Removing Background Noise with Phased Array Signal Processing

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The Problem

The models we test in the 9 x 15 Ft Wind Tunnel have been getting quieter, but the wind tunnel has not.
Approach

Remove wind tunnel background noise using an in-flow array and phased array signal processing techniques.
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Continuation of work at NASA Ames by Clif Horne and Nate Burnside.
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   - increases dynamic range of phased array measurements
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1) Functional Beamforming developed by Optinav
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2) Cross Spectral Matrix (CSM) subtraction
   - method for “turning off” noise sources
CSM Subtraction

Acquire background data.

Acquire background + signal data.

$$\text{CSM}_{\text{signal}} = \text{CSM}_{\text{background+signal}} - \text{CSM}_{\text{background}}$$

Process $\text{CSM}_{\text{signal}}$ using Functional Beamforming to determine the amplitude of the signal
Test Setup at NATR

- Acoustic Sources
- Level Sensing Array
- NATR Free-jet
Four Array Configurations

Flush

Kevlar

Thin Weave SS
325 x 325 threads/inch

Dense Weave SS
600 x 200 threads/inch
Conventional Single Microphone

Microphone stand from 9 x 15 Ft Wind Tunnel
FITE forebody
The “Correct” Answer

Acoustic driver signal measured by FITE microphone with no background (M = 0)
Another “Correct” Answer

Driver signal measured by Grid Cap microphone (M = 0)

![Graph showing driver signal measurements](image_url)
Off

Max-15dB
Off

Max-18dB
Max-6dB

Off

![Graphs showing PSD vs. Freq (Hz) for different conditions.](image-url)
Max-15dB

Off
Max-18dB

Off
Summary

These results are encouraging. They indicate that combining Functional Beamforming with CSM subtraction is an effective method for pulling signals out of background noise.

Future Work

More work needs to be done to understand how the angular position of the source relative to the array impacts the results.

Need to test with a source that extends higher in frequency.