Dan Saxton

Mechanical Option

STEM Center

Delaware County Community College – Media, PA

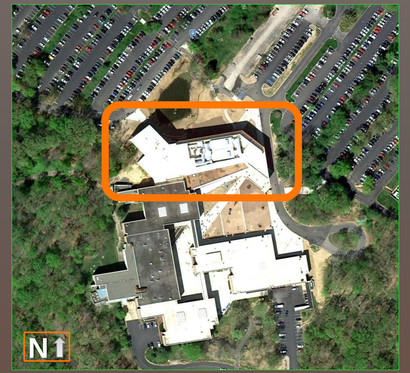
Thesis Final Presentation

Presentation Outline

- Introduction
  - **Building Information**
  - Existing Mechanical Design
  - Design Goals
- Radiant Floor Analysis
- Natural Ventilation Analysis
- Acoustical Breadth
- Construction Management Breadth
- Conclusion
- Acknowledgements
- Questions

STEM Center

Delaware County Community College – Media, PA



(Photos provided by Burt Hill)

Building Information:

- Part of new STEM Complex

- Building Area: **105,000 ft²**
- Building Height: **4 stories**

- Project Cost: $28.7 Million
- Construction Start: January 2008
- Construction End: December 2009

- Architects, MEP Engineers: **Burt Hill**

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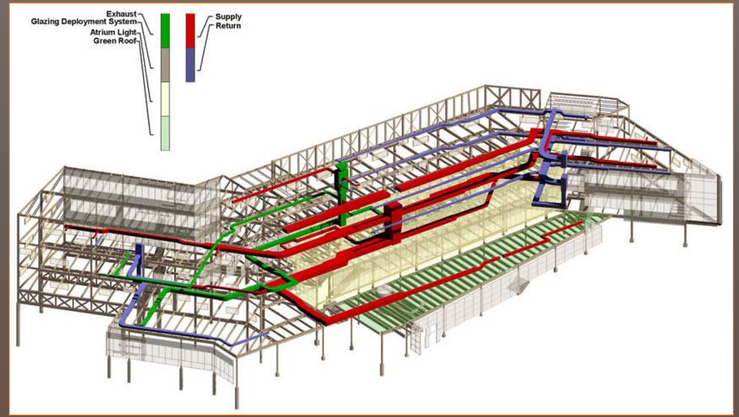
STEM Center

Delaware County Community College – Media, PA

Existing Mechanical Design:

- Chiller Plant: (1) 700 ton water-cooled chiller
- Heating Plant: (2) 250 BHP gas-fired boilers
- HVAC: (2) 89,500 CFM custom air handling units
  - Heat recovery
  - Variable air volume



(Photo provided by Burt Hill)

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Design Goals

- Lower Yearly Utility Costs
- Decrease Energy Consumption
- Greater System Efficiency
- Main Focus on Ground Floor

(Photo provided by Burt Hill)

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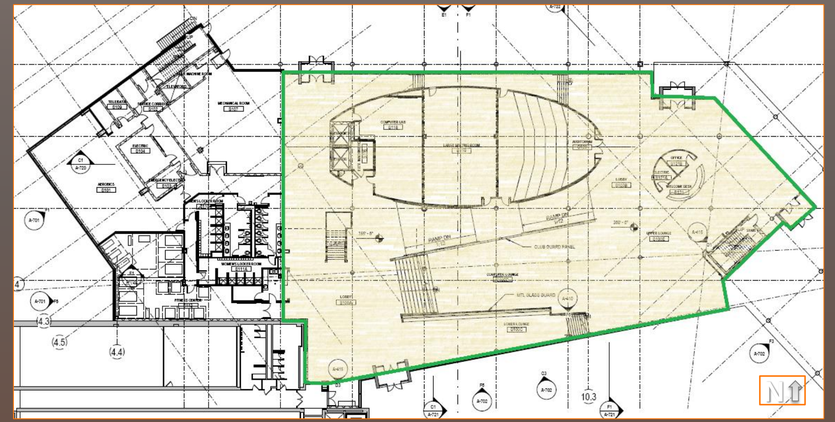
Radiant Floor Analysis

Alternate System Objectives

- Ground Floor: High volume spaces

- Condition the **occupants**, not the **space**

- Radiant Floor Heating: more common
- Radiant Floor Cooling: more unique



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Radiant Floor Analysis

Floor Design

- Floor Temperature Limits:
  - **67°F** for Cooling
  - **84°F** for Heating

- Cross-linked polyethylene (PEX) piping

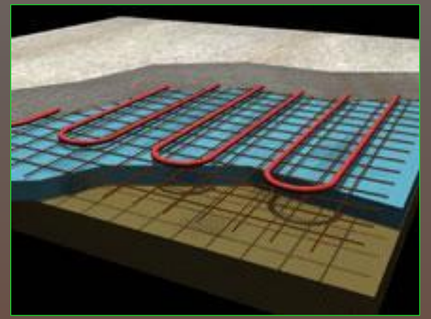
- 1-1/2” Gypsum Concrete

- Tile flooring required

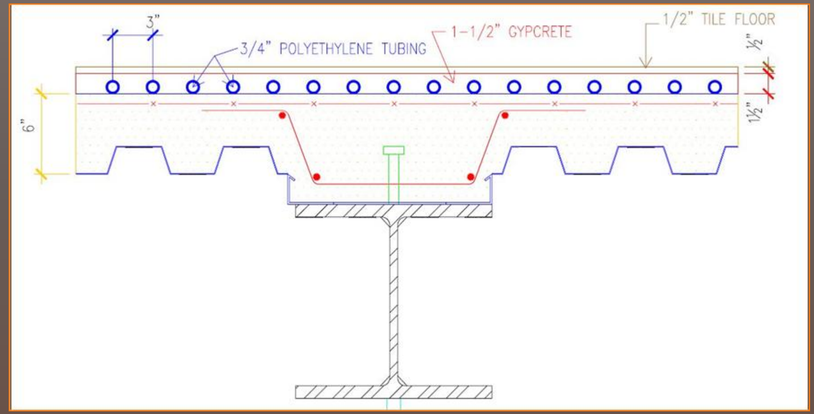
TABLE 5.2.4.4
Allowable Range of the Floor Temperature

Range of Surface Temperature of the Floor °C (°F)
19-29 (66.2-84.2)

ASHRAE Standard 55 (2004)



(Radiant Panel Association)



(Dustin Eplee, 2005)

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Radiant Floor Analysis

Increased Cooling Capacity

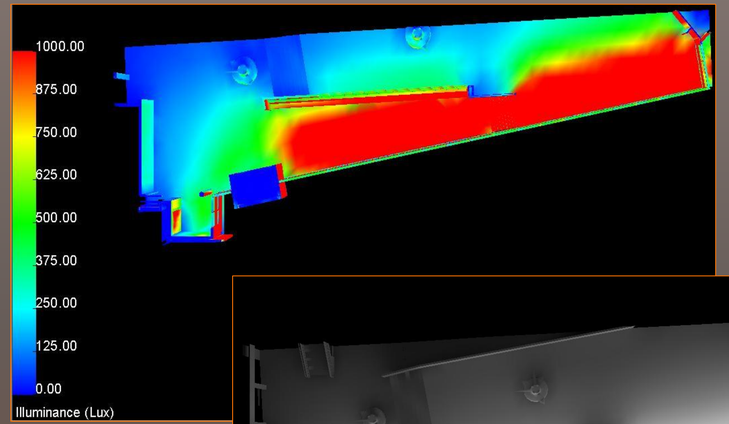
- Direct Sunlight: up to 2.89 times higher capacity

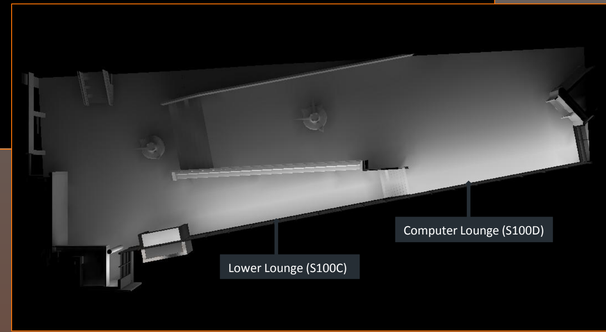
- South side curtain wall facades

AGI32 Daylight Study

- Sun Factors:
  - Lower Lounge: **2.51**
  - Computer Lounge: **1.60**

Lower Lounge Glass Façade





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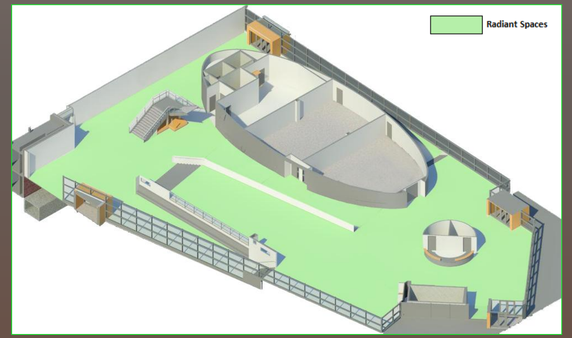
Radiant Floor Analysis

Adjusted Calculations

- Radiant floor: approx. **15,000 ft²** total



- **Radiant Floor**: Meets 100% of **Sensible Load** for both Heating and Cooling

RADIANT FLOOR HEATING SENSIBLE CAPACITY						
Room	Area (SF)	ΔT (°F)	Heating Coefficient	Sun Factor	RADIANT CAPACITY (BTUh)	Space Load (BTUh)
C-143 Lobby	5,011	10	1.94	1.00	97,213.40	49,628
C-243 Lobby	1,132	10	1.94	1.00	21,960.80	11,548
C-343 Lobby	1,154	10	1.94	1.00	22,387.60	13,195
C-443 Lobby	1,146	10	1.94	1.00	22,232.40	14,205
S100C Lower Lounge	1,220	10	1.94	1.00	23,668.00	18,481
S100D Comp Lounge	1,794	10	1.94	1.00	34,803.60	14,767
S100E Upper Lounge	3,063	10	1.94	1.00	59,422.20	16,479
S121 Welcome Desk	183	10	1.94	1.00	3,550.20	1,504
RADIANT FLOOR COOLING SENSIBLE CAPACITY						
C-143 Lobby	5,011	10	1.23	1.00	61,635.30	57,566
C-243 Lobby	1,132	10	1.23	1.00	13,923.60	10,924
C-343 Lobby	1,154	10	1.23	1.00	14,194.20	12,496
C-443 Lobby	1,146	10	1.23	1.00	14,095.80	13,573
S100C Lower Lounge	1,220	10	1.23	***2.51***	37,605.20	28,139
S100D Comp Lounge	1,794	10	1.23	***1.60***	35,305.92	34,993
S100E Upper Lounge	3,063	10	1.23	1.00	37,674.90	34,898
S121 Welcome Desk	183	10	1.23	1.00	2,250.90	2,095

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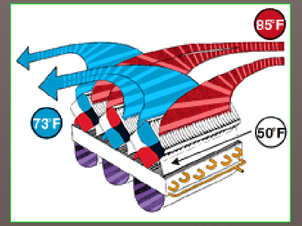
Radiant Floor Analysis

DOAS System

- Need to meet:
  - Latent Load
    - Use Heat Exchanger and Enthalpy Wheel
  - Ventilation
    - Maintain existing ventilation CFM

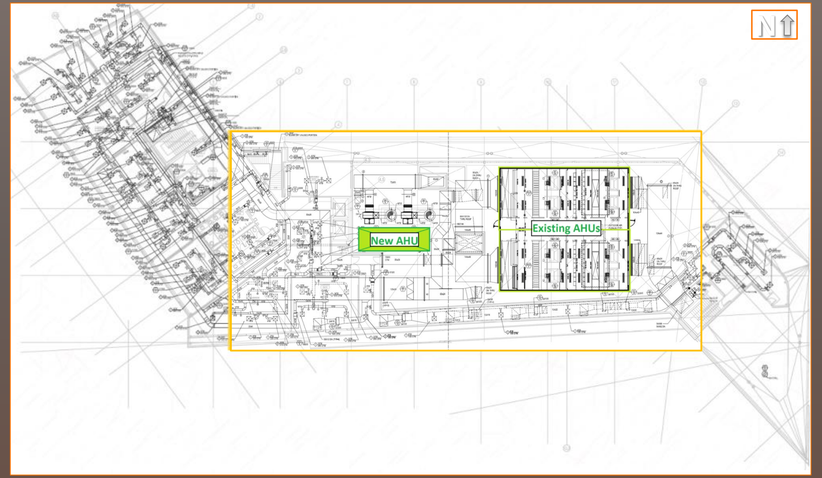


(MSP Technology)

TOTAL UTILITY SAVINGS:

- Slight decrease in yearly mechanical operating cost

Yearly Utility Costs		
	OLD SYSTEM	NEW SYSTEM
Electric	$210,505	$207,725
Gas	$8,954	$9,848
Total	**$219,459**	**$217,573**



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  - **Objectives**
  - CFD Model
  - CFD Results
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Natural Ventilation

Goals

- Study potential use of **exhaust-driven "natural" ventilation**

- Use Computational Fluid Dynamics (CFD) software
  - **PHOENICS VR 2009**

- Analyze natural airflow
  - **Velocity**
  - **Temperature**

- Compliance with ASHRAE Standard 55

(Photo provided by Burt Hill)

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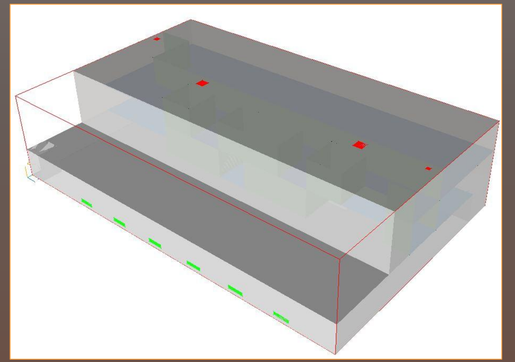
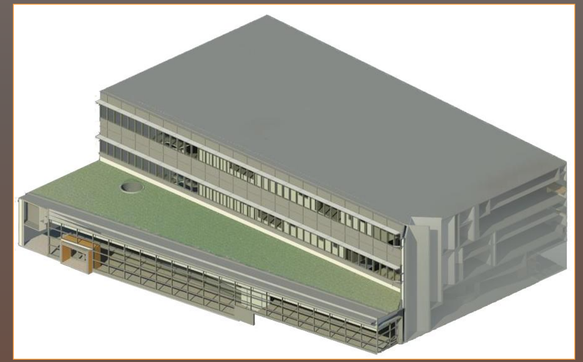
Natural Ventilation

CFD Model

- Weather Data for Philadelphia, PA
- Domain Mesh Refinement
- Turbulence Model: **k-ε**
- Numerical Differencing Scheme: **Hybrid**





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Natural Ventilation

CFD Results

Compliance with ASHRAE Standard 55

- **Section 5.2.4.2 – Draft**

Percentage Dissatisfied Due to Draft			
DR (%)	ta (°C)	v (m/s)	Tu
19.75%	21.24	0.27	0.10
18.46%	21.70	0.19	0.25
18.76%	21.84	0.18	0.30
18.74%	21.72	0.27	0.10
16.85%	21.88	0.24	0.10
17.56%	21.95	0.25	0.10
17.89%	22.08	0.26	0.10
17.37%	23.05	0.28	0.10
18.09%	23.23	0.30	0.10
18.81%	23.44	0.32	0.10
16.85%	22.62	0.25	0.10
16.25%	21.45	0.19	0.15

- **Section 5.2.4.3 – Vertical ΔT**

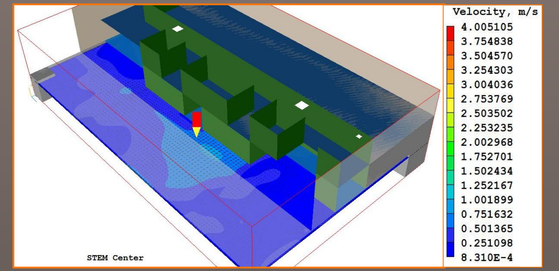
TABLE 5.2.4.3
Allowable Vertical Air Temperature Difference Between Head and Ankles

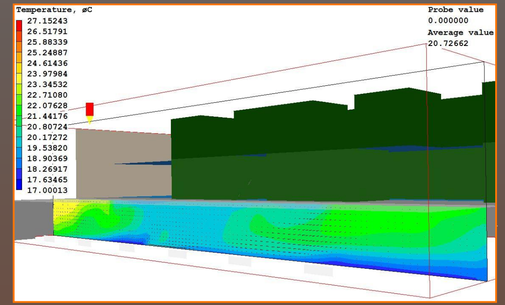
Vertical Air Temperature Difference °C (°F)
< 3 (< 5.4)

ASHRAE Standard 55 (2004)

Vertical Level	x (m)	y (m)	z (m)	Probe T (°C)	Difference (°C)
Ankles	30	1	0.1	18.01	1.11
Head	30	1	1.6	19.12	
Ankles	30	5	0.1	18.10	1.22
Head	30	5	1.6	19.32	
Ankles	30	10	0.1	19.97	0.61
Head	30	10	1.6	20.58	
Ankles	37	1	0.1	17.95	1.42
Head	37	1	1.6	19.37	
Ankles	37	5	0.1	18.53	2.13
Head	37	5	1.6	20.66	
Ankles	37	10	0.1	19.43	1.48
Head	37	10	1.6	20.92	

- **Natural Ventilation feasible to increase energy efficiency**





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Acoustical Breadth Analysis

- **Reverberation:** Floor finish change in Lounge spaces
  - Old flooring: **Carpet** **(α = 0.3425)**
  - New flooring: **Porcelain Tile** **(α = 0.01625)**

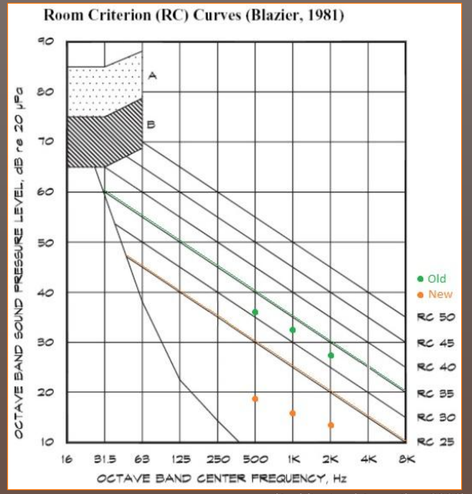
- Computer Lounge: **3,615.08 SF**

Upper Lounge	T60 (sec)
Old (Carpet)	**0.23**
New (Tile)	**0.31**

- Lower Lounge: **1,213.38 SF**

Lower Lounge	T60 (sec)
Old (Carpet)	**0.60**
New (Tile)	**0.80**

- **Mechanical Noise:** Reduction of terminal units



(Architectural Acoustics, 2006)

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Construction Management Breadth

- **Construction Implications of Radiant Floor**
  - **Cost**
    - Greater upfront cost
      - **$30,000** capital cost of alternative
  - **Schedule**
    - Construction duration
      - **1 month** increase
    - Complex radiant floor installation

DOAS System Costs		Initial Cost ($)
	AHU	$18,075.00
	HX/Wheel	$13,850.00
Radiant System Costs		
	Piping	$20,615.00
	Pumps	$6,570.80
Overall Redesign Savings		
	Terminal Units	-$27,058.00
	Ductwork	-$1,181.25
TOTAL		**$30,871.55**

Task	Old Days	New Days	Change Days
Rooftop HVAC Equipment	12	3	3
HVAC Pipe Rough-Ins	40	69	29
HVAC Equipment	20	18	-2
HVAC Duct Rough-Ins	10	9	-1
Porcelain Tile	17	22	5
Carpeting	10	0	-10
TOTAL			**+24 Days**

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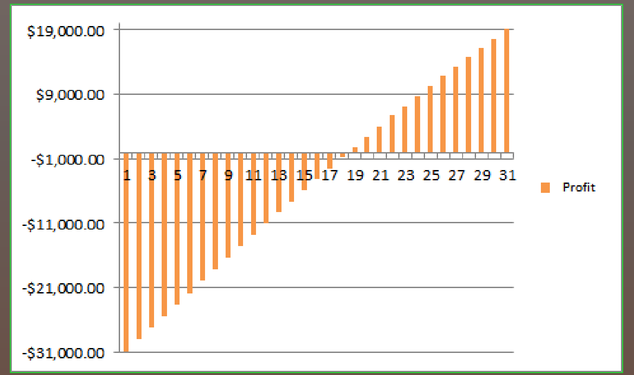
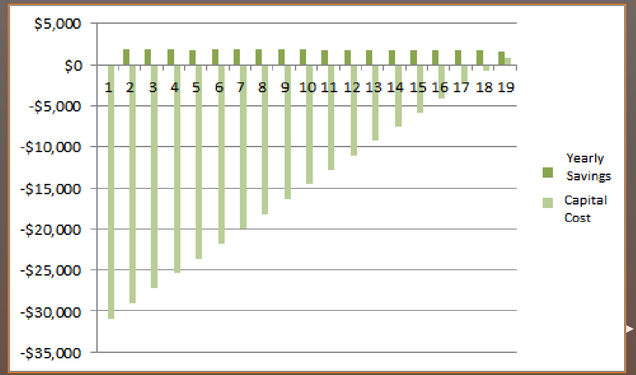
Cost Calculations

- Life-Cycle Cost for 30 years
  - **$19,073.15**



- Simple Payback
  - Profit after **18 years**



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Conclusion

- Implementation of Radiant Floor and DOAS Systems:
  - **$1,973 Yearly Savings**
  - **$30,128 Capital Investment**
  - **18-year Payback Period**
- Potential improvement through Natural Ventilation
- Overall Alternative Design
  - Improves Energy Efficiency
  - Maintains and Increase Occupant Comfort

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Special Thanks to:

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Burt Hill Architects

BURT, HILL

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