Determining the optimal number and configuration of sound monitoring devices for detecting and assessing directionality of cough in growing pigs

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INTRODUCTION

Continuous sound monitoring systems have been shown to effectively detect clinical episodes of respiratory disease.[1-4] However microphones used in such systems would all be expected to have distance-related limits of sound detection. The purpose of this project was to evaluate the optimal placement and configuration of a continuous sound monitoring system in large airspace buildings in the United States containing growing pigs to enable both a high sensitivity for detection and establishing directionality of clinical respiratory episodes.

MATERIALS AND METHODS

Respiratory Distress Monitors (SOMO+ Respiratory Distress Monitor, SoundTalks NV, Leuven, Belgium) were obtained and installed in three large commercial wean-to-finish facilities designed to house 1200 to 2400 pigs per airspace. (Figures 1 and 2).

Figure 1. 1200 head building setup.

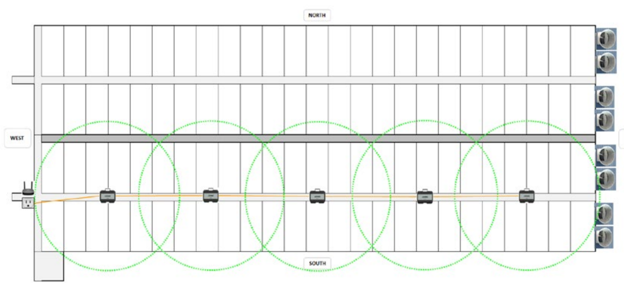
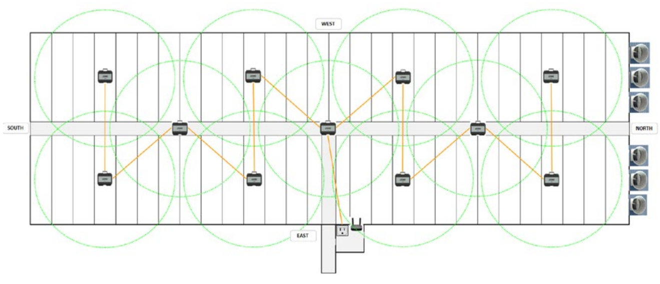


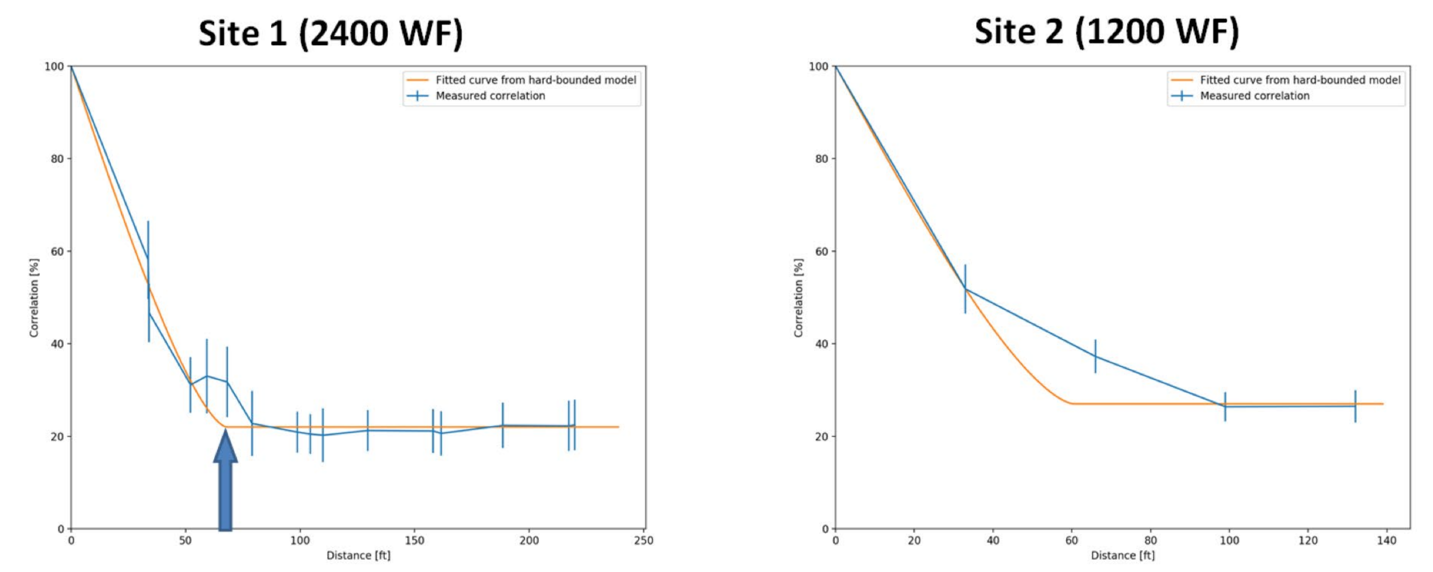
Figure 2. 2400 building setup.



The SOMO+ devices continuously monitored temperature using two sensors and humidity using one sensor. Each device had one connected microphone continuously recording sound. An algorithm was applied to the continuous stream of sound and classified specific sound events as coughs. The events classified as coughs were then counted, with the counts uploaded to a cloud database with a respiratory distress index (RDI) continuously generated from the cough counts.
A correlation analysis was conducted to estimate the optimal sound (cough) detection range for each microphone. The assumptions used for this analysis were: 1) Each microphone detects coughs inside a circle of radius R; 2) Radius R is equal for all microphones; 3) The circle, defined by R, around each microphone represents a "hard" boundary, i.e., coughs inside of the circle are reliably detected and coughs outside of the circle are not reliably detected; and 4) Pigs were (relatively) uniformly distributed inside the circle covered by each microphone.

The correlation of detected coughs for each pairing of two different microphones was calculated based on the overlapping area of the circles with radius R around each microphone. The cross-correlation was measured for each pair of microphones with overlapping circles, and the computed correlations were plotted as a function of distance between microphones in each pair. The measured correlation was fit to the correlation predicted by the hard-bounded model (Figure 4).

Figure 4. Fitted correlation of both sites.



The fitted correlation yields a coverage area of approximately 67ft (20.4m) in diameter and a baseline of 21%.

The fitted correlation yields a coverage area of approximately 60ft (18.3m) in diametre and a baseline of 25%.

RESULTS

The estimated optimal diameter for best detection of cough was determined to be approximately 18.3 meters in the 1200 head barn and 20.4 meters in the 2400 head barn (60 ft and 67 ft, respectively).
For optimal sound coverage in the 1200 head buildings the optimal number of devices was determined to be three to four per room (Figure 5), and for the 2400 head building the optimal number of devices was determined to be six to eight (Figure 6).

Figure 5. Optimal coverage for 1200 head barn.

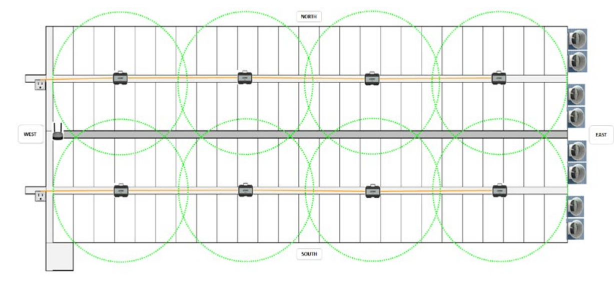
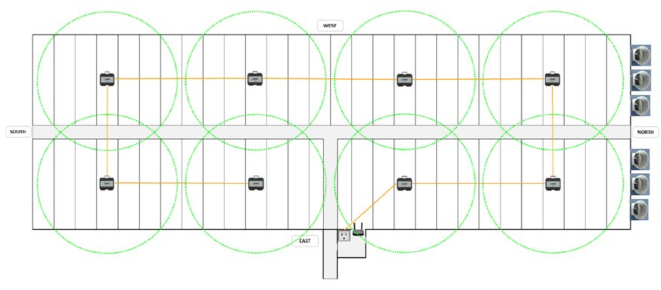


Figure 6. Optimal coverage for 2400 head barn.



CONCLUSION

Each device represents an 18.3 to 20.4 meter (60 to 67 ft) sound detection "zone". Inherent differences in the acoustical characteristics of each of the two barn types are likely at least partly responsible for the range in optimal sound detection zones between the barns.
The sensitivity for the detection of and judging the directionality of cough events is then a function of the square meters covered by the "zones" out of the total possible square meters of animal space in a barn. This dynamic is highly analogous to the impact of sample size and sample selection– i.e., the hard-bounded "zone" sampled when using a single rope to collect oral fluids constitutes one or two pens. Thus, fewer microphones (zones) would be expected to result in decreased cough detection sensitivity and reduce the ability to determine directionality of cough events.

REFERENCES

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