Rating of the loudest college basketball arenas for ESPN magazine

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3pAA6. Rating of the loudest college basketball arenas for ESPN magazine

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A recent ESPN magazine article ("These go to 11," ESPN Magazine 15 Nov 2010) ranked the top collegiate basketball arenas according to "noise potential." The rankings were established by a team of Penn State Acoustics students using the theory for sound build up in large rooms, since actual measurements were infeasible. Both diffuse field and direct field contributions of the sound pressure were estimated at center court for octave band frequencies from 125 Hz to 4 kHz. Seating geometries, materials and other relevant information were collected for each arena and used with estimated absorption coefficients to determine the room constant. The diffuse field contributions were then combined with approximate sources terms based on the seating capacity of the arena, the proximity of the fans to the court and whether they were students. The sound pressures were then combined into a total A-weighted sound pressure level and used to determine the ranking. The direct and reverberant contributions of each arena were then compared to establish the positive and negative aspects of each arena in terms of noise potential. This comparison reveals how Kansas and Duke reached the top of the ranking, despite having drastically different arena geometry and capacity.

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I. Introduction

In Sept 2011, ESPN Magazine asked the authors to rank 10 pre-selected college basketball arenas according to their loudness. The ranking would be the basis of an article in a college basketball pre-season edition of the magazine ("Loud Edition" printed on 15 November 2010). The list of 10 arenas was chosen by ESPN by asking play-by-play announcers and journalists which arenas they thought were the loudest. The list included Cameron Indoor Stadium (Duke University), Allen Fieldhouse (Kansas University), Gallagher-Iba Arena (Oklahoma State University), Rupp Arena (Kentucky University), O-Connell Center (University of Florida), The Pit (New Mexico University), Assembly Hall (University of Illinois), Bramlage Coliseum (Kansas State University), MacAurthur Court (University of Oregon), Petersen Events Center (Pittsburgh University). Since on-court measurements at all arenas were not feasible, the authors objectively performed the ranking by estimating a "noise potential." This paper will describe the methodology and theory used to make the rankings and compare the arenas potential for loudness.

II. Methodology

With both time and budget constraints, the authors decided to use the theory of sound build-up in large rooms to do the ranking instead of doing field measurements or creating ray-tracing models. The sound pressure level in a large room can be computed based on the sound power input to the room and the sound build-up according to

$$L_p \approx L_w + 10\,\boldsymbol{log}\left(\frac{Q}{4\pi r} + \frac{4}{R}\right),$$

where L_w is the sound power input, r is the distance to the source, Q is the source directivity and R is the room constant. The ten arena managers were contacted and asked to provide information on the total capacity, seating layup, arena geometry and surface materials.

The total seating capacity was used to estimate the total power input to the arena with each fan inputting some amount of sound power. Fig. 1 shows a recreated plot of the average male voice levels in Beranek [1] which were assigned to the fans. Although these values were not measured at octave bands, the values were assumed to be the nearest octave band to maintain the general trend. Since student fans typically yell louder than non-student fans, they were given the levels under "loudest" and non-students were given "raised." Fans were also given a directivity factor of 2. The room constant was determined by estimating absorption coefficients and surface areas for all the surfaces based on the information provided by the arenas.

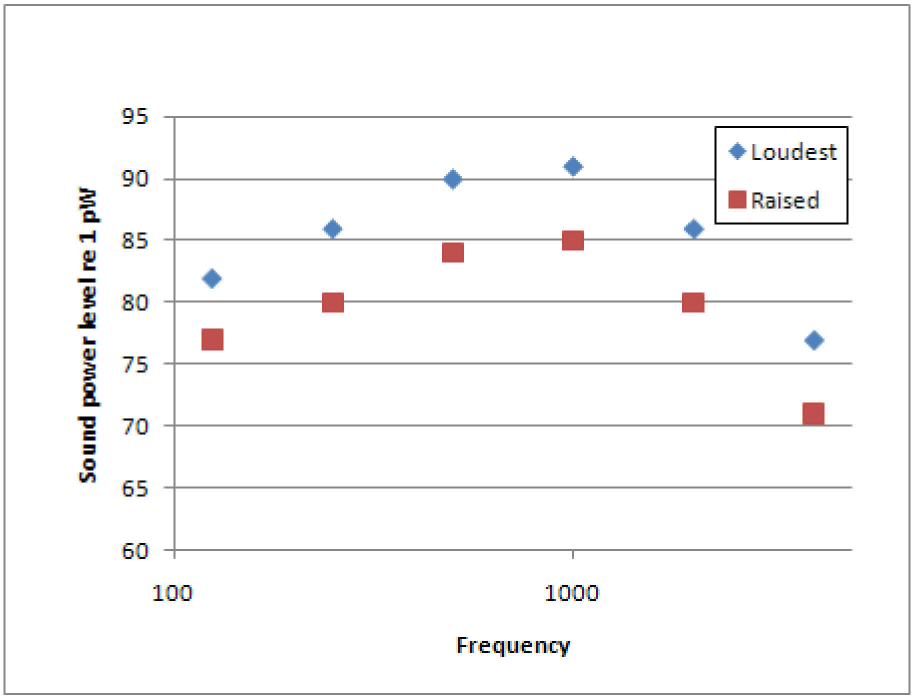

Figure 1. The sound power level of an average male (recreated in octave bands from Beranek [1]). Student fans were assigned the 'loudest' levels and non-student fans were assigned the 'raised' level.

To simplify the procedure for finding the distance *r* between each source and the court, all fans were grouped into disks centered at center court. The number of student and non-student fans was estimated within each disk to get an effective source power. The middle radius of the disk was then used as the effective distance for a source with that amount of sound power. The size of each disk was determined assuming direct sound contributions decay as *1/r.* The maximum difference in direct sound due to spreading between the front of the disk and the back of the disk was set at 2 dB. Fig. 2 shows a set of disks around a typical basketball court.

The levels in Eq. 1 were estimated for the octave bands from 125 Hz to 4 kHz. Air absorption due to molecular relaxation was also included in the room constant estimate [2]. The octave band levels were then A-weighted and summed to produce a single number. Since each arena required some amount of estimation of fans within disks and surface area, each arena was evaluated by two of the authors independently. Each evaluator used reverberation time as a check to see if the values seemed reasonable. By interpolating a T60 chart from Pierce [3], the range for reverberation times at 1 kHz was estimated to be between 2-4 s. The values were then averaged to produce the final value used for the ranking.

Several assumptions were required to use this procedure. First, each arena was at full capacity and each fan is yelling at the level previously described. Second, all fans have the same absorption characteristics. Third, the sound at center court is composed of only direct and reverberant sound. Fourth, temperature and humidity effects were constant. Finally, only yelling fans contributed to the ranking (i.e. no band, stomping, vuvuzelas, etc.).

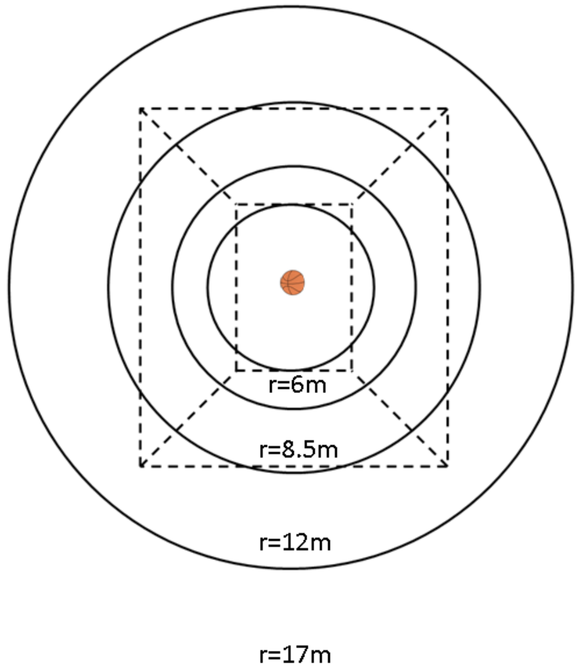

Figure 2. The disks used to approximate the source distances from center court. As the fans are further from center court, their direct contribution becomes less and the disks become larger.

III. Results and Comparisons

After completing the analyses, the results were tabulated and a final ranking was created, as shown in Table 1. The top four arenas were all fairly close and likely all within the error tolerances of the analysis. As an interesting note, a newspaper study was found that described measurements at games in the later 1990's and listed Kansas, Duke and New Mexico in their top 4 loudest games [4].

Table 1. The final rankings of the 10 arenas evaluated for ESPN magazine. The rankings are based on a "noise potential" metric including the effects of total fan capacity and room reverberation.

1	Kansas	6	Pittsburgh
2	Duke	7	Kansas State
3	Kentucky	8	Illinois
4	New Mexico	9	Oklahoma State
5	Florida	10	Oregon

Several additional comparisons were performed to determine trends of the arenas. Fig. 3 compares the total number of student and non-student fans in each arena. This relates the total sound power input to each arena. The highest total capacity was Kentucky, while the lowest was Duke. Since Duke ranked higher than Kentucky, one cannot judge an arena based solely on the total number of fans. Fig. 4 displays the contributions due to direct and reverberant sound in percentages. Kansas State has the highest direct contribution, while New Mexico has the highest reverberant contribution. Both Kansas and Duke have a 70/30 ratio, which seems to be an optimal ratio of reverberant to direct sound for loudness at center court.

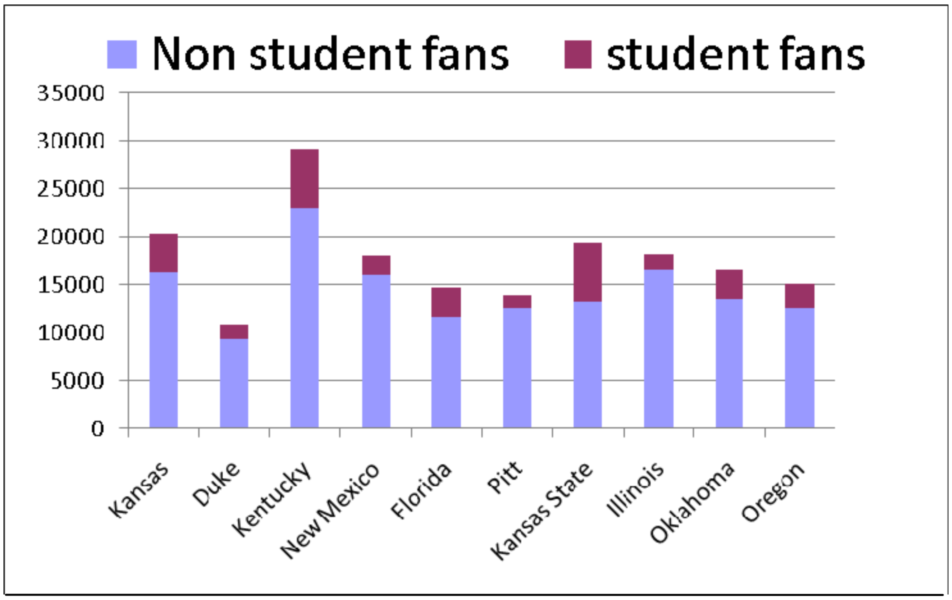

Figure 3. The total student and non-student fan capacity of each arena. Kentucky has the highest total capacity and Duke has the lowest.

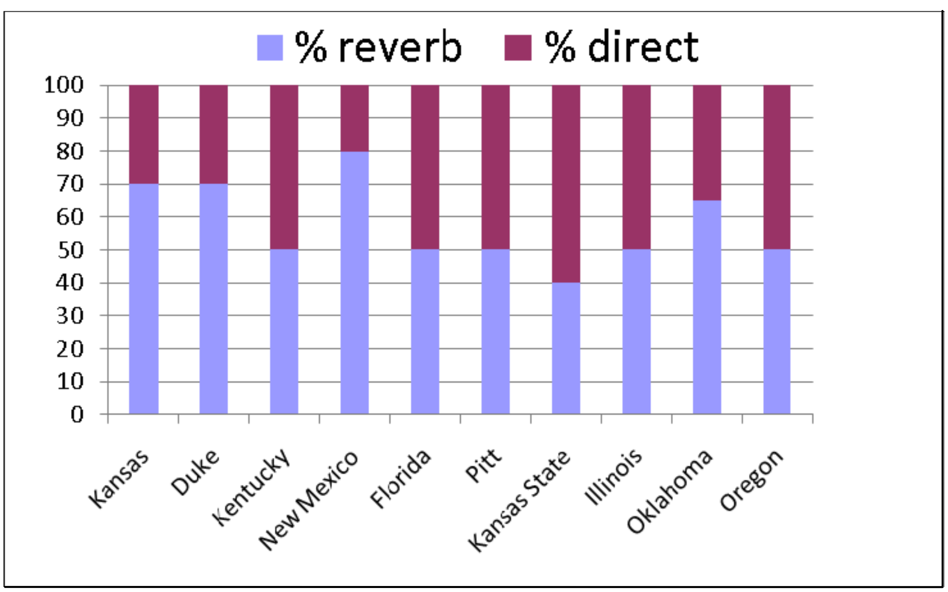

Figure 4. The percent direct and reverberant contributions in each arena. Kansas State has the highest percentage of direct sound while New Mexico has the highest percentage of reverberant sound.

Figure 5 reveals the reverberation times for the octave frequencies between 125 Hz to 4 kHz and Fig. 6 has the average absorption at 1 kHz. The general trend shows that higher reverberation time and lower absorption will lead to higher rankings. The fact that there are a few outliers can reveal that high reverberation is not sufficient to be the loudest arena.

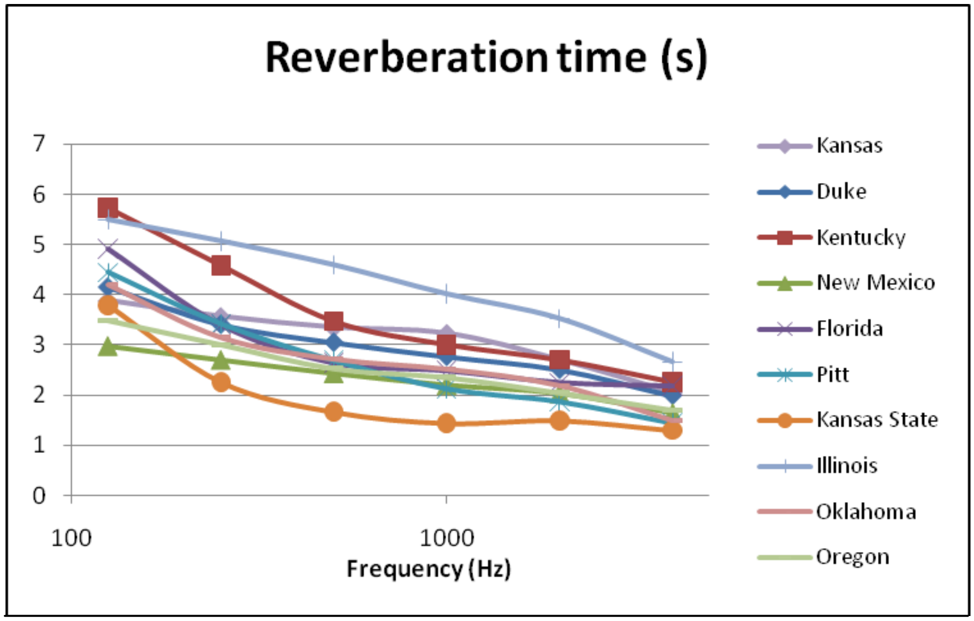

Figure 5. The estimated reverberation times of each arena.

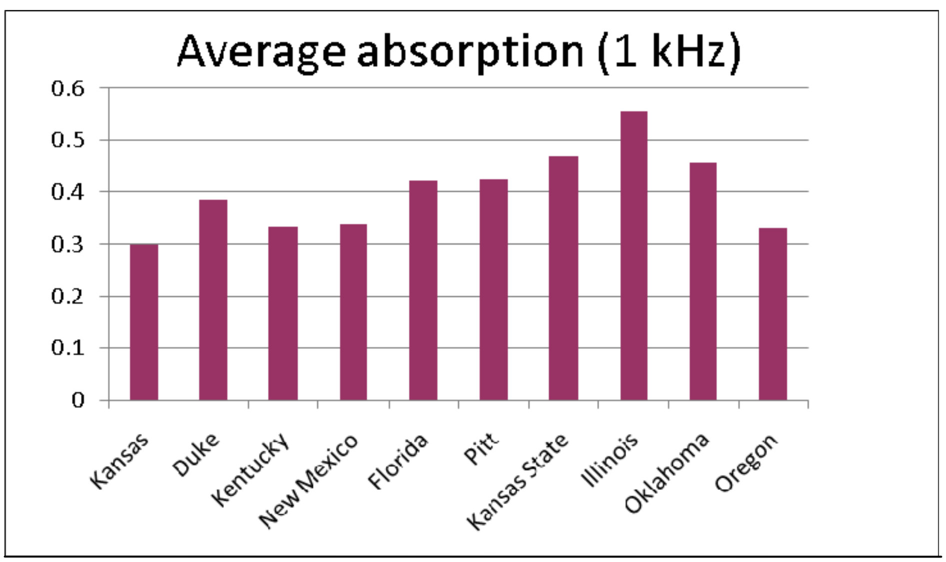

Figure 6. Average absorption in the 1 kHz octave band.

IV. Conclusion

The authors were asked to rank 10 college arenas for ESPN magazine in a period of 3 weeks. The rankings were completed using the theory of sound buildup in large rooms as absorption areas and fan levels were estimated using simple, first-order principles. The rankings were published in ESPN magazine on 15 Nov, 2010 in the 'Loud Edition,' an edition dedicated to pre-season college basketball with an emphasis on sound and noise. The article was entitled 'These go to 11,' and discussed the rankings as well as what aspects of an arena make it loud. The results were well received by the ESPN management and public in general.

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