### Presentation Outline

<table>
<thead>
<tr>
<th>Title</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Information</strong></td>
<td></td>
</tr>
<tr>
<td>Existing Mechanical System</td>
<td></td>
</tr>
<tr>
<td>Mechanical System Redesign - Depth</td>
<td></td>
</tr>
<tr>
<td>Two-Pipe to Four-Pipe Conversion</td>
<td></td>
</tr>
<tr>
<td><strong>Background</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Existing Piping Analysis</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Installation &amp; Results</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Chilled Beam Renovation</strong></td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td><strong>Sizing and Selection</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Energy Consumption and Operation</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Results</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Construction Management – Breadth</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Background</strong></td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
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<td><strong>Conclusions and Recommendations</strong></td>
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</table>
### General Building Information

Building Name: SHA Headquarters—707 Systems Renovations  
Location: Baltimore, MD  
Occupancy Type: Office Building  
Gross Building Area: 226,000 SF  
Total Number of Stories: 8 (including 2 below grade)  
Total Renovation Cost: Approx. $4,435,500  
Project Delivery Method: Design-Bid-Build

### The 707 Building

#### The 707 Building

![The 707 Building](image)

### Primary Project Team

**AE Firm**  
![AE Firm](image)

**Architect**  
![Architect](image)

**Mechanical Contractor**  
![Mechanical Contractor](image)
Presentation Outline

Project Information

Existing Mechanical System

Mechanical System Redesign - Depth

Two-Pipe to Four-Pipe Conversion

Background

Existing Piping Analysis

Installation & Results

Chilled Beam Renovation

Background

Sizing and Selection

Energy Consumption and Operation

Results

Construction Management – Breadth

Background

Schedule

Cost Estimate

Payback Analysis

Conclusions and Recommendations
**Air Side**

**AHU-S1:**
- Built-up air handler with steam preheat, filters, cooling coil, and steam reheat coil
- Constant volume
- Serves perimeter induction units on 6 office floors

**AHU-S2 & S3:**
- Built-up air handler with filters and cooling coil
- Constant volume
- Serve core of 6 office floors - one north, one south

**Induction Units:**
- (534) perimeter induction units on 6 office floors

---

**Existing Mechanical System**

**Water Side**

**Chilled Water:**
- Plant includes dual compressor, single condenser, single evaporator chiller and primary chilled water pump
- Induced draft cooling tower

**Hot Water:**
- (2) gas-fired steam boilers
Presentation Outline

Project Information
Existing Mechanical System

**Mechanical System Redesign - Depth**
Two-Pipe to Four-Pipe Conversion
Background
Existing Piping Analysis
Installation & Results

Chilled Beam Renovation
Background
Sizing and Selection
Energy Consumption and Operation
Results

Construction Management – Breadth
Background
Schedule
Cost Estimate
Payback Analysis

Conclusions and Recommendations
**Planned Mechanical System Redesign**

**Air Side**
- **AHU-S1:**
  - Replace with 32,000 CFM unit
  - Constant volume
  - Continue serving perimeter of 6 office floors
- **AHU-S2 & S3:**
  - Replace with 30,000 and 37,000 CFM units
  - Constant volume
  - Continue serving core of 6 office floors
- **Induction Units:**
  - Replace (534) perimeter induction units on 6 office floors

**Goals**
- **Improve:**
  - Energy efficiency
  - Occupancy comfort
- **Criteria:**
  - Disturbance to tenants
  - Maintenance requirements

**Water Side**
- **Hot Water:**
  - (2) hot water boilers - no steam
**Mechanical System Redesign Proposal**

**Benefits**

- Enhance occupancy comfort
- Few maintenance requirements
- Highly energy efficient

**Chilled Beams:**
- Replace induction units with **Active Chilled Beams**
- Redesign water distribution system to **four-pipe**

**Four-Pipe:**
- Enhance occupancy comfort
- Additional flexibility and control
- Constant availability of heating and cooling
Presentation Outline

Project Information
Existing Mechanical System
Mechanical System Redesign - Depth
Two-Pipe to Four-Pipe Conversion
  Background
  Existing Piping Analysis
  Installation & Results
Chilled Beam Renovation
  Background
  Sizing and Selection
  Energy Consumption and Operation
  Results
Construction Management – Breadth
  Background
  Schedule
  Cost Estimate
  Payback Analysis
Conclusions and Recommendations
Presentation Outline

Project Information
Existing Mechanical System
Mechanical System Redesign - Depth
  Two-Pipe to Four-Pipe Conversion
    Background
    Existing Piping Analysis
    Installation & Results
Chilled Beam Renovation
  Background
  Sizing and Selection
  Energy Consumption and Operation
  Results
Construction Management – Breadth
  Background
  Schedule
  Cost Estimate
  Payback Analysis
Conclusions and Recommendations

Two-Pipe

Four-Pipe
Project Information

Existing Mechanical System

Mechanical System Redesign - Depth

Two-Pipe to Four-Pipe Conversion

- Existing Piping Analysis
- Installation & Results

Chilled Beam Renovation

- Background
- Sizing and Selection
- Energy Consumption and Operation
- Results

Construction Management – Breadth

- Background
- Schedule
- Cost Estimate
- Payback Analysis

Conclusions and Recommendations

Presentation Outline

Existing Piping

Two-Pipe:

- 15 vertical runs
Project Information

Existing Mechanical System

Mechanical System Redesign - Depth

Two-Pipe to Four-Pipe Conversion

Existing Piping Analysis

Installation & Results

Chilled Beam Renovation

Background

Sizing and Selection

Energy Consumption and Operation

Results

Construction Management – Breadth

Background

Schedule

Cost Estimate

Payback Analysis

Conclusions and Recommendations

Presentation Outline

Installation

Four-Pipe:

• 15 vertical runs

• 6,000 LF

Selection:

• Hot water piping of 1-1/2"

Four-Pipe:

• No zoning of two-pipe system

• No changeover from heating to cooling = decreased energy consumption

Results

Piping Determines:

• Quality of performance

• Ease of operation

• Initial cost
Presentation Outline

Project Information
Existing Mechanical System
Mechanical System Redesign - Depth
Two-Pipe to Four-Pipe Conversion
  Background
  Existing Piping Analysis
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    Background
    Sizing and Selection
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Construction Management – Breadth
  Background
  Schedule
  Cost Estimate
  Payback Analysis
Conclusions and Recommendations
Presentation Outline

Project Information
Existing Mechanical System
Mechanical System Redesign - Depth
Two-Pipe to Four-Pipe Conversion

Construction Management – Breadth

Conclusions and Recommendations

Background

How They Work:
- Can both heat and cool
- Water can transport energy more efficiently than air

Increased Usable Square Footage:
- Area of induction unit ~ 21 ft²

Types:
- Passive
- Active

Passive Chilled Beam

How They Work:
- Only supply cooling
- No fans, ductwork
- Chilled water piped to finned tube heat exchanger coil
Presentation Outline

Project Information
Existing Mechanical System
Mechanical System Redesign - Depth
Two-Pipe to Four-Pipe Conversion

Chilled Beam Renovation

Construction Management – Breadth

Conclusions and Recommendations

Active Chilled Beam (ACB)

How They Work:
1. Primary air supplied through nozzles
2. Room air rises to ACB
3. Air pulled through secondary water coil & induced air is cooled/heated
4. Primary air and induced air mixed
5. Discharged through diffuser

Summary:

<table>
<thead>
<tr>
<th>Crucial</th>
<th>Less Concern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower operating cost</td>
<td>Noiseless</td>
</tr>
<tr>
<td>Lower energy consumption</td>
<td>Higher ceiling heights</td>
</tr>
<tr>
<td>Highly efficient</td>
<td>Future tenant flexibility</td>
</tr>
<tr>
<td>Greater occupancy comfort</td>
<td>Little maintenance</td>
</tr>
<tr>
<td>Reduced maintenance</td>
<td>Increased usable square footage</td>
</tr>
<tr>
<td>Reduced ductwork</td>
<td></td>
</tr>
<tr>
<td>Increased usable square footage</td>
<td></td>
</tr>
</tbody>
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   - Calculate minimum ventilation air from ASHRAE Standard 62.1
     - Primary Air Required = 5 CFM/person x People in Zone

2. Sensible Cooling Capacity:
   - Sensible cooling refers to dry bulb temperature of the building;
     - Sensible Cooling Capacity = 1.08 x Primary Air CFM x (T_{room} - T_{supply})

3. Latent Load:
   - Latent loads must be satisfied by primary air
     - Latent Load = 0.69 x Primary Air CFM x (RH_{room} - RH_{supply})

4. Latent Cooling Capacity:
   - If Latent Cooling Capacity > Latent Load, primary air can support latent load
     - Latent Cooling = 4840 x Primary Air CFM x (W_{room} - W_{primary})

<table>
<thead>
<tr>
<th>Floor</th>
<th>Zone</th>
<th>People</th>
<th>Primary Air (CFM)</th>
<th>Sensible Cooling Capacity (BTU/hr)</th>
<th>Latent Load (BTU/hr)</th>
<th>Latent Cooling Capacity (BTU/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>SW</td>
<td>10</td>
<td>90</td>
<td>1171</td>
<td>148</td>
<td>303</td>
</tr>
</tbody>
</table>

DADANCO’s ACB40:
- 4-pipe ceiling unit
- 2-way supply discharge
- Delivers higher energy efficiency at lower air quantities
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### Floor Zone

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<tr>
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<th>Area (ft²)</th>
<th>Number of Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>South West</td>
<td>1669</td>
<td>12</td>
</tr>
</tbody>
</table>

### Summary

- **Total Number of ACB's = 391**

Additional notes:
- **Primary Air:**
  - DADANCO’s rule of thumb
  - Number of Units = Area / 150ft²

### Table

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<td>South West</td>
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**DADANCO’s ACB40:**
- Comfort
- Uniform temperatures throughout
- Elimination of drafts and hot spots
Project Information

Existing Mechanical System

Mechanical System Redesign - Depth

Two-Pipe to Four-Pipe Conversion

Background

Existing Piping Analysis

Installation & Results

Chilled Beam Renovation

Background

Sizing and Selection

Energy Consumption and Operation

Results

Construction Management – Breadth

Background

Sizing and Selection

Energy Consumption and Operation

Results

Conclusions and Recommendations

Baltimore:

Energy Analysis

Energy Consumption & Operating Cost

Monthly Energy Consumption

Redesign Total Cost per Year = $178,719 or $1.03/sf

Electricity

- Up to first 10,000 therms

- Above 10,000 therms

Natural Gas

- Up to first 10,000 therms

- Above 10,000 therms

ASHRAE HOF Values

Summer Design Cooling (0.4%)

Winter Design Heating (99.6%)

OA Dry Bulb (°F)

93.9

12.9

OA Wet Bulb (°F)

78.1

- Lighting - 35%

- Space Heating - 32%

- Receptacles - 22%

- Space Cooling - 11%

- Total Energy Consumption (kWh)

- 1,551,951

- 100%

- Redesign Total Cost per Year =

- $178,719

- or

- $1.03/sf

- Original Total Cost per Year =

- $200,808

- or

- $1.17/sf

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Project Information
Existing Mechanical System
Mechanical System Redesign - Depth
Two-Pipe to Four-Pipe Conversion

Background
Existing Piping Analysis
Installation & Results

Chilled Beam Renovation

Background
Sizing and Selection
Energy Consumption and Operation

Results

Benefits:
- Lower energy consumption
- Improved comfort
- More usable square footage
- No regular maintenance
- Primary air reduction → duct reduction

Reduced Maintenance:
- No moving parts

Construction Management – Breadth

Background
Schedule
Cost Estimate
Payback Analysis

Conclusions and Recommendations

Presentation Outline

Primary Air Reduction:
- Percent PA Reduction = \[1 - \text{Primary Air CFM/Total Current Supply CFM}] \times 100

Average Percent of PA Reduction = 80%

Duct Reduction:
- With PA decrease, downsize amount of ductwork
- Flex duct connects PA duct to PA spigot of ACB unit

Results

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Background
Schedule
Cost Estimate
Payback Analysis

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Existing Mechanical System

Mechanical System Redesign - Depth

Two-Pipe to Four-Pipe Conversion

Background
Existing Piping Analysis
Installation & Results

Chilled Beam Renovation

Background
Sizing and Selection
Energy Consumption and Operation
Results

Construction Management – Breadth

Background
Schedule
Cost Estimate
Payback Analysis

Conclusions and Recommendations
Project Information
Existing Mechanical System
Mechanical System Redesign - Depth
Two-Pipe to Four-Pipe Conversion

Background
Existing Piping Analysis
Installation & Results

Chilled Beam Renovation
Background
Sizing and Selection
Energy Consumption and Operation
Results

Construction Management – Breadth
Background
Schedule
Cost Estimate
Payback Analysis

Conclusions and Recommendations

Potential Savings:
- Installation schedule
- Construction costs

Research Tools:
- Microsoft Project 2010
- Microsoft Excel 2010
Project Information

Existing Mechanical System

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Background
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Chilled Beam Renovation

Background
Sizing and Selection
Energy Consumption and Operation
Results

Construction Management – Breadth

Background
Schedule
Cost Estimate
Payback Analysis

Conclusions and Recommendations

Presentation Outline

Existing System

Proposed System
## Project Information

- Existing Mechanical System
- Mechanical System Redesign - Depth
- Two-Pipe to Four-Pipe Conversion
  - Background
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  - Sizing and Selection
  - Energy Consumption and Operation
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## Construction Management – Breadth

- Background
- Schedule
- Cost Estimate
- Payback Analysis

## Conclusions and Recommendations

## Initial Cost Estimate

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Cost Estimate</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Existing System</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Purchase &amp; Installation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Labor &amp; Equipment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Other Costs</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Included

### Removal of Induction Units Includes:
- Relocating tenants
- Verifying existing utilities
- Floor protection & furniture moving
- Draining riser & pipe capping
- Patching & painting wall

### Initial Cost of:
- Materials
- Labor
- Equipment

### Assumptions:
- 5% sales tax
- 20% labor overhead
Presentation Outline

Project Information
Existing Mechanical System
Mechanical System Redesign - Depth
Two-Pipe to Four-Pipe Conversion

Background
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Chilled Beam Renovation
Background
Sizing and Selection
Energy Consumption and Operation

Results

Construction Management – Breadth
Background
Schedule
Cost Estimate

Payback Analysis

Conclusions and Recommendations

Cost Estimate

<table>
<thead>
<tr>
<th>Description</th>
<th>2023 Estimate</th>
<th>2024 Estimate</th>
<th>2025 Estimate</th>
<th>2026 Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Piping &amp; Hanger</td>
<td>$32,000</td>
<td>$34,000</td>
<td>$36,000</td>
<td>$38,000</td>
</tr>
<tr>
<td>New Equipment</td>
<td>$18,000</td>
<td>$20,000</td>
<td>$22,000</td>
<td>$24,000</td>
</tr>
<tr>
<td>New Chilled Beam Systems</td>
<td>$25,000</td>
<td>$27,000</td>
<td>$29,000</td>
<td>$31,000</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>$5,000</td>
<td>$6,000</td>
<td>$7,000</td>
<td>$8,000</td>
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<tr>
<td>Total</td>
<td>$80,000</td>
<td>$90,000</td>
<td>$100,000</td>
<td>$110,000</td>
</tr>
</tbody>
</table>

Potential payback of 12 years!
Project Information
Existing Mechanical System
Mechanical System Redesign - Depth
Two-Pipe to Four-Pipe Conversion
  Background
  Existing Piping Analysis
  Installation & Results
Chilled Beam Renovation
  Background
  Sizing and Selection
  Energy Consumption and Operation
  Results
Construction Management – Breadth
  Background
  Schedule
  Cost Estimate
  Payback Analysis
Conclusions and Recommendations
**Conclusions**

**Improve:**
- Energy efficiency
- Occupancy comfort

**Criteria:**
- Disturbance to tenants
- Maintenance requirements

**Additionally:**
- Lowered operating cost
- Reduced ductwork
- Increased usable square footage

**$22,089** energy savings per year

Reasonable payback of **12** years!
Penn State Architectural Engineering Faculty
Thesis Advisor
William Bahnfleth

Corporate Consultants
Matt Keller, JMT – Facilities Senior Associate
Pat Harillal, JMT – Mechanical Engineer
Ron Saunders, JMT – Environmental Facilities CADD Technician
Adam Raver, JMT – Facilities CADD Technician
Jim Hovey, JMT – Construction Management
Alyssa Adams, McClure Company – Energy Services Specialist
Panda Aumpansub, Havtech Corporation – Application Engineer
Cassidy Bowman, DADANCO – Project Manager
Jan Kaczmarek, SHA Project Manager

Family & friends
AE Class of 2011