# Infrasonic Detection

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**Abstract.** Infrasonic signals have traditionally been hard to detect because of wind and background noise interference. A new type of hardened foam windscreen, which was designed at NASA, was tested to determine how well it works at reducing noise. Different densities and shapes were tested at different elevations. The windscreens were quite effective at filtering out superfluous background noise. The medium density, sphere-shaped windscreen was the most effective at reducing background noise. These windscreens should be effective tools in future infrasonic research. More rigorous tests should be performed in order to better catalog the exact properties of the windscreens, such as how they perform at different temperatures, elevations, and humidities.

## Introduction

There are many natural sources of infrasound, such as tornadoes, volcanoes, clear air turbulence, and earthquakes. There are also many man-made sources of infrasound, such as rocket and shuttle launches, satellite re-entry, and other large machinery. Infrasonic detection could be used to find precursor signs to natural disasters, or as a way to monitor heavy machinery and equipment for failure. But what is infrasound?

Infrasound is sound with a frequency of 0 Hz to 20 Hz. It lies below the human hearing range of 20 Hz to 20,000 Hz, and is therefore not usually of interest to us. There has not been much research in infrasonics because of the difficulty creating a microphone that can readily detect infrasound, and because of the difficulty distinguishing infrasonic signals of interest from background noise. The system designed by NASA was created to overcome these problems and begin research on actual infrasonic signals.

The project my team was working on was a method to detect wake vortexes from planes taking off and landing. A wake vortex is like a tornado that comes off the tips of a plane's wings. They are dangerous because another plane can fly into them and get pushed around violently. Wake vortexes are especially dangerous on runways during take-off and landing due to the proximity to the ground where it is much more likely that the plane be forced into the ground and crash. Currently, airports have a system where they wait a predetermined amount of time after each plane takes off before they let another plane take off, giving time for the wake vortexes to dissipate. By detecting these wake vortexes it is possible to make air travel safer and more efficient by potentially reducing the time between airplane take-offs.

My part of the project was to test the windscreens that were designed to find out how well they reduce background and wind noise. I tested different shapes and densities (referred to as “weights”) at different elevations to determine how effective the windscreens are.

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## Equipment

There were three primary pieces of equipment used for my experiments with the windscreens: the infrasonic microphone, the windscreen, and the data acquisition hardware. I will briefly explain each piece of equipment and how it was used during the experiment.

The infrasonic microphone was developed at NASA. It was built specifically to detect sound under 50 Hz. It is one of the most sensitive infrasonic microphones ever built. During the windscreen tests the microphones were placed on second and third story roofs, as well as the ground, in order to collect the background noise.

Traditional infrasonic microphones require a large area to set up in. They need that space in order to set up a hose system around the microphone. These hoses have small holes punctured in them at regular intervals and act to filter out the noise from the wind blowing over the microphone. The microphone developed by NASA however, does not require a hose system to operate, but instead uses a compact windscreen to filter out wind and other background noise. The windscreens are made of a hardened, foam-like material. They were made in different shapes, such as spheres and cylinders, and different densities, also referred to as “weights.” The windscreens were placed over the microphones during the experiments in order to test how well they reduced background noise.

The data acquisition hardware was a PULSE brand piece of hardware and a laptop. The PULSE card converted the raw signal from the microphone into something that could be processed by the PULSE software on the laptop and then displayed on screen.

## Experiment

The goal of my experiments was to determine approximately how effective the windscreens were. To do this I needed an area that was exposed to a fair amount of wind and background noise. The most convenient location was the roof of the building I worked in. There were no trees or buildings blocking the wind or other background noise on the roof, so it was a good place to conduct the tests.

Three locations were set up to collect data from, the third floor roof, the second floor roof, and the ground. Each location had a place to mount the microphone and windscreen. The second and third floor roof locations had a concrete pillar to mount the equipment on in order to raise the microphone above the meter-high safety wall running around the roof. From each location, a coaxial cable was run back to the control room on the second floor. The same microphone was used at each location in order to remove the possibility of differences between microphones skewing the results.

The cables were all run on the outside of the building and brought in through the window. Running the cables on the outside of the building created the possibility that the cables would act as antennas and pick up background radiation that would interfere with the microphone signal. The cables were measured with an oscilloscope to ensure that the background noise was a low enough level that it would not interfere with the microphone signal.

The data collection was a fairly simple, two-part process. First, I recorded the signal from the microphone without the windscreen for two minutes. Then I collected another two minutes of data from the microphone with a windscreen on. A fourier transform was applied to each of these sets of data and then they were compared to determine the reduction in noise at frequencies below 20 Hz. This same process was repeated for each of the locations (third floor roof, second floor roof, and ground) and different windscreens (light, medium, and heavy), and different windscreen shapes (sphere and cylinder).

The experiments were run multiple times, on different days, and at different times of the day. Multiple tests were performed so a more accurate noise reduction value could be determined. The unpredictable nature of the wind made it very important that many tests were run. It was entirely possible that the wind would be blowing during one test and not another. By running the tests many times the results are more likely to be accurate.

## Results

For the 15 pound (medium density) windscreens, the spherical shape performed the best overall, reducing the noise by 33.5 dB at 20 Hz and 31.2 dB at 10 Hz. The cylindrical windscreen had a noise reduction level of 28.6 dB and 26.2 dB at the same frequencies, respectively. Unexpectedly the cylindrical windscreen performed slightly better on the ground than the spherical windscreen. It is unknown at this time if that is a typical result. Another promising result is the similar level of background noise was picked up at all three heights. Because the background noise is similar at all three elevations, the noise reduction results between the three elevations can be more easily compared.

The experiment was repeated with 12-pound windscreens instead of 15-pound windscreens. The microphone was the same one used in the previous experiment. The results were similar, though the noise reduction was not as great as the 15-pound windscreens. The noise reduction of the spherical windscreen at 20 Hz was 23.6 dB and at 10 Hz reduction was 21.8 dB. These results are not surprising. The less dense windscreens should allow more noise to pass through them. The background noise on the 2nd and 3rd floors was also higher for this experiment than the 15-pound experiment. Interestingly the cylindrical windscreen performed better than the spherical windscreen at all three elevations.

The next test was performed with only the spherical windscreens on the second and third floors. The purpose of the test was to compare noise reduction of the differently weighted spherical windscreens. Table 1 shows the results of this test. From these preliminary test results the 15-pound spherical windscreens seem to perform the best over the broader infrasonic range.

Comparison of Noise Reduction (dB) for Spherical Windscreens

| | 3rd Floor | | | 2nd Floor | | |
|---|---|---|---|---|---|---|
| Frequency (Hz) | 30 Pound | 15 Pound | 12 Pound | 30 Pound | 15 Pound | 12 Pound |
| 0.125 | -4.5 | 10.5 | 1.5 | 1.1 | -1.1 | 1.1 |
| 1 | 1.8 | 15.1 | 7.0 | 5.6 | 8.3 | 1.6 |
| 5 | 18.5 | 19.8 | 23.4 | 18.1 | 24.7 | 8.8 |
| 10 | 17.5 | 20.1 | 25.7 | 22.0 | 31.2 | 21.8 |
| 20 | 16.0 | 26.9 | 21.7 | 18.9 | 33.5 | 23.6 |

Table 1 is a summary of the amount of noise reduction from the various tests performed on the 2nd and 3rd floor roofs. Negative values indicate noise level was higher with the windscreen on. This is likely due to the wind speed increasing.

The final test performed was to collect an hour of background noise from the second floor with the 15-pound spherical windscreen. The data were recorded as Pascals versus time. Once the data were collected a spectrogram was generated, shown below in Figure 1. A clear, repeated signal can be seen at 7 Hz and 4.5 Hz. There also appears to be another signal at 3 Hz, but it is hard to distinguish from the rest of the low frequency noise. Because of its very stable, repetitive behavior, the cause of these signals is likely the large, ground mounted air conditioner right next to the building.

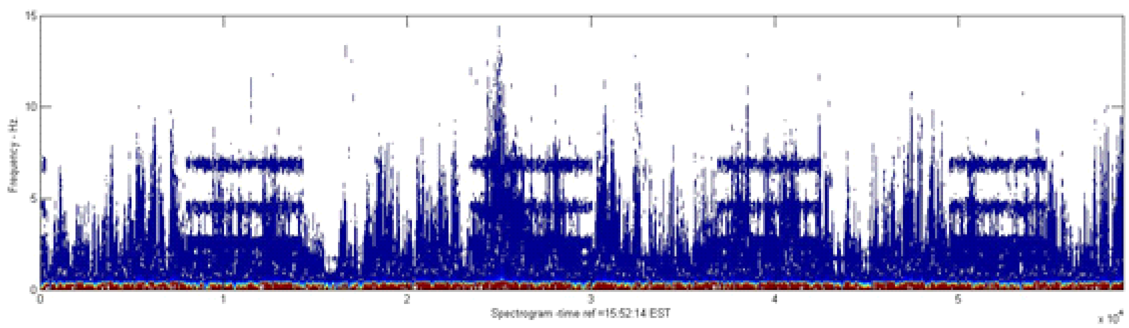


Figure 1 is a spectrogram of one hour of background noise from the microphone on the third floor roof.

## Conclusions

The infrastructure for an infrasonic detection array was set up on the roof of the test location. Preliminary testing has begun to characterize background noise and test the effectiveness of the windscreens. Because testing is still in an early stage only a few conclusions can be made. One, the windscreen is especially effective at reducing background noise, typically achieving 20 to 30 dB reductions between 10 and 20 Hz frequencies. Two, the 15-pound, spherical windscreen seems to perform the best at reducing background noise on the roof of the test site. Three, at this time the windscreens look promising for the wake vortex detection project.

## Future Work

Because of the scope of this research, there are still many tests that need to be done. The effects of wind speed, humidity, and temperature on signal reception and noise reduction must be determined through rigorous scientific testing. The windscreen weight and geometry should be optimized for the airport application.

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