Improving the Visitor Experience: A Noise Study and Treatment Design for the Smithsonian's National Zoological Park Great Ape House

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Improving the Visitor Experience:

A noise study and treatment design for the Smithsonian’s National Zoological Park Great Ape House

Ryan Schultz¹, Jon Alexander², J. Stuart Bolton¹, Stephanie Castiglione², Tom Hanschen², Ed Bronikowski³

¹Purdue University, ²3M Company, ³National Zoological Park
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What’s the Problem?
What’s the Problem?
What’s the Problem?

≈ 2 Million visitors each year

Lots of noise in a very reflective space

Difficult to hear conversations and fatiguing to the volunteers & staff
Process

Step 1: Baseline Measurements
Step 2: Design & Apply Treatment
Step 3: Final Measurements
Baseline Measurement: RT

Impulsive Measurement

Multiple Locations

Reverberation Time (space averaged)
What is the noise problem?

24/7 for 7 weeks

A-weighted Equivalent Level

Un-weighted Equivalent Levels in 1/3 Octave Bands
Baseline Measurement: Sound Level

What is the noise problem?

24/7 for 7 weeks

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Un-weighted Equivalent Levels in 1/3 Octave Bands
Baseline Measurement: Sound Level

What is the noise problem?

24/7 for 7 weeks

A-weighted Equivalent Level

Un-weighted Equivalent Levels in 1/3 Octave Bands

Average Over Time: Un-Weighted Equivalent Level Spectra

- All Times
- Exhibit Closed
- Exhibit Open
- 10 Loudest Intervals

Average of Equivalent SPL [dB]

1/3 Octave Band Frequency, [Hz]
What is the noise problem?

24/7 for 7 weeks

A-weighted Equivalent Level

Un-weighted Equivalent Levels in 1/3 Octave Bands

Baseline Measurement: Sound Level

Average Over Time: Un-Weighted Equivalent Level Spectra

Treatment

1/3 Octave Band Frequency, [Hz]
Micro-perforated film in a modular, tile-based design

Exhibit-friendly

Excellent absorption performance

![Graph showing absorption coefficient over different frequency bands]
<table>
<thead>
<tr>
<th>Material</th>
<th>Area, ft²</th>
<th>Area, m²</th>
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<tbody>
<tr>
<td>Gypsum Board</td>
<td>4183</td>
<td>389</td>
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<tr>
<td>Plastic</td>
<td>557</td>
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<td>Glass</td>
<td>2610</td>
<td>242</td>
</tr>
<tr>
<td>Dirt</td>
<td>479</td>
<td>44</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>12867</strong></td>
<td><strong>1195</strong></td>
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**Volume:**

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<th>ft³</th>
<th>m³</th>
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<tbody>
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<td>62318</td>
<td>1765</td>
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**Room Model**

**RT** = 0.161 \( \frac{V}{A} \)

- **RT** = Reverberation Time, [s]
- **V** = Volume of the Space, [m\(^3\)]
- **A** = Absorption, [Metric Sabins]

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</table>
Room Model

Predicted Reverberation Time: Baseline and Treated

<table>
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<tr>
<th>Octave Band Frequency, [Hz]</th>
<th>Reverberation Time, [s]</th>
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<tbody>
<tr>
<td>125</td>
<td>Baseline: 2.25, Treated: 1.80</td>
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<tr>
<td>250</td>
<td>Baseline: 2.50, Treated: 2.00</td>
</tr>
<tr>
<td>500</td>
<td>Baseline: 3.00, Treated: 2.50</td>
</tr>
<tr>
<td>1000</td>
<td>Baseline: 3.50, Treated: 3.00</td>
</tr>
<tr>
<td>2000</td>
<td>Baseline: 3.00, Treated: 2.50</td>
</tr>
<tr>
<td>4000</td>
<td>Baseline: 2.50, Treated: 2.00</td>
</tr>
</tbody>
</table>
After-Treatment Measurement: RT

67 m² (720 ft²) of tiles were installed over concrete sections of the walls.

Good Agreement Between Predictions & Measurements

RT: Prediction vs. Measured - Post Treatment

- Model Prediction
- Measurement

Frequency Band, [Hz]

250, 500, 1000, 2000, 4000

Roughly Time [s]

0.50, 1.00, 1.50, 2.00, 2.50, 3.00, 3.50, 4.00
**Conclusions**

**Problem**

- Lots of Visitors = Lots of Noise
- Rev. Time & SPL measurements to quantify the problem

**Treatment**

- Model of the room to predict the improvement from various treatment designs
- Modular, micro-perforated treatment provided good absorption performance

**Results**

- Reduction in Rev. Time of approximately 1 second
- Positive feedback from Zoo staff thus far
Future Work

1. Measure SPL over time, same as before, for the treated room

2. Investigate improvements to speech intelligibility due to the increased absorption in the space

3. Use continued measurements along with visitor and staff feedback to determine if more treatment is necessary
Thank you!

Any questions?