Underfloor Air Distribution Cost Analysis

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Overview

- Goal
  - Develop comprehensive first-cost and life-cycle cost (LCC) modeling tools for UFAD system cost analyses

- GSA sponsored

- History/schedule
  - Initial phase – Webcor (Eric Horn), Nash Hurley (Oct 2001)
  - Tate provides cost analysis software (Jul 2002)
  - GSA (Kevin Kampschroer) Project start (Oct 2002)
  - GSA review (May 2004)
  - Cost model workshop (Apr 2005)
  - Scheduled end (Sept 30, 2006)

Seattle Public Library
Significance

- Model provides means for:
  - Systematically determining cost differential between UFAD and overhead (OH) systems
  - Identifying cost drivers and magnitude of differences
  - Flexibility to evaluate impact of different design options
- There are no comprehensive studies by independent parties; most cost comparisons are anecdotal and project specific
- “The devil is in the details”...

Progress

- First cost model sensitivity analyses almost complete
- Life-cycle cost (LCC) model progressing
  - Developing churn scenarios
  - Developing LCC computations methods
UFAD HVAC system alternatives

UFAD-B: CAV/VAV
- Return from space
- Series fan powered mixing box
- Fan coil unit
- Plenum pressure control
- Variable speed fan coil unit (PSV)
- Modulating diffusers

UFAD-A: CAV
- Fan coil unit, heating only

UFAD-C: All VAV
- Fan coil unit, heating only
- Modulating diffusers

UFAD-D: All VAV (modulating diffusers)
- Fan coil unit
- Return ducting at terminal units only on UFAD D alternative
- Non-powered furniture for UFAD

Methods and assumptions

- Sensitivity study – impact of design options
  - ~25 parametric studies conducted to date
  - 11 integrated scenario variations
- Sensitivity study assumptions
  - Basic building configuration unchanged
  - “Medium” quality overhead system (OH) (lay-in diffusers, VAV/reheat, 16 interior zones)
  - Limit OH VAV boxes to 1500 CFM
  - 14” supply plenum for UFAD
  - Return ducting at terminal units only on UFAD D alternative
  - Equal airflow for overhead and UFAD
  - Non-powered furniture for UFAD
Open plan vs. private offices (PO) example

- Total cost differential for equal OH, UFAD zoning

![Graph showing cost differential with private office (PO) area as a percentage of floorplate.]

Open plan vs. private offices (PO)

- Increase interior and perimeter zoning

![Bar chart showing cost differential across different categories and percentages of private office area.]

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http://www.cbe.berkeley.edu/
Open plan vs. private offices (PO)

- Increase interior and perimeter zoning
- Electrical and HVAC differentials decrease…

Baseline
21% PO
Private office (PO) area, % of floorplate

-6 $/Gsf
-4 $/Gsf
-2 $/Gsf
0 $/Gsf
2 $/Gsf
4 $/Gsf
6 $/Gsf
8 $/Gsf
10 $/Gsf

Mechanical / HVAC
Electrical, V&D
Workstations
Core, carpet, access flooring
Facade, ceiling
Total

Total cost differential
(UFAD premium)

Total = $3.50

Open plan vs. private offices (PO)

- Increase interior and perimeter zoning
- …while workstation furniture savings decrease

Baseline
21% PO
Private office (PO) area, % of floorplate

-6 $/Gsf
-4 $/Gsf
-2 $/Gsf
0 $/Gsf
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4 $/Gsf
6 $/Gsf
8 $/Gsf
10 $/Gsf

Mechanical / HVAC
Electrical, V&D
Workstations
Core, carpet, access flooring
Facade, ceiling
Total

Total cost differential
(UFAD premium)

Total = $3.50
Integrated scenarios

- Combined options

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost Differential from OH - $/Gsf</th>
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<tbody>
<tr>
<td>Baseline</td>
<td>Steel structure</td>
</tr>
<tr>
<td>A</td>
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</tr>
<tr>
<td>B</td>
<td></td>
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<tr>
<td>C</td>
<td></td>
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<tr>
<td>D</td>
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<tr>
<td>Steel</td>
<td>Steel structure, Exposed ceiling,</td>
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<tr>
<td>structure</td>
<td>2 ft wall savings</td>
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<tr>
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<td>Mechanical/HVAC</td>
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<td>Electrical/V&amp;D/Workstations</td>
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<tr>
<td>Total</td>
<td>Electric / V&amp;D / Workstations</td>
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<tr>
<td></td>
<td>Raised Core / Carpeting / Access</td>
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<tr>
<td></td>
<td>Flooring</td>
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</tbody>
</table>

Additional findings

- Floor height savings ~$1.65/Gsf/ft of wall height saved

- HVAC
  - Airflow uncertainty (±30%), add/subtract ~$2/Gsf
  - Limit OH VAV boxes to 1500 cfm, add $2/Gsf to OH (lowers premium)
  - UFAD C vs UFAD D:
    - UFAD C, add return ducting to FCU at perimeter; add ~$2/Gsf
    - UFAD C, increase interior zones from 1 to 16; add ~$2/Gsf

- Small effects, $1/Gsf or less

<table>
<thead>
<tr>
<th>Item</th>
<th>Change in baseline premium</th>
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</thead>
<tbody>
<tr>
<td>Increase floorplates (20K to 50K)</td>
<td>lower</td>
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<tr>
<td>Increase % core or increase % raised core</td>
<td>higher</td>
</tr>
<tr>
<td>Delete mains ducting (direct to plenum)</td>
<td>lower</td>
</tr>
<tr>
<td>Increase wall thermal quality</td>
<td>lower</td>
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</tbody>
</table>
Summary and conclusions

- Based on study assumptions, overall UFAD C, D baseline premiums ~$3-6/Gsf
  - Premium most affected by HVAC (airflow), wall height/quality, electrical, and workstation (WS) furniture assumptions

- HVAC zoning
  - Cost impact depends on system type & zoning assumptions (~$2/Gsf)

- Electrical
  - Modular wiring labor vs. material tradeoff yields no cost difference
  - Modular wiring might offer greater opportunities for lower labor rates
  - Non-powered furniture yields large advantage for UFAD WS costs
  - With powered furniture, UFAD electrical is cheaper than OH power pole

Next steps

- Complete first cost analysis
  - Equivalent zoning
  - Identify ranges
  - Write report/journal article

- Continue life-cycle cost (LCC) model development
  - Churn
  - Maintenance and repair
  - Energy
  - Tax savings

- Seeking partner assistance with LCC