Outline

- Primary System Design Constraints
- Venue Illustration
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- Loudspeaker Selection, Placement, and Rigging
- EASE Simulation Results
- Power Amplifier Requirements and Selection
- Signal Processing Requirements and Selection
- Mixing Console Requirements and Selection
- Microphone Requirements and Selection
- Signal Path Wiring Diagram
- Rack Requirements and Design
- Cabling and Wiring Requirements
- System Component List and Street Price Estimate
- Summary and Recommendations
Primary System Design Constraints

- generic fan-shaped high school auditorium with seating for 5000 (approx. 4000 main floor, 1000 balcony)
- minimum SPL of 105 dB at back row of seating
- no more than ±5 dB variation in SPL over the entire seating space for the 1 KHz, 2 KHz, 4 KHz, and 8 KHz frequency bands
- frequency response of 40 – 16,000 Hz ± 5 dB
- %ALCONS no greater than 10% over entire seating space
- minimum 48-channel mixing console
- minimum of 4 separate monitor mixes (and corresponding monitor loudspeaker systems)
- support for 20 compatible wireless microphone channels
- good assortment of general-purpose wired and wireless microphone systems
- digital media recording/playback capability
- all equipment mounted in rack cabinet(s)
- budget of $500,000
Venue Illustrations
System Design Constraints

- Entirely active audience speaker system
- Complete digital transmission
- Separated point-source array
  - Result of long, narrow venue
- Satisfaction of mix system requirements

CobraNet® technology reduces the cost and hassle of routing multiple noise-free channels, all through a single CAT-5 Ethernet network.
Loudspeaker Selection, Placement, and Rigging

• Loudspeaker Selection Criteria
  – Active System
  – Digital Transmission
  – Narrow Horizontal Dispersion

• Considered:
  – JBL Vertex
  – EV X-Line
  – Renkus-Heinz Varia
Loudspeaker Selection, Placement, and Rigging
Acoustic Treatment

- Two Fold Simulation
- Room characteristics
  - Rear Material
    - ⅝” gypsum board, concrete
  - Inner Materials
    - More complex
Inner Treatment

- Side Wall and Balcony Face
  - Auralex 2” Pro Panel
Inner Treatment

- Ceiling and Under Balcony
  - Auralex T fusor e-350
Inner Treatment

- Back Wall (Floor and Balcony)
  - Auralex Space Array
Inner Treatment

- Parallel Walls
  - Auralex LENRD Bass Trap
Inner Treatment

- Rear Stage Corners
  - Auralex LENRD Bass Trap
EASE Simulation Results

Broadband SPL

THEATRE.TYP
Used:
Map: Total SPL (Z)
Warning: --- Rough Approximation Only ---
Freq: 1000 Hz
(Broad Band Sum)
Energy: 2° Epot
(1/3rd Octave)

(c) EASE 4.3 / THEATRE.TYP / 5/8/2014 1:53:06 AM / Purdue University ECE 40020

110-112 dB
EASE Simulation Results

Total Frequency Response

(c) EASE 4.3 / THEATRE.TYP / 5/7/2014 12:53:35 PM / Purdue University ECE 40020
EASE Simulation Results

Direct Frequency Response

Direct SPL (dB) at A14 #1 (-90.64; -156.00; 11.82)

(c) EASE 4.3 / THEATRE.TYP / 5/1/2014 11:31:18 AM / Purdue University ECE 40020
EASE Simulation Results

Total SPL Plots

1kHz

2kHz

4kHz

8kHz

100-104 dB

101-103 dB

98-102 dB

94-97 dB
EASE Simulation Results

Room RT60
Power Amplifier Requirements and Selection

• Array Elements
  – 500W Program Power
  – 96dB (1W/1m)
  – 126dB Maximum SPL (1 meter)

• Fill Elements
  – 600W Program Power
  – 98dB(1W/1m)
  – 128dB Maximum SPL (1 meter)
**Signal Processing Requirements and Selection**

- Individual DSP processing
  - Individualized delay timing
  - Frequency-dependent amplitude shading
  - Re-configurability
  - Beam Steering
  - Component monitoring and safety

- Signal Processing in MIDAS
  - Handled by external “brains”
Mixing Console Requirements and Selection

- Midas Pro3 w/ DL351
  - 48 input channels, 8 output channels, 24 mix busses, CobraNet-powered mains
Mixing Console Requirements and Selection

• Allen and Heath iLive 112 w/ iDR-48 (alternative)
  – 48 input channels, 16 output channels, 32 mix busses, AES-powered mains
Mixing Console Requirements and Selection

• Monitoring
  – In Ear Monitoring: Aviom A360 Personal Mixers
  – Wedges: Yamaha CM12V and CM15V speakers powered by Crown XTi2 power amplifiers
Microphone Requirements and Selection

- Microphone selection rationale and alternatives considered
  - Vocal: Shure SM58, Shure Super 55, AKG c3000
  - Drums: Shure Beta 52A, Sennheiser e905, Sennheiser e614
  - Jazz/Orchestral: Crown PZM 30D, Shure PG81-LC, AKG c519, AKG c516 ML, AKG c411 (vibration)
  - Shure ULX-D2 system
Signal Path Wiring Diagram
Rack Requirements and Design

- Rack selection was based on functional groups
  - Front of house
  - Wireless system
  - MIDAS Processing and I/O
  - Monitoring system
- All racks include surge protection and power conditioning
- Largest racks are power sequenced
- Largest racks also on wheels, facilitates mobility
Cabling and Wiring Requirements

• CobraNet ethernet system
  – Latency
  – Power Dissipation
  – High Frequency Loss
• All transmitted information is digital, with balanced line connections
• MIDAS I/O -> MIDAS Pro3 -> Klark-Teknik Interface -> Renkus-Heinz Arrays
## System Component List and Street Price Cost Estimate

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model No.</th>
<th>Description</th>
<th>Unit Cost</th>
<th>Qty</th>
<th>Total Cost</th>
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<tbody>
<tr>
<td>Shure</td>
<td>SM58</td>
<td>Dynamic vocal, instrument</td>
<td>100</td>
<td>1</td>
<td>1200</td>
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<td>Dynamic vocal, instrument, amplifier</td>
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<td>Shure</td>
<td>Super 55</td>
<td>Dynamic vocal</td>
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<td>Shure</td>
<td>Beta 52A</td>
<td>Bass drum</td>
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<td>Sennheiser</td>
<td>E905</td>
<td>Toms, snare</td>
<td>170</td>
<td>6</td>
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<tr>
<td>Sennheiser</td>
<td>E614</td>
<td>Hi-hat, cymbals, overhead</td>
<td>200</td>
<td>5</td>
<td>1000</td>
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<tr>
<td>Crown</td>
<td>Sound Grabber II</td>
<td>PZM</td>
<td>200</td>
<td>6</td>
<td>1200</td>
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<tr>
<td>Shure</td>
<td>PG81-LC</td>
<td>Violin, cello, piano, acoustic guitar</td>
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<td>8</td>
<td>992</td>
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<tr>
<td>AKG</td>
<td>C414-XLS</td>
<td>Voice, guitar, amplifier,</td>
<td>850</td>
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<td>AKG</td>
<td>C3000</td>
<td>Vocal, guitar, brass, drums</td>
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<td>AKG</td>
<td>C519</td>
<td>Mini brass instrument clip-on</td>
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<tr>
<td>AKG</td>
<td>C516 ML</td>
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<td>378</td>
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<td>AKG</td>
<td>C411</td>
<td>Mini violin, brass, acoustic guitar, vibration pickup</td>
<td>129</td>
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<td>1290</td>
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### Microphone System Cost

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<th>Model No.</th>
<th>Description</th>
<th>Unit Cost</th>
<th>Qty</th>
<th>Total Cost</th>
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<tr>
<td>MIDAS</td>
<td>Pro3</td>
<td>Mixing Console (Digital)</td>
<td>13000</td>
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<td>MIDAS</td>
<td>DL251</td>
<td>I/O Unit</td>
<td>3400</td>
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<tr>
<td>Apple</td>
<td>iPad Air</td>
<td>Wireless mixing tool</td>
<td>500</td>
<td>1</td>
<td>500</td>
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<tr>
<td>Klark Teknik</td>
<td>DN9650</td>
<td>Network Bridge (CobraNet)</td>
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<tr>
<td>Aviom</td>
<td>AN-16/4-m</td>
<td>Mic Input Module</td>
<td>2500</td>
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### Mixing System Cost

<table>
<thead>
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<th>Qty</th>
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<tbody>
<tr>
<td>Aviom</td>
<td>A360</td>
<td>Personal Mixer</td>
<td>800</td>
<td>8</td>
<td>6400</td>
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<tr>
<td>Aviom</td>
<td>A-16D Pro</td>
<td>Signal Distributor</td>
<td>1400</td>
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<td>Crown</td>
<td>XTi21002</td>
<td>2 Channel Power Amplifier</td>
<td>600</td>
<td>4</td>
<td>2400</td>
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<tr>
<td>Yamaha</td>
<td>CM12V</td>
<td>12&quot; floor monitor</td>
<td>350</td>
<td>6</td>
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<td>Yamaha</td>
<td>CM15V</td>
<td>15&quot; floor monitor</td>
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### Monitoring System Cost

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<th>Total Cost</th>
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<td>Apple</td>
<td>Mac Pro</td>
<td>Digital Playback Source</td>
<td>3000</td>
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<td>Sonnet</td>
<td>Mac Pro Rack</td>
<td>Rack mount for Mac Pro</td>
<td>1500</td>
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<td>RPM</td>
<td>TB248/48</td>
<td>AES50 to Thunderbolt I/O</td>
<td>4000</td>
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### Recording/Playback Cost

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### Total Cost

|continued...|    |    |

### TOTAL COST

$15,920
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<th>Manufacturer</th>
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<tr>
<td>Shure</td>
<td>ULX-D4Q</td>
<td>Quad Channel Receiver</td>
<td>5015</td>
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<td>25075</td>
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<td>Shure</td>
<td>ULX-D1</td>
<td>Bodypack Transmitter</td>
<td>445</td>
<td>8</td>
<td>3560</td>
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<td>Shure</td>
<td>ULX-D2/SM58</td>
<td>Wireless SM58 Handheld Microphone</td>
<td>474</td>
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<td>3792</td>
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<td>Shure</td>
<td>ULX-D2/KSM9</td>
<td>Wireless KSM9 Handheld Microphone</td>
<td>1050</td>
<td>2</td>
<td>2100</td>
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<td>Shure</td>
<td>ULX-D2/B87C</td>
<td>Wireless Beta87 Handheld Microphone</td>
<td>630</td>
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<td>1260</td>
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<td>Shure</td>
<td>SBC800</td>
<td>Bulk Battery Recharging Station</td>
<td>454</td>
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<td>908</td>
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<td>Shure</td>
<td>PGA31</td>
<td>Headset Condenser</td>
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<td>Shure</td>
<td>PG185</td>
<td>Lavalier Condenser</td>
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<td><strong>WIRELESS MICROPHONE COST</strong></td>
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<td><strong>$37,087</strong></td>
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<td>Renkus-Heinz</td>
<td>VA101-7</td>
<td>Self-Powered 7 degree Array Element</td>
<td>7923</td>
<td>14</td>
<td>110922</td>
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<td>Renkus-Heinz</td>
<td>VA101-15</td>
<td>Self-Powered 15 degree Array Element</td>
<td>7923</td>
<td>6</td>
<td>47538</td>
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<td>Renkus-Heinz</td>
<td>VA155</td>
<td>Self-Powered 15 inch Subwoofer</td>
<td>6518</td>
<td>9</td>
<td>58622</td>
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<td>Renkus-Heinz</td>
<td>PN121</td>
<td>Self-Powered 12 inch Downfill Speaker</td>
<td>3880</td>
<td>22</td>
<td>85360</td>
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<tr>
<td>Renkus-Heinz</td>
<td>RHANG101LA</td>
<td>Flybar for 101 Elements</td>
<td>1235</td>
<td>2</td>
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<td>Renkus-Heinz</td>
<td>ICB-VA101-715</td>
<td>Interconnect Bar VA101-7 to VA101-15 - pair</td>
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<td><strong>AUDIENCE SPEAKER COST</strong></td>
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<td>Middle Atlantic</td>
<td>DTRK-1218</td>
<td>12 Space Rack</td>
<td>410</td>
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<td>Middle Atlantic</td>
<td>PD-915R</td>
<td>9 Outlet Power Distribution</td>
<td>140</td>
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<td>280</td>
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<td>Middle Atlantic</td>
<td>UD2</td>
<td>2 Space Utility Drawer</td>
<td>160</td>
<td>6</td>
<td>960</td>
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<td>Middle Atlantic</td>
<td>PTRK-14MDK</td>
<td>14 Space Rolling Rack</td>
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<td>PDS-1620R-NS</td>
<td>16 Outlet Power Distribution and Sequencing</td>
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<td>PTRK-21MDK</td>
<td>21 Space Rolling Rack</td>
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<td>Middle Atlantic</td>
<td>VTP-2</td>
<td>2 Space Slotted Vent Panel</td>
<td>36</td>
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<td><strong>RACK SYSTEM COST</strong></td>
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<td><strong>$6,349</strong></td>
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<tr>
<td>Univoxaudio</td>
<td>EJ-7XT</td>
<td>Wireless Body pack transmitter for Assistive Listening</td>
<td>25</td>
<td>50</td>
<td>1250</td>
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<tr>
<td>Univoxaudio</td>
<td>HDC-750</td>
<td>Charging Station for 50 Units</td>
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<td><strong>HEARING ASSIST COST</strong></td>
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<td><strong>TOTAL COST</strong></td>
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</table>
Summary and Recommendations

• Pair of separated J-arrays
  – Front Fills
  – Under Balcony
  – Over Balcony
• Met criteria with exception of total frequency response
• Dimensions of venue contributed to difficulty
• Realistic simulations
  – Direct vs. Total SPL
  – Wall Treatments
Questions / Discussion