



Rebecca Rubert  
Mechanical Option

NWI Enterprises  
Frazer, PA



NWI Enterprises

Corporate Office Building

Honors Senior Thesis    April 16, 2003



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## Outline

- Existing Conditions
- DOAS/Radiant System
- Cost Analysis
- Lighting Study
- Productivity Study



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## Project Team

- Owner: NWI Enterprises
- Architect/Engineer/Interior Designer: Kling
- General Contractor: Barclay White



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# Existing Conditions



## Site Conditions

- Site previously utilized by the owner
- Master Plan to include 885,000 ft<sup>2</sup>
- Two buildings:
  - Phase 1-336,000 ft<sup>2</sup>
  - Phase 2-186,000 ft<sup>2</sup>





## Existing Conditions-Architectural



- Red brick curtain wall enclosure
- Aluminum window system
- Mechanical penthouses
- Office space
- Dining room/Servery
- 24-space parking garage



## Existing Conditions-Building Systems

- Structural-Steel Framing
  - Lateral System-Braced Frames
  - Gravity System-Composite Beams
- Electrical/Lighting
  - Existing 4160V substation serves 480Y/277V transformers throughout the campus via underground 5 kV cables
  - Indoor lighting-fluorescent and incandescent lamps



## Existing Conditions- Central Chiller Plant

- Located in Phase 1 building
- (3) 650-ton water cooled vapor compression chillers
- (1) 650-ton gas-fired LiBr absorption chiller
- (4) Induced draft cooling towers located in service yard





## Existing Conditions- Air Handling System

- (4) 45,000 cfm Rooftop Air Handling Units (AHU)
- VAV air distribution system
- Cooling coils served by 44° F chilled water from chilled water plant
- Air is supplied at 55° F



## Problems with the System

- VAV system does not adequately meet the intent of ASHRAE Standard 62-2001
- Less than adequate quality of indoor air
- Less than thermally comfortable

## Proposed Solution

- Dedicated Outdoor Air System (DOAS) in parallel with a Radiant Cooling Panel chilled ceiling



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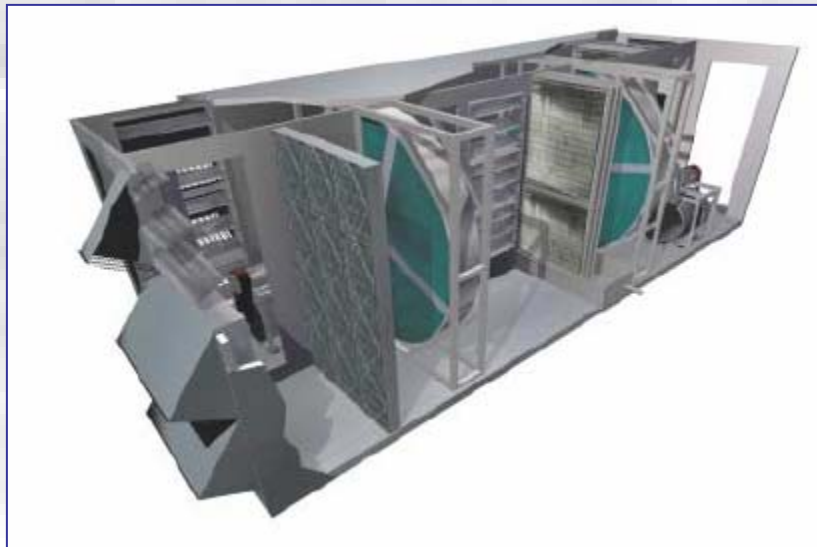
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# Mechanical Study



## Dedicated Outdoor Air System

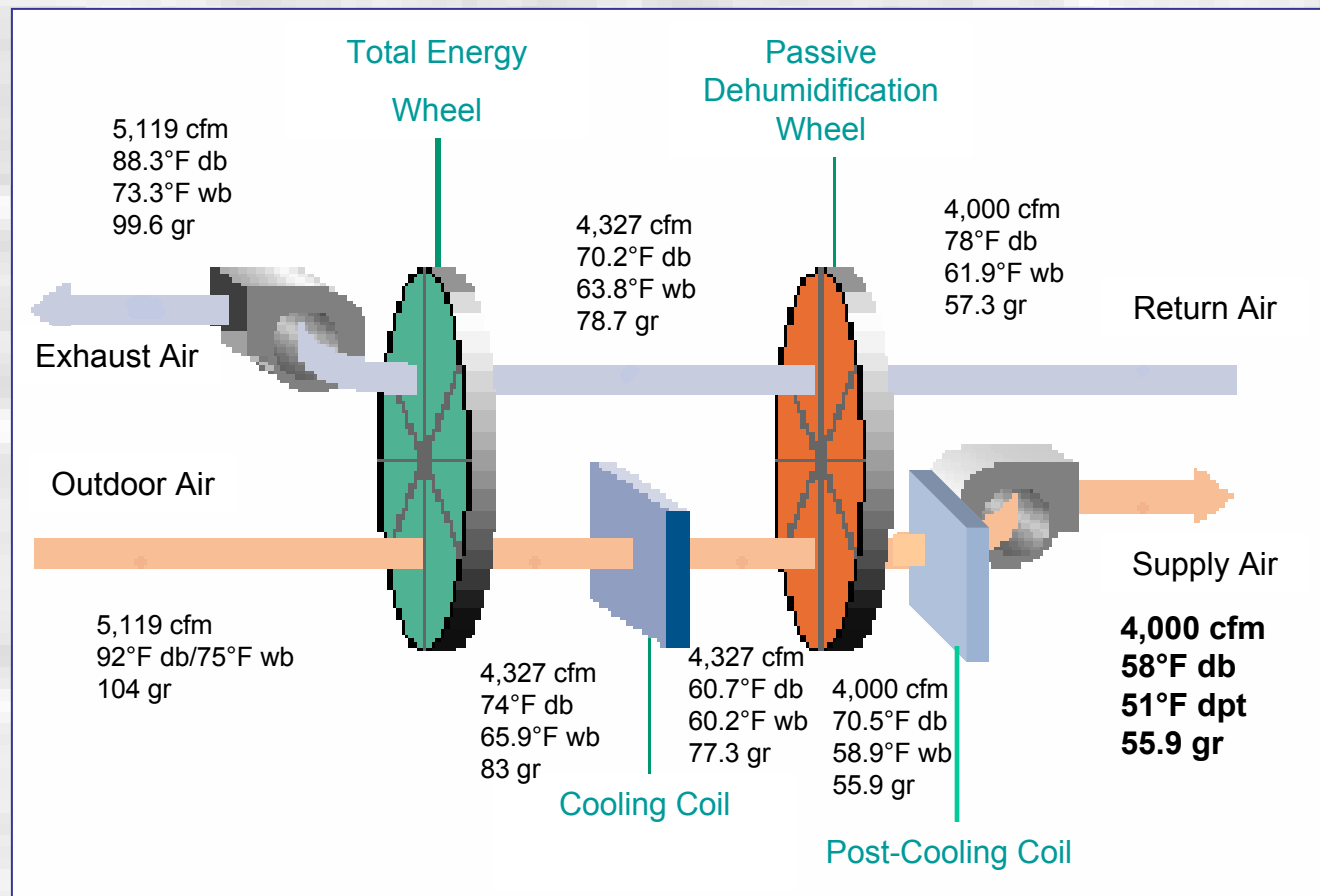
- Replaced existing 45,000 cfm rooftop AHUs with SEMCO **Pinnacle Ventilation Systems** (PVS) that handle outdoor air exclusively



AHU-#	CFM
AHU-1	4,000
AHU-2	5,600
AHU-3	9,700
AHU-4	6,650



## Pinnacle Ventilation System





## Pinnacle Ventilation System Advantages

- Completely removes latent load
- Passive dehumidification wheel (PD) produces low dew point supply temperatures **no matter what the chilled water supply temperature is**
- Central plant supplies both buildings at the same CHW temperature



## Magic Six Panels



- Handles **sensible** load not met by DOAS system
- Not more than 50% of ceiling area
- 2'×4' Panels
- Free-hanging at a height of 8'-0"



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## Panel Piping

For security reasons, this picture is unavailable.





## Radiant Panel Control Closets

- Located in duct shafts-utilizes space open by using smaller ducts
- Contain valves for each “mini zone”
- Convenient to maintain and control manually

For security reasons,  
this picture is unavailable.



## System Energy Comparison

System	Chiller Load
VAV System	<b>541 tons</b>
DOAS/Radiant	<b>324 tons</b>

Electric Usage (kWh)		
Month	DOAS	VAV
Jan	540,757	606,443
Feb	517,403	579,503
Mar	609,632	687,669
Apr	616,664	714,326
May	654,107	764,653
Jun	768,431	911,262
Jul	839,679	952,718
Aug	805,920	935,599
Sep	744,782	886,787
Oct	630,335	734,301
Nov	599,605	683,471
Dec	596,817	670,487
Total	7,924,132	9,127,219
Savings		<b>1,203,087 kWh</b>



## System Cost Comparison First Cost

Item	Unit Cost-VAV	Units-VAV	VAV	Unit Cost-Parallel	Units-Parallel	Parallel	Savings
650 tonAbs Chiller	\$321,000	1	\$353,100	\$321,000	1	\$353,100	\$0
650 ton WC Chiller	\$229,500	3	\$757,350	\$229,500	2	\$504,900	\$252,450
350 ton WC Chiller	N/A	N/A		\$132,000	1	\$145,200	-\$145,200
650 ton CT	\$26,796	4	\$117,902	\$26,796	3	\$88,427	\$29,476
350 ton CT	N/A	N/A		\$16,433	1	\$18,076	-\$18,076
Ductwork <sup>1</sup>	\$4/ft <sup>2</sup>	186000	\$744,000	\$1/ft <sup>2</sup>	186000	\$186,000	\$558,000
AHU-1	\$77,808	1	\$85,589	\$24,378	1	\$26,816	\$58,773
AHU-2	\$77,808	1	\$85,589	\$26,366	1	\$29,003	\$56,586
AHU-3	\$77,808	1	\$85,589	\$35,903	1	\$39,493	\$46,096
AHU-4	\$77,808	1	\$85,589	\$28,372	1	\$31,209	\$54,380
Radiant Panels <sup>1</sup>	N/A	N/A	N/A	\$13/ft <sup>2</sup>	44528 ft <sup>2</sup>	\$636,750	-\$636,750

**Savings:**  
**\$255,733**



## System Cost Comparison Operating Cost

Electric Cost		
Month	DOAS	VAV
Jan	\$37,569	\$45,143
Feb	\$36,159	\$41,649
Mar	\$41,326	\$49,954
Apr	\$42,668	\$52,720
May	\$45,969	\$56,471
Jun	\$52,421	\$64,663
Jul	\$56,219	\$68,312
Aug	\$54,478	\$67,740
Sep	\$51,367	\$63,633
Oct	\$44,134	\$53,844
Nov	\$42,248	\$51,454
Dec	\$40,651	\$48,280
Total	\$545,207	\$663,860

**Savings:  
\$118,653**



## Drawbacks

- Radiant panels take up >50% of the ceiling in some spaces
  - May not be enough room for sprinkler heads
- Hard to sell the architect on lower ceiling heights in some rooms (8'-0")
- Free-hanging panels block light from luminaires



## Conclusions

- DOAS/Radiant System meets the intent of Standard 62-2001
- System saves on first cost and operating cost
- System reduces building electrical usage
- **Cost savings and increased occupant comfort outweigh the drawbacks**



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# Lighting Study



## Basis of Redesign

- Free-hanging radiant panels block light from luminaires in ceiling
- Must move luminaires down to the same level as radiant panels (8'-0")
- Reselect fluorescent fixtures for correct lighting power density and illuminance



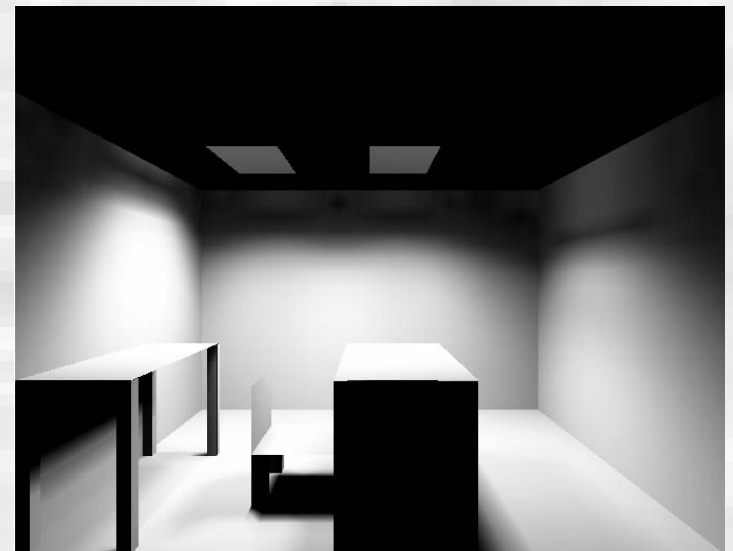


## Private Office



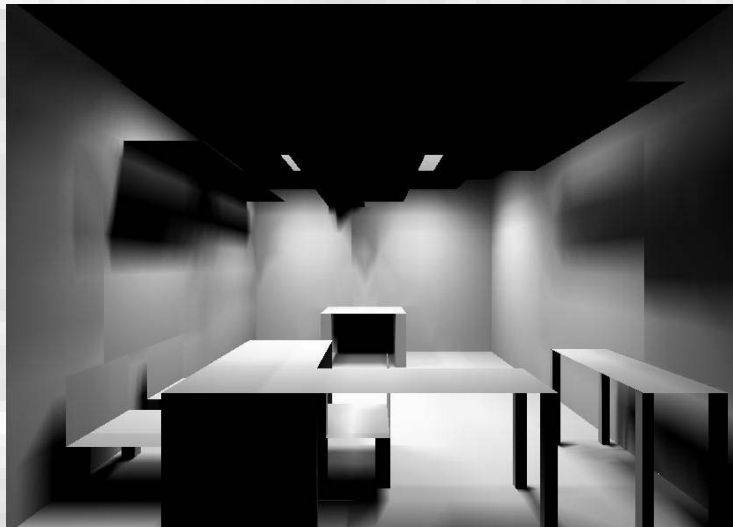
- Provides 49.7 fc
- LPD of 1.33 W/ft<sup>2</sup>

- (2) 3-32W lamp  
2'×4' fluorescent  
fixtures



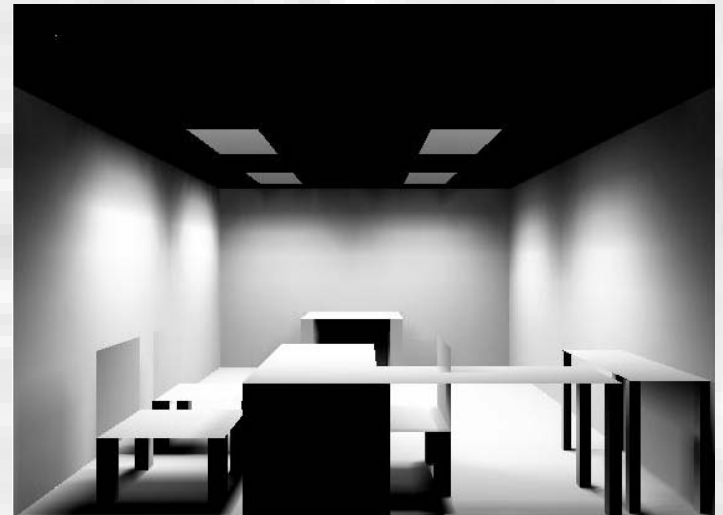


## Corner Office



- (4) 2-40W 2'×4' fluorescent fixtures

- Provides 35.7 fc
- 1.46 W/ft<sup>2</sup>





## Conference Room



- (3) 3-32W 2'×4' fluorescent fixtures
- (4) Track lighting fixtures

- 34.7 fc/46.6 fc
- 0.67 W/ft<sup>2</sup>/2.43 W/ft<sup>2</sup>





## Conclusions

- Necessary to move luminaires down to panel height for adequate illuminance
- Can afford to spend a little more on lighting because of the huge mechanical first cost savings



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# Productivity Study



## Basis of Study

- Smaller amount of ductwork in DOAS system requires less time to install
- Larger clearances in plenum due to smaller ductwork leads to increased productivity of crew



## Criteria

- Labor productivity is pounds of galvanized steel duct the crew can install in a day
- Labor productivity is a function of the weight of the steel in pounds
- 6% decrease in productivity from working above 10'-0"
- Conservative 10% increase in productivity from extra clearance in plenum



## Results

### Schedule savings with normal productivity

System	Time (man hours)	Time Savings	% Time Saved
VAV	1392		
DOAS-Normal productivity	603.5	<b>33 days</b>	56.7

### Schedule savings with 10% more productivity

System	Time (man hours)	Time Savings	% Time Saved
VAV	1392		
DOAS-Increased productivity	517.9	<b>3.5 days</b>	6.1
DOAS-Total productivity		<b>36.5 days</b>	62.8





## System Cost Comparison First Cost

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## Acknowledgements

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PSU AE Students

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Questions?



**Bring it  
on.**





## Existing Conditions-Architectural



- Bridge links Phase 1 and Phase 2
- Tunnel also links buildings underground



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## Magic Six Panels

Inlet Temp	52° F	<b>&gt;51° SA DPT</b>
Outlet Temp	60° F	
Mean Temp Difference	22° F	
Capacity	33.6 Btu/ft <sup>2</sup>	
Flow	0.606 gpm	
Velocity	85 fpm	<b>&lt;137 fpm</b>
Pressure Drop	2.8 psi	<b>&lt;3.0 psi</b>



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