Location - Madison city
Location - Madison city
Location - Madison city
Location - Madison city

VIEW 3

VIEW 4

VIEW 5
Location - Madison city
Location – Climate conditions

Temperature conditions

[Graph showing temperature conditions with bars and lines representing different months and temperature ranges.]
Location – Climate conditions

Snow conditions

Typical Madison Monthly Snow (inches)

- Jan: 10.9
- Feb: 7.9
- Mar: 6.1
- Apr: 2.3
- May: 0
- Jun: 0
- Jul: 0
- Aug: 0
- Sept: 0
- Oct: 0.3
- Nov: 8.6
- Dec: 10.6
### Wind conditions

#### Number of windy days per month

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<th>&gt; 15 mph</th>
<th>&gt; 20 mph</th>
<th>&gt; 25 mph</th>
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<tr>
<td>December</td>
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</table>
Concepts
Boat – Big Idea

Freedom of sailing + Enthusiasm for knowledge = Boat taking off
Footprint with surrounding buildings, roads and green areas

- Muir Woods
- Muir Knoll viewing platform
- Flow of students
- To the campus
- Atlantic - ARCH 14

Boat – Location
Boat – Location

Footprint with plaza and closer area of interest
Boat – Plaza

Inspiration

Boat
First floor plan

- Small classroom
- Large classroom
- Auditorium
- Instructional
- Student office
- Faculty office
- Support rooms
- Bathrooms
- Hallways

- Boat – Plans

Atlantic - ARCH 17
Boat – Multipurpose stairs

Inspiration
Boat – Touch transparent walls

Walls between classrooms are modular (can be moved around). They are also touch enabled and if needed transparent.
Second floor plan

- Small classroom
- Large classroom
- Instructional
- Student office
- Faculty office
- Support rooms
- Bathrooms
- Hallways

- Instructional Lab: 15 (1060 SF)
- Glass/Collaboration Space: 03 (1300 SF)
- Lobby and Hall: 01 (2600 SF)
- Large Class: 14 (823 SF)
- Small classroom: 12 (580 SF)

Dimensions:
- 36'-6" to 38'-7"
- 27'-6" to 30'-11"
- 5'-6" to 57'-9"
- 9'-5" to 55'-8"
Boat – Open collaboration space

Inspiration

Actual render
Third floor plan

- Small
- classroom
- Large
- Support rooms
- Student office
- Faculty office
- Bathrooms
- Hallways
Boat – Collaboration space

Inspiration
Boat – Meeting/resting spot

Inspiration
Boat – Sight – virtual reality

Atlantic - ARCH 25
Roof terrace
Boat – Roof garden

Inspiration
Boat – Section

Section through roof access
Section through large classroom
Section through auditorium
Skylight with photovoltaic cells baked between glass.
Boat – LED facade

Inspiration

Boat
<table>
<thead>
<tr>
<th></th>
<th>Live (psf)</th>
<th>Dead (psf)</th>
<th>Snow (psf)</th>
<th>Wind (kip)</th>
<th>E (kip)</th>
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<tr>
<td>Roof</td>
<td>100</td>
<td>90</td>
<td>23.1</td>
<td>24.45</td>
<td>19.09</td>
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<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; floor</td>
<td>57.82</td>
<td>90</td>
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<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; floor</td>
<td>68.27</td>
<td>90</td>
<td></td>
<td>45.48</td>
<td>10.63</td>
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<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; floor</td>
<td>84.45</td>
<td>90</td>
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<td>22.74</td>
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<tr>
<td><strong>Wood Alternative</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Roof</td>
<td>100</td>
<td>32</td>
<td>23.1</td>
<td>24.45</td>
<td>21.97</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; floor</td>
<td>57.82</td>
<td>32</td>
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<td>46.96</td>
<td>19.34</td>
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<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; floor</td>
<td>68.27</td>
<td>32</td>
<td></td>
<td>45.48</td>
<td>9.67</td>
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<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; floor</td>
<td>84.45</td>
<td>32</td>
<td></td>
<td>22.74</td>
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</tbody>
</table>
2nd Floor

- Filler Beams W18x40
- Girder W21x62
- Auditorium Girder W21x62
- Auditorium Filler Beam W18x65
- Column W14x61
3rd Floor

- Filler Beams W18x40
- Girder W21x62
- Auditorium Girder W21x62
- Auditorium Filler Beam
- W18x65
- Column W14x61
Roof

- Filler Beams W18x40
- Girder W21x62
- Auditorium Girder W21x62
- Auditorium Filler Beam W18x65
- Column W14x61
Pu = 309k  
Pn = 626k  
Pl = 120k

Beams take PL as tension loads  
W14x61

Pu = 617k  
Pn = 626k

W14x61
Moment Frame

W21x83

W14x193
W21x83

W14x193
W21x83

W14x193

30 ft

12 ft

\[ \sum V = 187.03 \text{ Kips} \]
Boat-Wood-Typical Load Path
2nd Floor

- Truss 3’ Deep
- Joists 6.75” x 19.5”
- Shear Walls 4’ Thick
- Columns 15”x 15”
3rd Floor

- Truss 3’ Deep
- Auditorium Truss 5’ Deep
- Joists 6.75” x 19.5”
- Auditorium Joists 6.75” x 9.5”
- Shear Walls 4’ Thick
- Columns 15”x 15”
Roof

- Truss 3’ Deep
- Auditorium Truss 5’ Deep
- Joists 6.75” x 19.5”
- Auditorium Joists 6.75” x 9.5”
- Shear Walls 4’ Thick
- Columns 15”x 15”
Typical Framing

<table>
<thead>
<tr>
<th>Joist</th>
<th>Truss Chord</th>
<th>Truss Diagonal</th>
<th>Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.75”X19.5”</td>
<td>10”X12”</td>
<td>5”X5”</td>
<td>15”X15”</td>
</tr>
<tr>
<td>6.75”X9.5”</td>
<td>10”12”</td>
<td>5”X5”</td>
<td>10”X10”</td>
</tr>
</tbody>
</table>
Boat-Wood-Column

Pu = 180 k
Pn = 202 k
Pf = 72 k

Beams take PL as tension loads

Exterior Columns

15" X 15"

Interior Columns

Pu = 180 k
Pn = 202 k

15" X 15"
Cross Lam Shear Walls

• Load Combination
  1.2D+1.6W+L+0.5(Lr or S or R)

Control
  1.2D+1.0E+L+0.2S

• \( \Sigma V = 187.03 \) Kips
  Shear Demand = 4.45 Kip/ft
  Thickness = 4 in
  Shear Capacity = 6.94 Kip/ft
  OK
Steel-Composite Deck

- Deflections during construction
- Camber when design beams
- Normal Weight Concrete = 145pcf

Wood-Cross Laminated Timber

- Cross-layered construction
- Reduce carbon footprint
- Ready to assemble system
Mat Foundation

- Avoid water table
- Extra costs of earthwork
- Concrete Slab
- \( Df \) (steel) = \( 2.25 \) ft
- \( Df \) (wood) = \( 1.5 \) ft
Boat & Wave - Retaining Wall

Atlantic - SE 49
Variable-Air-Volume boxes with overhead diffusers to deliver air, heating and cooling to most spaces

Under-floor air distribution to deliver air, heating and cooling to auditorium
Alternative 2 - ACB

- Chilled beams to deliver heat and cooling to most spaces

- Radiant heat floors in larger spaces

- Overhead delivery of outside air in all spaces
## Motivations for Alternatives

<table>
<thead>
<tr>
<th>Motivation</th>
<th>Alt 1 – VAV</th>
<th>Alt 2 – ACB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation</td>
<td>• Simple solution</td>
<td>• Lowered fan energy</td>
</tr>
<tr>
<td></td>
<td>• Adaptable to occupancy flux</td>
<td>• Decreased duct sizes</td>
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<tr>
<td>Challenges</td>
<td>• Floor sandwich</td>
<td>• Dehumidification</td>
</tr>
<tr>
<td></td>
<td>• UFAD for auditorium</td>
<td>• Extensive piping</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Handling flux</td>
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</table>
# Boat Summary

<table>
<thead>
<tr>
<th>Metric</th>
<th>VAV</th>
<th>ACB</th>
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</thead>
<tbody>
<tr>
<td>Peak Ventilation</td>
<td>26,000 CFM</td>
<td>13,000 CFM</td>
</tr>
<tr>
<td>Largest Branch</td>
<td>28” x 43”</td>
<td>24” x 46”</td>
</tr>
</tbody>
</table>
Boat – VAV Layout

- 2 AHU: one for main supply, one for auditorium
- Chilled water pump
- Steam to hot water pump
- Domestic water pump
- Storage tank for rainwater
Boat – VAV Layout
Alternative 1 - Vertical Distribution

- MEP Shaft
- Campus Steam, CHW in
- MEP Room
- AHU
- OA
- RA
- SA
Boat – ACB Layout

- Chilled water pump
- Steam to hot water pump
- Domestic water pump
- Storage tank for rainwater
Dedicated Outside Air AHU
Alternative 2 – Vertical Distribution

- MEP Shaft
- MEP Room
- Campus Steam, CHW in
- AHU

- Hot Water
- Chilled Water
- Chilled Beams
ACB Floor Sandwich

Level 3

24' x 31''

8' 3''
Wave – Big Idea

ENERGY OF WAVES + CAPTURING THE LANDSCAPE = FROZEN WAVE
Footprint with surrounding buildings, roads and green areas.
Footprint with plaza and closer area of interest.
Wave – PLaza

Inspiration

Wave
Wave – Plans

First floor plan

- Small classrooms
- Large classrooms
- Student offices
- Faculty offices
- Support rooms
- Bathrooms
- Hallways

Legend:
- Small
- Classroom
- Large
- Classroom
- Auditorium
- Instructional
Wave – Living Wall
Third floor plan

classroom
Auditorium
Student office
Faculty office
Support rooms
Bathrooms
Hallways
Wave – Plans

Roof terrace plan
Wave – Roof terrace

Inspiration
Section through vertical communication
Section through large classroom
Section through communication and roof access
Section through communication and roof access
2nd Floor

- Filler Beam W18x40
- Girder W21x83
- Column W14x61
- Moment Frame (Beam W21X83)
  (Column W14X193)
3rd Floor

- Filler Beams W18x40
- Girder W21x83
- Girder W21x131
- Auditorium Filler Beam
- W18x65
- Column W14x61
- Moment Frame (Beam W21x83)
Roof

- Filler Beams W18x40
- Girder W21x83
- Girder W24x131
- Column W14x61
- Moment Frame (Beam W21X83) (Column W14X193)
Interior Columns

Pu = 410k
Pn = 626 k
W14x61

Exterior Columns

Pu = 265k
Pn = 626 k
Pl = 120k

Beams take PL as tension loads
W14x61

Pu = 410k
Pn = 626 k
W14x61

Interior Columns
Wave-Steel-Lateral System

Moment Frame

W21x83
W14x193
W21x83
W14x193
W21x83
W14x193

38 ft

12 ft

W14x193
W21x83
W14x193
W21x83
W14x193
W21x83

∑V=187.03 Kips

Atlantic - SE 83
Open Web Joist TJM

- 1.5”x4.75” Machine Stress Rated Lumber
- 2” tubular steel member
- Allowable Uniform Load: 119psf (46’ span)

Truss

5”x5” Lumber
Minimum Depth = Span/20”

Load Path

36” ~ 48”
2nd Floor

- Truss 3’ Deep
- Open Web Joists 26” Deep
- Shear Walls 4’ Thick
- Columns 15”x 15”
3rd Floor

- Truss 3’ Deep
- Auditorium Truss 5’ Deep
- Open Web Joists 26” Deep
- Shear Walls 4’ Thick
- Columns 15”x 15”
Wave-Wood-Floor Framing

Roof
- Truss 3’ Deep
- Truss 5’ Deep
- Open Web Joists 26” Deep
- Shear Walls 4’ Thick
- Columns 15”x 15”
- Hang Column 15”X15”

Hang Column
### Typical Framing

- **Joist**: TJM26"
- **Truss Chord**: 10"X12"
- **Truss Diagonal**: 6"X6"
- **Column**: 15"X15"

### Framing Above Auditorium

- **Length**: 15@4.5´
- **Width**: 38´

<table>
<thead>
<tr>
<th>Joist</th>
<th>Truss Chord</th>
<th>Truss Diagonal</th>
<th>Column</th>
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</thead>
<tbody>
<tr>
<td>TJM26”</td>
<td>10”X12”</td>
<td>6”X6”</td>
<td>15”X15”</td>
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</tbody>
</table>

**Auditorium**
Pu = 160k
Pn = 202 k
Pl = 64k

Beams take PL as tension loads
15”X15”

Interior Columns

Pu = 190k
Pn = 202 k

Exterior Columns

15”X15”

Atlantic - SE
Cross Lam Shear Walls

- Load Combination
  1.2D + 1.6W + L + 0.5(Lr or S or R) \[\text{Control}\]
  1.2D + 1.0E + L + 0.2S

- \(\sum V = 187.03\) Kips
  - Shear Demand = 5.30 Kip/ft
  - Shear Capacity = 6.94 Kip/ft \[\text{OK}\]
  - Thickness = 4 in

- If not add shear wall ③,
  - Shear Demand = 7.19 Kip/ft
  - Shear Capacity = 13.87 Kip/ft, Thickness = 6 in \[\text{Not Economic}\]

Economic: 38 ft, 13 ft, 10 ft, 36 ft
## Wave Summary

<table>
<thead>
<tr>
<th>Metric</th>
<th>VAV</th>
<th>ACB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Ventilation</td>
<td>31,000 CFM</td>
<td>14,000 CFM</td>
</tr>
<tr>
<td>Largest Branch</td>
<td>24” x 46”</td>
<td>24” x 31”</td>
</tr>
</tbody>
</table>
Wave – VAV Layout

- 2 AHU: one for main supply, one for auditorium
- Chilled water pump
- Steam to hot water pump
- Domestic water pump
- Storage tank for rainwater
Wave – VAV Layout

Level 2
Wave – VAV Layout

- Dedicated Outside Air AHU
- Chilled water pump
- Steam to hot water pump
- Domestic water pump
- Storage tank for rainwater
Wave – ACB Layout

- Dedicated Outside Air AHU
**Access - Road Access**

- **Avoided access road**
- **Preferred access roads**
- **Non-preferred access road**

The map illustrates different access routes to a site, highlighting the preferred and avoided access roads.
## Schedule – Key milestones

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<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sept</th>
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<th>Nov</th>
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<td>M5</td>
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</table>
Site Plan

Crane Radius 125 feet

- subassembly area
- portable toilets
- rest area
- site trailer
- waste recycle area
- storage area
- mobile crane
- bump-out area (just in time delivery)
- worker access
- site entrance
Completion of Mobilization (5/29/2015)

Completion of Structural System (10/02/2015)

Completion of Project (04/08/2016)
Cat 320D L Hydraulic Excavator

Net Flywheel Power: 148.0 hp
Operating Weight: 44820.0 lb

Price
850 USD/day
2300 USD/week

Cat 226B Series 3 Skid-Steer Loader

Net Flywheel Power: 56.0 hp
Rated Operating Capacity: 1500.0 lb

Price
200 USD/day
600 USD/week
Maximum radius needed ~125ft

Two options depending on the maximum lift

**LTM 1090-4.1**

Max. lifting capacity 179,000 lbs at 8 ft rad.
Telescopic boom 36 ft - 164 ft
Maximum lift at 119 ft 8.1 kilopounds

**LTM 1160-5.1**

Max. lifting capacity 352,700 lbs at 10 ft rad.
Telescopic boom 43 ft - 203 ft
Maximum lift at 116ft 18 kilopounds
Production Strategy – Erection sequence

**Boat**

- Zone 1
- Zone 2
- Zone 3

**Wave**

- Zone 1
- Zone 2
- Zone 3

**Crane**
Prefabricated Elements
Multi-trade prefabrication
Production Strategy - Prefabrication

Prefabrication of Multi-functional Facade

Prefabricate the facade with windows in the form of modular facade panels.
Production Strategy - Material suppliers

- **Material suppliers**
  - **DAILY METAL GROUP**
    - Distance: **3.7 miles**
    - Estimated time: **12 min**
  - **WIEDENBECK INC**
    - Distance: **4.6 miles**
    - Estimated Time: **15 min**
Production Strategy - Material suppliers

Wood & SIP-Panels

ACH Foam Technologies, LLC
Distance: 72.2 miles
Estimated Time: 1 hour 19 min

Thermocore Panel Systems
Distance: 341 miles
Estimated Time: 5 ½ hour

Material suppliers:
- Wood & SIP-Panels
- Thermocore Panel Systems
- ACH Foam Technologies, LLC
Constructability – Steel Structure

**BENEFITS**

- Good strength to weight ratio
- High Consistency in Manufacturing and Erection
- Readily Available in Markets

**DRAWBACKS**

- Elaborate sequence of advance planning and preparation required
- Low Flexibility in Shape
- Fireproofing concerns
Constructability – Wood Structure

**BENEFITS**

- Greater flexibility in planning and design
- More shapes can be made
- Almost perfect in a carbon point of view
- Can be more efficient in an operating point of view
- Almost no waste during construction

**DRAWBACKS**

- Low strength
- Fireproofing concerns
Schedule – Boat

Boat Steel – 230 days

- Site Preparation: 20 days
- Mobilization: 5 days
- Retaining Wall: 15 days
- Substructure: 30 days
- Excavation: 5 days
- Mat Foundation: 25 days
- Shell: 80 days
  - 1st floor: 25 days
  - 2nd floor: 25 days
  - 3rd floor: 25 days
- Roof: 1 day
- Façade: 30 days
- Interiors: 80 days
  - 1st floor: 60 days
  - 2nd floor: 70 days
  - 3rd floor: 80 days
- Services: 45 days
  - 1st floor: 20 days
  - 2nd floor: 25 days
- Roof: 5 days
- Landscaping: 30 days
- Commissioning: 10 days

Boat Wood – 226 days

- Site Preparation: 20 days
- Mobilization: 5 days
- Retaining Wall: 15 days
- Substructure: 30 days
- Excavation: 5 days
- Mat Foundation: 25 days
- Shell: 75 days
  - 1st floor: 12 days
  - 2nd floor: 18 days
  - 3rd floor: 13 days
- Roof: 1 day
- Façade: 30 days
- Interiors: 80 days
  - 1st floor: 60 days
  - 2nd floor: 70 days
  - 3rd floor: 80 days
- Services: 45 days
  - 1st floor: 20 days
  - 2nd floor: 25 days
- Roof: 5 days
- Landscaping: 30 days
- Commissioning: 10 days

Longer duration for the erection of the steel shell
Schedule – Wave

**Wave Steel – 245 days**

[Diagram of Wave Steel schedule showing 245 days for various tasks]

**Wave Wood – 239 days**

[Diagram of Wave Wood schedule showing 239 days for various tasks]

Longer duration for Wave roof, facade & interiors
Schedule – Critical path

<table>
<thead>
<tr>
<th>WBS</th>
<th>Task Mode</th>
<th>Task Name</th>
<th>Duration</th>
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<tbody>
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<td>7</td>
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<td>Mat Foundation</td>
<td>25 days</td>
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<tr>
<td>8</td>
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<td>Shell</td>
<td>80 days</td>
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<td>9</td>
<td></td>
<td>1st floor</td>
<td>15 days</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>2nd floor</td>
<td>15 days</td>
</tr>
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<td>11</td>
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<td>3rd floor</td>
<td>15 days</td>
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<td>12</td>
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<td>Roof</td>
<td>5 days</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Façade</td>
<td>30 days</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Interiors</td>
<td>80 days</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>1st floor</td>
<td>60 days</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>2nd floor</td>
<td>70 days</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>3rd floor</td>
<td>80 days</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>Services</td>
<td>45 days</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>1st floor</td>
<td>20 days</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>2nd floor</td>
<td>25 days</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>3rd floor</td>
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</tr>
<tr>
<td>22</td>
<td></td>
<td>Roof</td>
<td>5 days</td>
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<tr>
<td>23</td>
<td></td>
<td>Landscaping</td>
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<tr>
<td>24</td>
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<td>25</td>
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<tr>
<td>26</td>
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<td>Commissioning</td>
<td>10 days</td>
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</tbody>
</table>
Schedule - Comparison

Construction Start Date: May 25th 2015

Earliest Finish Date: April 4th 2016 – Boat-Wood
Latest Finish Date: April 29th 2016 – Wave-Steel

1 week time contingency included for bad weather
### Steel with Variable Air Volume-system

<table>
<thead>
<tr>
<th>Description</th>
<th>Estimated Value</th>
<th>Target Value</th>
<th>Value Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Substructure</td>
<td>$605 000</td>
<td>$594 000</td>
<td>$(11 000)</td>
</tr>
<tr>
<td>B Shell</td>
<td>$1 865 480</td>
<td>$1 926 818</td>
<td>$61 338</td>
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<tr>
<td>C Interiors</td>
<td>$1 007 200</td>
<td>$1 210 091</td>
<td>$202 891</td>
</tr>
<tr>
<td>D Services</td>
<td>$2 346 211</td>
<td>$2 349 000</td>
<td>$2 789</td>
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<tr>
<td>E Specialty Construction</td>
<td>$350 000</td>
<td>$493 364</td>
<td>$143 364</td>
</tr>
<tr>
<td>F Building Sitework</td>
<td>$565 000</td>
<td>$640 636</td>
<td>$75 636</td>
</tr>
<tr>
<td>G General Conditions</td>
<td>$1 060 000</td>
<td>$886 091</td>
<td>$(173 909)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$7 798 891</strong></td>
<td><strong>$8 100 000</strong></td>
<td><strong>$301 109</strong></td>
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</table>

### Wood with Active Chilled Beams

<table>
<thead>
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<th>Description</th>
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<th>Value Delta</th>
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<tr>
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<td>$(43 264)</td>
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<tr>
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<td>$146 891</td>
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<td>$2 349 000</td>
<td>$(172 211)</td>
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<tr>
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<td>$350 000</td>
<td>$493 364</td>
<td>$143 364</td>
</tr>
<tr>
<td>F Building Sitework</td>
<td>$565 000</td>
<td>$640 636</td>
<td>$75 636</td>
</tr>
<tr>
<td>G General Conditions</td>
<td>$1 060 000</td>
<td>$886 091</td>
<td>$(173 909)</td>
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<tr>
<td><strong>Total</strong></td>
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### Steel with Variable Air Volume-system

<table>
<thead>
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<th></th>
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<th>TARGET VALUE</th>
<th>VALUE DELTA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Substructure</td>
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<td>$ 594 000</td>
<td>$(11 000)</td>
</tr>
<tr>
<td>B Shell</td>
<td>$ 2 096 700</td>
<td>$ 1 926 818</td>
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<tr>
<td>C Interiors</td>
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<tr>
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<td>$ 2 349 000</td>
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<tr>
<td>E Specialty Construction</td>
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<td>$ 493 364</td>
<td>$ 93 364</td>
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<tr>
<td>F Building Sitework</td>
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<td>$ 640 636</td>
<td>$ 75 636</td>
</tr>
<tr>
<td>G General Conditions</td>
<td>$ 1 060 000</td>
<td>$ 886 091</td>
<td>$(173 909)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$ 7 974 811</strong></td>
<td><strong>$ 8 100 000</strong></td>
<td><strong>$ 125 189</strong></td>
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</table>

### Wood with Active Chilled Beams

<table>
<thead>
<tr>
<th></th>
<th>ESTIMATED VALUE</th>
<th>TARGET VALUE</th>
<th>VALUE DELTA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Substructure</td>
<td>$ 505 000</td>
<td>$ 594 000</td>
<td>$ 89 000</td>
</tr>
<tr>
<td>B Shell</td>
<td>$ 2 009 050</td>
<td>$ 1 926 818</td>
<td>$(82 232)</td>
</tr>
<tr>
<td>C Interiors</td>
<td>$ 1 007 900</td>
<td>$ 1 210 091</td>
<td>$ 202 191</td>
</tr>
<tr>
<td>D Services</td>
<td>$ 2 521 211</td>
<td>$ 2 349 000</td>
<td>$(172 211)</td>
</tr>
<tr>
<td>E Specialty Construction</td>
<td>$ 400 000</td>
<td>$ 493 364</td>
<td>$ 93 364</td>
</tr>
<tr>
<td>F Building Sitework</td>
<td>$ 565 000</td>
<td>$ 640 636</td>
<td>$ 75 636</td>
</tr>
<tr>
<td>G General Conditions</td>
<td>$ 1 060 000</td>
<td>$ 886 091</td>
<td>$(173 909)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$ 8 068 161</strong></td>
<td><strong>$ 8 100 000</strong></td>
<td><strong>$ 31 839</strong></td>
</tr>
</tbody>
</table>
Target Value – Boat

Steel with Variable Air Volume-system

Wood with Active Chilled Beams
Target Value - Comparison

Construction Start Date: May 25th 2015

Lowest Estimated Value: Boat-Steel

Highest Estimated Value: Wave-Wood
### Decision matrix based on schedule and cost

<table>
<thead>
<tr>
<th></th>
<th>Boat – Steel</th>
<th>Boat – Wood</th>
<th>Wave – Steel</th>
<th>Wave - Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Schedule</strong></td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>7</strong></td>
<td><strong>6</strong></td>
<td><strong>4</strong></td>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>

**Most beneficial:** Boat-Steel

**Least beneficial:** Wave-Wood
Life Cycle Financial Management
WLCC = Total WLCC in present-value (PV) dollars of a given alternative
I = PV investment costs
Repl = PV capital replacement costs
Res = PV residual value (resale value, salvage value) less disposal costs
E = PV of energy costs
W = PV of water costs
OM&R = PV of non-fuel operating, maintenance and repair costs
O = PV of other costs (e.g., contract costs for ESPCs or UESCs)
S = Salaries
## LCFM - Risks

<table>
<thead>
<tr>
<th>Risk Description</th>
<th>Cause</th>
<th>Effect</th>
<th>Probability of Occurrence</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire regulation issues</td>
<td>visibility of MEP pipes, material</td>
<td>construction delay, increase in costs</td>
<td>1</td>
<td>2,5</td>
</tr>
<tr>
<td>Drainage of excavation</td>
<td>shallow water table</td>
<td>time delay, increase in costs</td>
<td>3</td>
<td>4,5</td>
</tr>
<tr>
<td>Earth pressure</td>
<td>building is built into hill, constant pressure against construction</td>
<td>higher costs for material</td>
<td>5</td>
<td>2,5</td>
</tr>
</tbody>
</table>

**Diagram:**
- **Wave 2nd floor**
- **Excavation**
- **Boat**
**LCFM – Risk management**

**V1: Aerogel Panels**

- + environmental friendly
- + translucent
- + Increase thermal insulation
- + Improve sound insulation
- + Gain LEED® points
- + Reduces energy consumption
  (R8 per inch)
- - F60
- - expensive

**Visibility of MEP Shafts**

**V2: Fireproof Glazing**

+ F90
+ prefabrication
+ cheap
- No translucent
- No LEED® points
LCFM – Why we need it!? 

Based on our design:

<table>
<thead>
<tr>
<th></th>
<th>Boat _ Steel</th>
<th>Boat _ Wood</th>
<th>Wave _ Steel</th>
<th>Wave _ Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction costs</strong></td>
<td>20</td>
<td>$7,971,000</td>
<td>$8,034,000</td>
<td>$7,975,000</td>
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<tr>
<td><strong>O &amp; M costs</strong></td>
<td>75</td>
<td>$23,913,000</td>
<td>$24,102,000</td>
<td>$23,925,000</td>
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</tbody>
</table>

Based on assumptions found in current literature

Source: APOGEE (2006)
<table>
<thead>
<tr>
<th></th>
<th>per sft effective floor space</th>
<th>Boat Steel</th>
<th>Boat Wood</th>
<th>Wave Steel</th>
<th>Wave Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>sft</td>
<td>34.620</td>
<td>34.620</td>
<td>30.906</td>
<td>30.906</td>
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<tr>
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<td>$9 - $32.5*</td>
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<td>$300.000 – $1.000.000</td>
<td>$270.000 – $1.000.000</td>
<td>$270.000 – $1.000.000</td>
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<tr>
<td>Facilities management</td>
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<td>$350.000 – $1.200.000</td>
<td>$300.000 – $1.080.000</td>
<td>$300.000 – $1.080.000</td>
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<td>Energy</td>
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<td>$70.000</td>
<td>$70.000</td>
<td>$60.000</td>
<td>$60.000</td>
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</table>

Based on assumptions found in current literature
### LCFM – Energy Costs

#### Electricity Use

<table>
<thead>
<tr>
<th>Component</th>
<th>Boat</th>
<th>Boat Savings</th>
<th>Wave</th>
<th>Wave Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>100%</td>
<td>$70,000</td>
<td>$60,000</td>
<td>~ $49,000</td>
</tr>
<tr>
<td>Lighting</td>
<td>32%</td>
<td>$22,400</td>
<td>$19,200</td>
<td>$8,000 (~40%)</td>
</tr>
<tr>
<td>Ventilation</td>
<td>23%</td>
<td>$16,100</td>
<td>$13,800</td>
<td>$1,500 (~10%)</td>
</tr>
<tr>
<td>Cooling</td>
<td>18%</td>
<td>$12,600</td>
<td>$10,800</td>
<td>$1,000 (~10%)</td>
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</table>

Based on assumptions found in current literature.
LCFM—Operation & Maintainance

HVAC Systems

- Energy Costs
- Maintainence
- Operation
- HVAC first cost

<table>
<thead>
<tr>
<th>Item</th>
<th>VAV</th>
<th>ACB</th>
<th>Net for ACB</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHU</td>
<td>Large</td>
<td>Small</td>
<td>+</td>
</tr>
<tr>
<td>Ductwork</td>
<td>Large</td>
<td>Small</td>
<td>+</td>
</tr>
<tr>
<td>Risers</td>
<td>Large</td>
<td>Small</td>
<td>+</td>
</tr>
<tr>
<td>Ceiling Space</td>
<td>Large</td>
<td>Small</td>
<td>+</td>
</tr>
<tr>
<td>Pipework</td>
<td>Small</td>
<td>Large</td>
<td>-</td>
</tr>
<tr>
<td>Fan Energy</td>
<td>High</td>
<td>Low</td>
<td>+</td>
</tr>
<tr>
<td>Pump Energy</td>
<td>Low</td>
<td>High</td>
<td>-</td>
</tr>
<tr>
<td>Tenant Satisfaction</td>
<td>Low</td>
<td>High</td>
<td>+</td>
</tr>
<tr>
<td>Air Side System Cost</td>
<td>Low</td>
<td>High</td>
<td>+</td>
</tr>
<tr>
<td>Water Side System Cost</td>
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</tr>
<tr>
<td>Individual Control</td>
<td>Low</td>
<td>High</td>
<td>+</td>
</tr>
<tr>
<td>Thermal Comfort</td>
<td>Low</td>
<td>High</td>
<td>+</td>
</tr>
<tr>
<td>Generated Noise</td>
<td>High</td>
<td>Low</td>
<td>+</td>
</tr>
<tr>
<td>Maintenance</td>
<td>High</td>
<td>Low</td>
<td>+</td>
</tr>
<tr>
<td>Risk of Condensation</td>
<td>Low</td>
<td>High</td>
<td>-</td>
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</table>
Based on current design decisions
Mens sana in corpore sano

Urban roof gardening / creating new habitats

Workspace with natural daylight and healthy material
<table>
<thead>
<tr>
<th>Economic</th>
<th>Construction</th>
<th>boat</th>
<th>wood</th>
<th>steel</th>
<th>wood</th>
<th>wave</th>
<th>steel</th>
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<tr>
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<td>81,76</td>
<td>80,01</td>
<td>78,38</td>
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</tbody>
</table>

**Collaboration**

|          | collaboration space | 15,00 | 82    | 82    | 80    | 80    |
|          | atrium             | 18,00 | 74    | 74    | 76    | 76    |
|          | connection between interior & exterior | 25,00 | 80    | 77    | 71    | 70    |
|          | connection to the hill | 15,00 | 78    | 75    | 73    | 70    |
|          | inside experience  | 20,00 | 91    | 90    | 83    | 83    |
|          | representation of University | 7,00 | 88    | 87    | 72    | 71    |
TEAM ATLANTIC proudly presents...

BOAT WOOD

Thanks to all the great Mentors and their helpful and constructive feedback
Team Process
8 STRANGERS
GETTING TO KNOW EACH OTHER
Team Process Development

PROFESSION
ATLANTIC

TEAM ATLANTIC
8 FRIENDS WORKING TOGETHER