwork than OH systems
- Primary fan pressure reduced 1/2 to 1 in. H<sub>2</sub>O, a reduction of about 25%
- Substantial energy savings on primary fan power possible, however this may be offset by fan-powered boxes or terminals



# Plenum Air Leakage

- Air leakage from a pressurized plenum may impact energy use and can impair system performance if not accounted for.



- Types of leakage
  - Leakage between floor panels
  - Leakage due to poor sealing and construction





# Carpet Tile Configurations



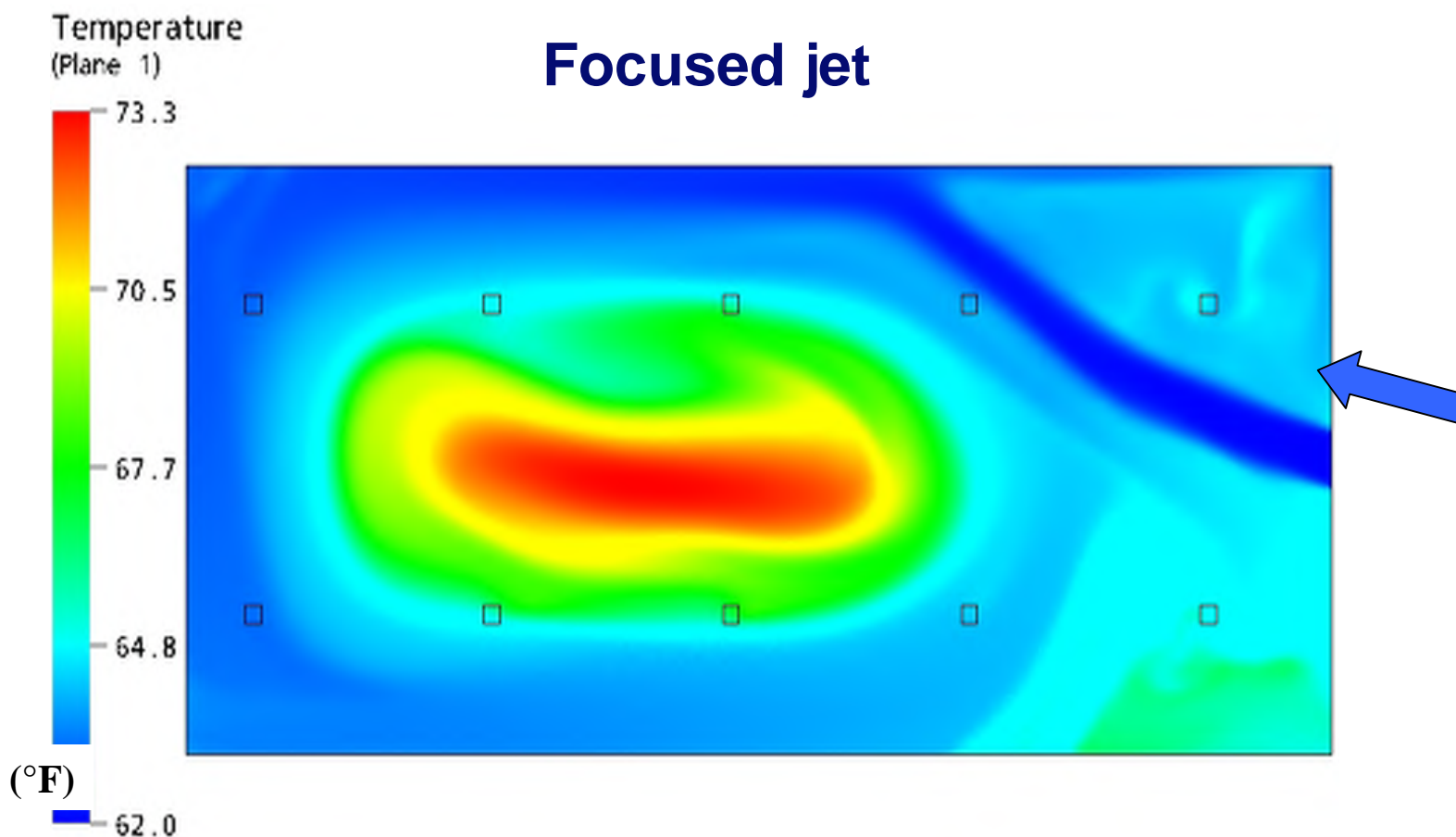
Aligned



Offset



# Plenum Air Temperature – CFD Model





Design and construction practices that significantly reduce or eliminate the negative impact of buildings on the environment and occupants in five broad areas:

Sustainable site planning

Safeguarding water and water efficiency

Energy efficiency and renewable energy

Conservation of materials and resources

Indoor environmental quality

## Summary of Potential LEED Points

Optimized energy performance	1 – 4 points
Recycled content	1 – 2 points
Regional materials	1 point
Carbon dioxide monitoring	1 point
Increased ventilation effectiveness	1 point
Construction IAQ Management Plan	1 point
Controllability of systems	1 point
Thermal comfort	1 – 2 points
Low-emitting materials	1 point
Daylight and views	1 – 2 points

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<b>Potential Contribution</b>	<b>10 – 16 points</b>
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# Potential LEED points with UFAD

- Energy & Atmosphere
  - **Optimized energy performance** – reduce building energy use below levels specified in ASHRAE Standard 90.1 (1-10 pts)
- Indoor Environmental Quality
  - **Improved ventilation effectiveness** – performance of UFAD system results in ventilation effectiveness greater than 0.9 (average for overhead mixing systems), as measured according to ASHRAE Standard 129-1997 (1 pt)
  - **Controllability of systems** – provide individual control of thermal, ventilation, and lighting systems to support improved occupant comfort, health, and productivity (1-2 pts)



# Case Study: MIT Stata Center - Cambridge



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



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



# Liberty View Elementary School – Oathe, KS



Olathe, Kansas  
(near Overland Park)  
78,000SF Elementary School





## **Blue Valley Elementary School # 19**

### **DDVAV .vs. FlexSys**

Values were calculated on 55,800 sq. ft. (Athletic / Kitchen wing not included).

	<u>Dual Duct</u>	<u>FlexSys</u>	<u>SAVINGS</u>
AHU 1,2,3	\$44,000	\$44,000	
Labor @ \$5,000 each AHU	\$15,000	\$15,000	
Boilers 1,2,3, installed	\$75,000	\$75,000	
Chillers, air cooled scroll	\$94,824	\$94,824	
Sheet Metal - dual duct sys (\$7.15/sq ft)	\$399,000	\$60,000	<b>\$339,000</b>
MIT / MFT w/controls & floor grilles installed	- - - -	\$118,955	( <b>\$118,955</b> )
DDC Controls (52 dual duct units)	\$30,200	- - - -	<b>\$30,200</b>
Test & Balance	\$40,000	\$10,000	<b>\$30,000</b>
Tate floor (38,000 sq ft)	- - - -	\$202,650	( <b>\$202,650</b> )
Electrical: Floor recept., wire, & cable	- - - -	\$10,200	( <b>\$10,200</b> )
Electrical: Wall recept., wire, & cable	\$66,629	\$39,978	<b>\$26,651</b>
Electrical: Labor	\$179,854	\$119,783	<b>\$60,071</b>
G.C. cost for electrical	\$50,000	- - - -	<b>\$50,000</b>
G.C. cost for AS IS walls & penthouse	\$194,921	- - - -	<b>\$194,921</b>
G.C. cost for proposed Low walls & basement	- - - -	\$147,765	( <b>\$147,765</b> )
Data Cable installed classrooms (150 drops)	\$30,000	\$17,000	<b>\$13,000</b>
Hot Water System/ w/labor		\$30,000	( <b>\$30,000</b> )
	<u>\$1,219,428</u>	<u>\$985,155</u>	<u><b>\$234,273</b></u>
<b>Operating Savings assumptions:</b>			
1. 65° Air Temp = 17% to 30% chiller savings		(CMR) 6% Job Expense	\$14,056
2. ASHRAE 62 Ventilation Effectiveness: Ve = 1.2 vs 0.8		(CMR) 7% Overhead	\$16,399
		(CMR) 8% Profit	\$18,742
			<u><b>\$283,471</b></u>
<b>Predicted Annual operating cost: HVAC</b>	<b>\$43,500</b>	<b>\$30,451</b>	<b>\$13,049</b>





# In Summary:

- Underfloor air distribution is the next generation in air conditioning systems.
- Provide significantly better indoor air quality.
- Provides a medium for easier installation of other trades.
- Enhances a buildings ability to change and adapt to its own needs and requirements.
- Reduces operating cost and reduces a buildings lifecycle cost.



- ❑ ***University of California at Berkeley*** - Center for the Built Environment  
[www.cbe.berkeley.edu/underfloorair](http://www.cbe.berkeley.edu/underfloorair)
- ❑ ***Carnegie Mellon University*** - Center for Building Performance & Diagnostics  
[www.arc.cmu.edu/cbpd](http://www.arc.cmu.edu/cbpd)
- ❑ ***Center for Renewable Energy & Sustainable Design*** [www.crest.org](http://www.crest.org)
- ❑ ***Rocky Mountain Institute*** [www.rmi.org](http://www.rmi.org)
- ❑ ***U.S. Green Building Council*** [www.usgbc.com](http://www.usgbc.com)
- ❑ ***General Services Administration*** [www.gsa.gov](http://www.gsa.gov)



Thank You!