AE Senior Thesis on Mechanical System Redesign:

Applying Chilled Water VAV and DOAS HVAC system to the Medical Office Building

at Johns Hopkins Hospital

in Baltimore, MD

Presentation Outline

- Introduction of Building and Thesis
  - Current HVAC Equipment
- HVAC Equipment Selection
  - Alternative #1, Chilled Water VAV w/ Hot Water Reheat
  - Alternative #2, DOAS w/ active chilled/heated beams
  - Parallel System Selection
  - Enthalpy Wheel Selection
- IAQ Comparison
- Economic Analysis
- Breadth #1, Electrical Distribution Redesign
- Breadth #2, Constructability Review
- Thesis Conclusion

Building Introduction

- New Medical Office Building for JHH
- Area of 88,000 sq ft
- Approximate cost of 15.5 million dollars
- Four floors, one below grade, three above
- Stratified Use
  - Basement and First Floor contain examination rooms as well as phlebotomy, radiation, dialysis etc.
  - Second and Third Floor contain mostly JHH staff offices and conference rooms.

Building Location

Existing HVAC Equipment

- Six rooftop DX packaged units
  - 21,000cfm each at 10% OA
  - 61 Tons of cooling each
  - Ducted together in third floor plenum to serve entire building
- Heating by terminal electric reheat VAV boxes
  - 118 fan power boxes with reheating capability
- One 7.5 Ton FCU & ACCU
  - Serves the elevator mechanical room
  - Not considered for change in redesign

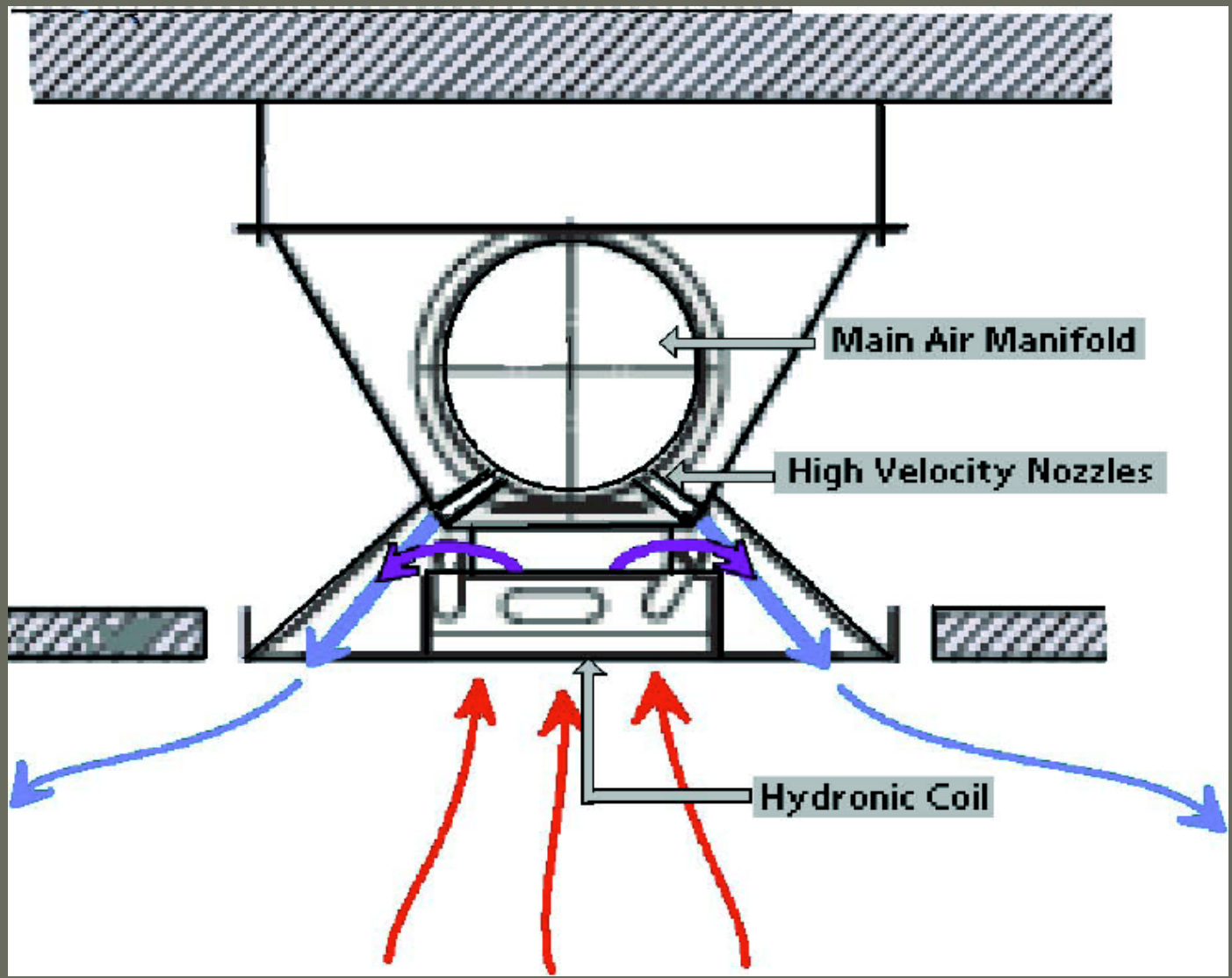
Alternative #1
VAV system with six rooftop AHUs

- Chilled water used for cooling
  - Generated at the South of Orleans Energy Plant
  - Supply temperature of 38F
  - Cost of $10.33 per MMBTU
- Hot water used for terminal reheat
  - Steam generated at the South of Orleans Energy Plant
  - Cost of $1.08 per therm

Alternative #2
DOAS with three rooftop AHUs

- AHU Differences
  - 19,000cfm per unit max
  - 86 Tons of cooling each
  - Temp of SA is 45 F
- Chilled water used for cooling
- AHUs paired with Enthalpy Wheel
  - Lessens impact of treating all outdoor air
- Heating and supplementary cooling accomplished through parallel system.

Trox Active Beam Section



Parallel System

- Active heated and chilled beams
  - Induces room air through a hydronic coil with high velocity supply air within the unit
  - Mounted Flush to acoustical ceiling
  - Four pipe system allows for heating and cooling
- Hot water (150F) supplied from steam to water HTX in lower level mechanical room
- Cold water (60F) tapped from AHU return line (52F) and mixed to proper temp.

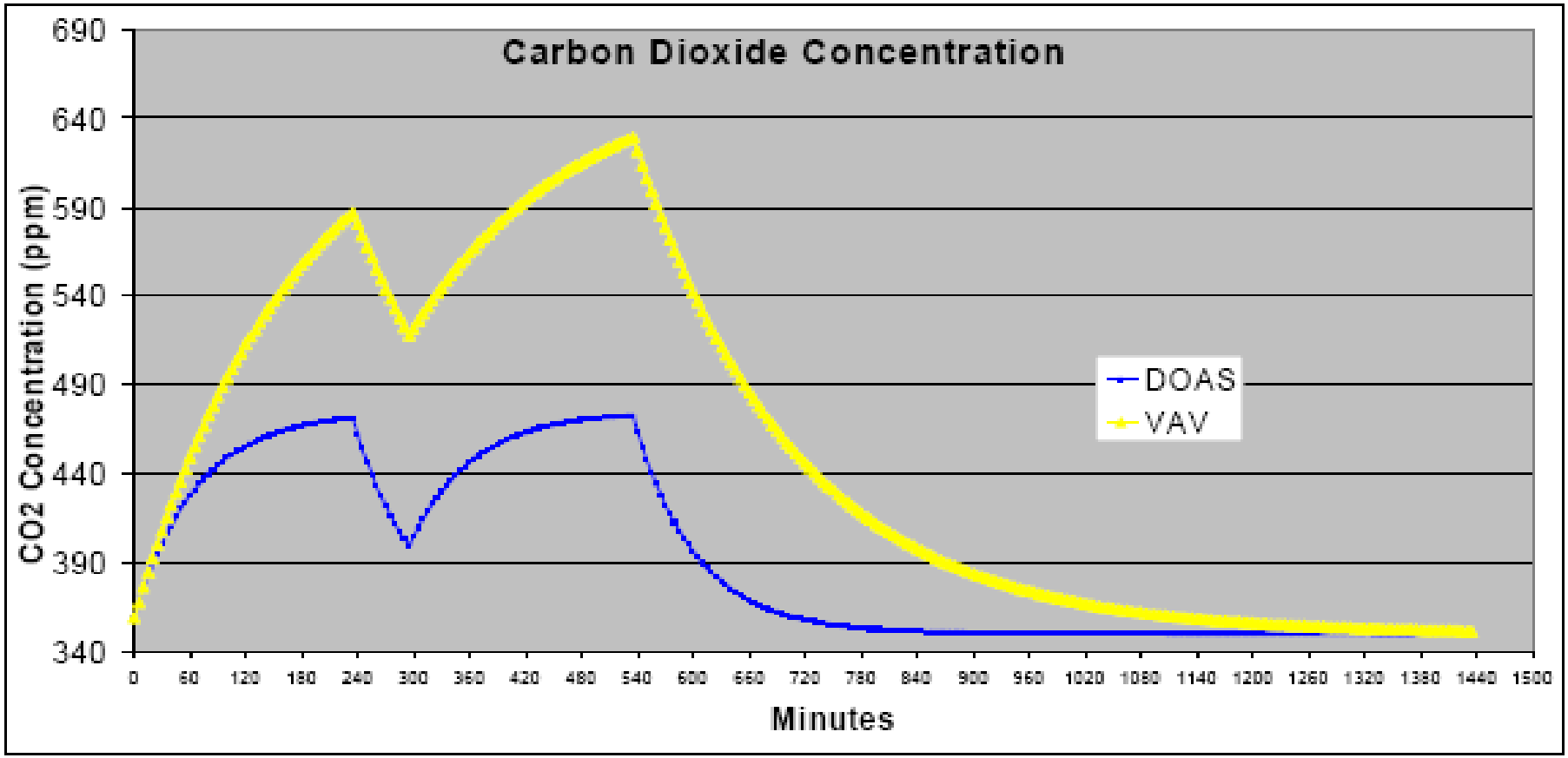
Enthalpy Wheel

- DOAS needs heat recovery/rejection device due to high volumes of OA treated
- Enthalpy Wheel Modeled on Semco TE3-43 (Total Energy, 43”)
- 80% transfer efficiency for latent and sensible energy
- No measured cross contamination for common pollutants (Georgia Tech Research Institute)
- Able to treat OA to within 2 degrees of Mixed air in standard system

IAQ Comparison

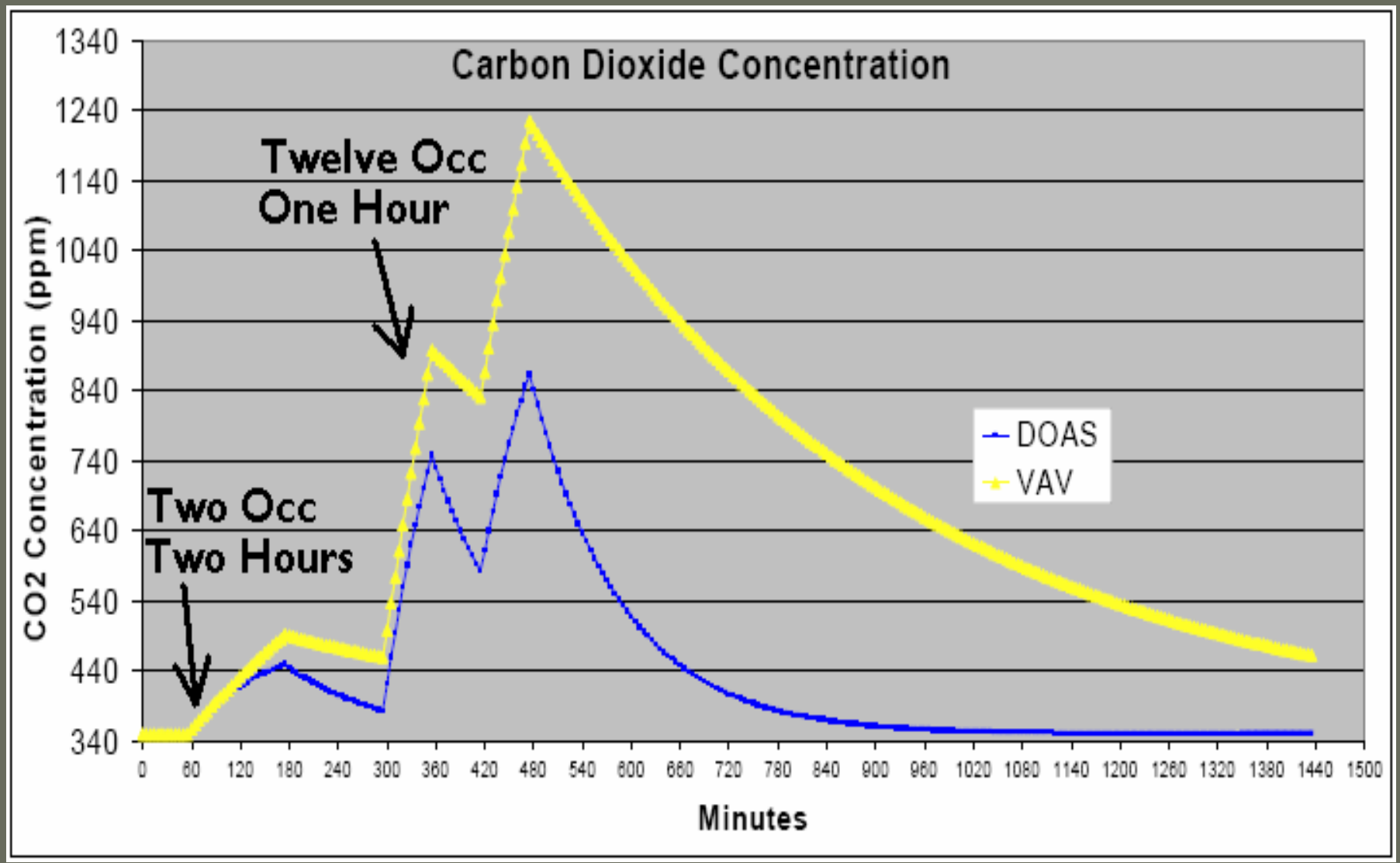
- MOB host to many ill patients
- Many spaces purposely over-ventilated
  - Waiting rooms
  - Examination rooms
- Graphs of CO2 in two sample rooms
  - Generation rate of .31 l/s
  - VAV system at 10% OA
  - DOAS at 100% OA

CO_2 Levels in Office 3037



In this graph, the curves represent an eight hour work day with one occupant. The dip beginning at 240 (12:00), and ending at 300 (1:00), represents the lunch hour when the office is unoccupied.

CO_2 Levels in Conference 3080



Economic Analysis

- First Cost
  - RS Means used for all equipment
  - Parallel system priced from similar English units
- Operating Cost
  - HAP generated the costs for the Existing System and Alternative #1
  - Alternative #2 was scaled from Alternative #1 by comparing the amount of fan, pump and chilled water energy used annually

Economic Analysis

- First Cost
  - Existing System
    - $353,460
  - VAV w/ chilled water
    - $519,881 (+166,000)
  - DOAS w/ parallel system
    - $560,514 (+207,000)

- Operating Cost
  - Existing System
    - $165,509
  - VAV w/ chilled water
    - $130,004 (-35,500)
  - DOAS w/ parallel system
    - $106,603 (-58,900)

Payback Period Analysis

- Alternative #1 vs. Existing System
  - 4.7 years
- Alternative #2 vs. Existing System
  - 3.5 years
- Alternative #2 vs. Alternative #1
  - 1.7 years

Breadth #1
Electrical Distribution System Redesign

- Changing away from all electric HVAC
- Existing Equipment
  - Two 800Amp panel boards serve the six AHUs
  - Seven 225 Amp panel boards are dedicated to the fan powered VAV boxes
- DOAS w/ Parallel System
  - Supported equipment lowered to three water pumps and a three AHU fans
  - Require only two 100 Amp panel boards
- Cost savings of $21,860

Breadth #2 Constructability Review

- Chilled Water and Steam Piping Constructability
  - Connection of the MOB to the South of Orleans Energy Plant
  - Feasibility
  - Location of piping
  - Impact on Construction

MOB Block Layout

Pipe Location Options

- Option one, Buried Piping
  - Formerly vacant block facilitates installation
  - Will not impact construction of loading dock
- Option two, Above Ground Piping Recommended
  - No conflict with existing buried utilities
  - Piping is accessible
  - Installation cost may be lower without excavation

Schedule Impact of Piping

- Minimal schedule impact for the following reasons
  - Easy to coordinate construction since the whole was block planned as one extension of the JHH campus
  - Source of Chilled Water and Steam is very close to the MOB
  - Structure between the Energy Plant and the MOB is very utilitarian

Thesis Conclusions

- Alternative #1 Chilled water VAV w/ hot water reheat
  - Initially more expensive but lower operating cost yields a pay back period of only 4.7 years
  - Can use same number and layout for AHUs and VAV boxes

Thesis Conclusions

- Alternative #2 DOAS with parallel system
  - Highest first cost but lowest operating cost of all systems considered, yields a pay back period of 3.5 years
  - Uses only three AHUs
  - Paired with enthalpy wheel and parallel system
  - Capable of significantly improving IAQ

Thesis Conclusions

- Enthalpy Wheel
  - Lowers overall cooling need dramatically
  - No risk of cross contamination
- Parallel System
  - Active heated and chilled beams
  - Can either heat or cool a space
- Electrical System Redesign
  - With deletion of all electrical HVAC equipment panel boards drop from nine to two in number
  - Cost savings of $21,860 in equipment

Thesis Conclusions

- Constructability Review of steam and chilled water piping from the energy plant to the MOB
  - Minimal schedule impact
  - Two easily constructed options
  - Block development facilitates coordination with surrounding buildings

Questions