Evaluation of next-generation infrasound sensors: calibration techniques and air-blast data parameterization

K. Asmar[1], J. Schnurr[1], M. Garces[1], A. Christe[1], D.Hart[3], A. Rodgers[2], K. Kim[2], B. Williams[1]

[1]Infrasound Laboratory, University of Hawaii at Manoa

[2]Geophysical Monitoring Program, Lawrence Livermore National Laboratory

[3]Sandia National Laboratories, Albuquerque NM

Milton Garces, milton@isla.hawaii.edu

Consortium for Verification Technology (CVT)

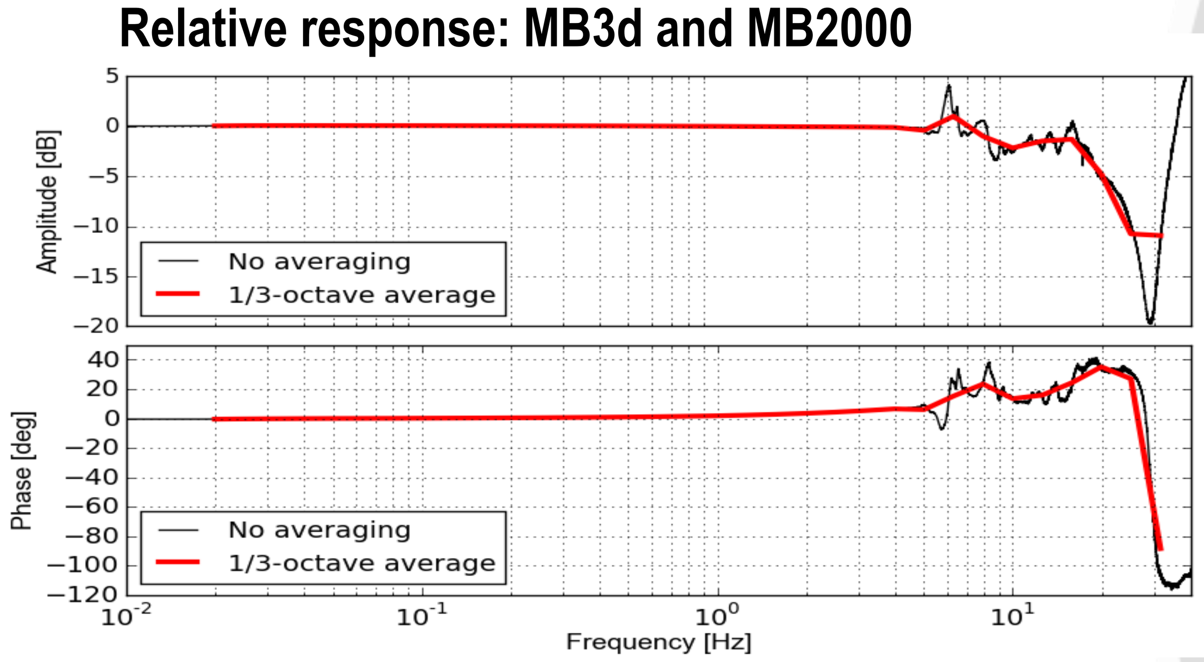
1. Motivation

- A new generation of sensors is emerging to supplement legacy IMS infrasound sensors and traditional networks
- Notable features include reduction in size, weight, power, and cost, and integration of analog-to-digital converters
- We report on the characterization of the MB3 digital (MB3d) infrasound sensor against its predecessors
- We use air-blast and acoustic pressure time-histories recorded by traditional overpressure sensors from controlled surface explosions to improve air-blast models
- Improved air-blast and acoustic models with well-characterized infrasound sensors will contribute to the improved detection and characterization of blasts, undeclared activities and inaccessible facilities

2. MB3d Infrasound Sensor Evaluation

- The MB3d is a recent digital infrasound sensor developed to meet the Comprehensive Nuclear-Test-Ban Treaty (CTBT) International Monitoring System (IMS) requirements, and currently the only one with a self-calibration capability
- We examined the digital output signals of the MB3d sensor against two established analog sensors connected to an external digitizer, and validated its response in the 0.02 – 4 Hz IMS infrasound pass band
- Our findings show MB3d improvements within the passband, and possible sensitivity to higher-frequency seismic vibration

Relative response: MB3d and MB2000



Relative response: MB3d and Chaparral 50A

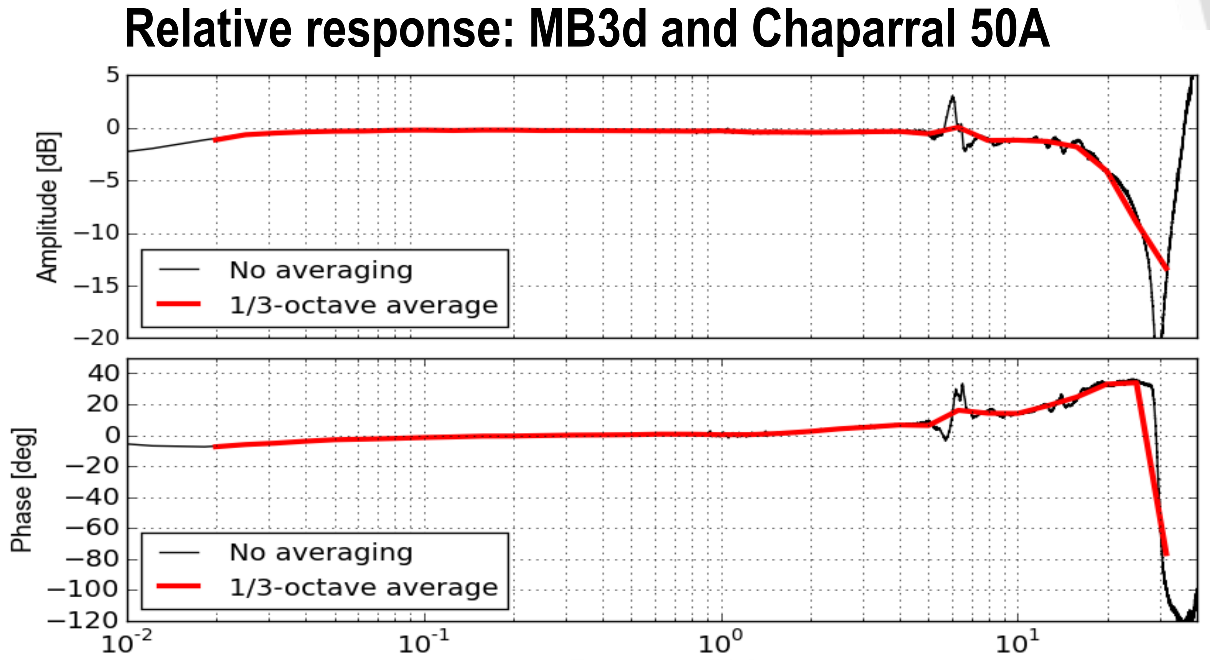


Figure 1. Relative response results for MB3d and reference sensors based on measurements from a white noise broadband source.

Sensor	Pa/Ct @ 1 Hz
MB2000	2.728e-05
MB3d	1.894e-04
Chaparral 50A	4.892e-06

Table 1. Preliminary sensitivity values relative to the MB2000 measured at 1 Hz. Results were obtained from sinusoidal-tone measurements and sine-fit waveform processing.

Self-noise Power Spectral Density

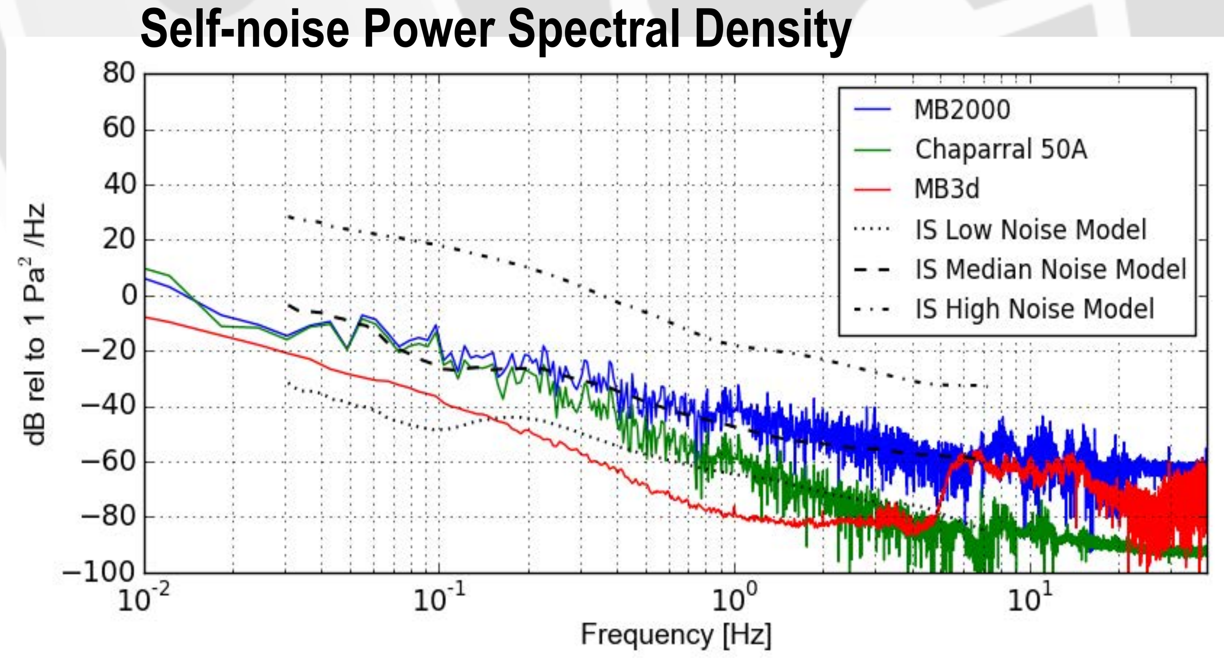


Figure 2. Incoherent self-noise power spectral density levels compared to Infrasound Station Noise Models. Data was acquired from 10 PM to 11 PM local time. The MB3d self-noise is consistent with its CEA model.

3. Improved Overpressure Modeling for Near-Surface Explosions

- The accurate recording and characterization of air-blast acoustic waveforms are key components of the forensic analysis of explosive events
- We improved impulse models that better account for non-linearity in log space due to propagation effects
- The measurements from these datasets are valuable for testing signal models and yield estimation algorithms for above ground explosions

Empirical nonlinear model: Impulse vs. range

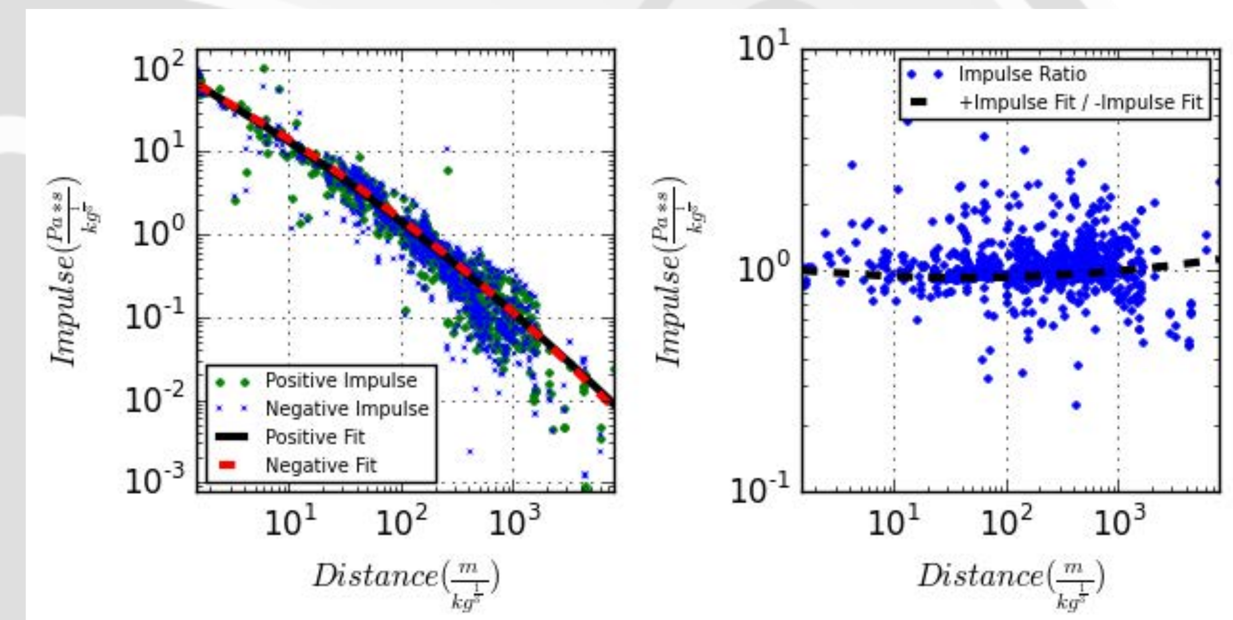


Figure 3. Empirical non-linear model results. The fit could potentially extend the range over which explosion yield is estimated from impulse measurements

Physics based nonlinear model: Impulse as a function of range and pulse duration

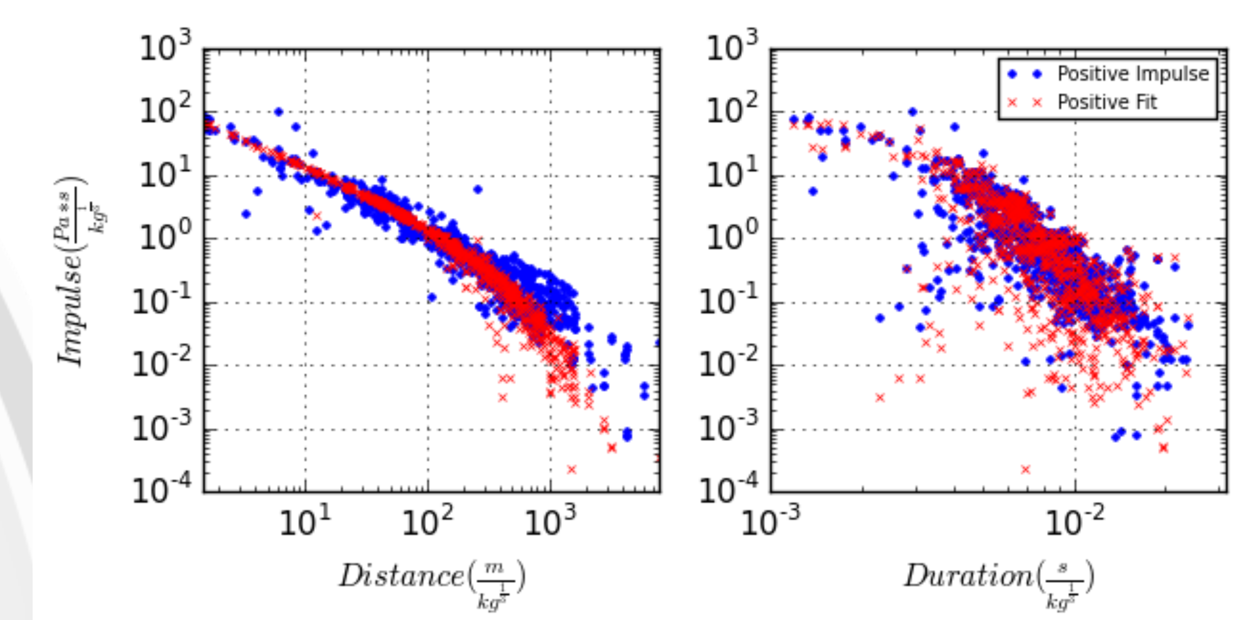


Figure 4. Physics-based non-linear impulse model accounts for the yield-dependent positive phase duration.

Air blast negative phase trends

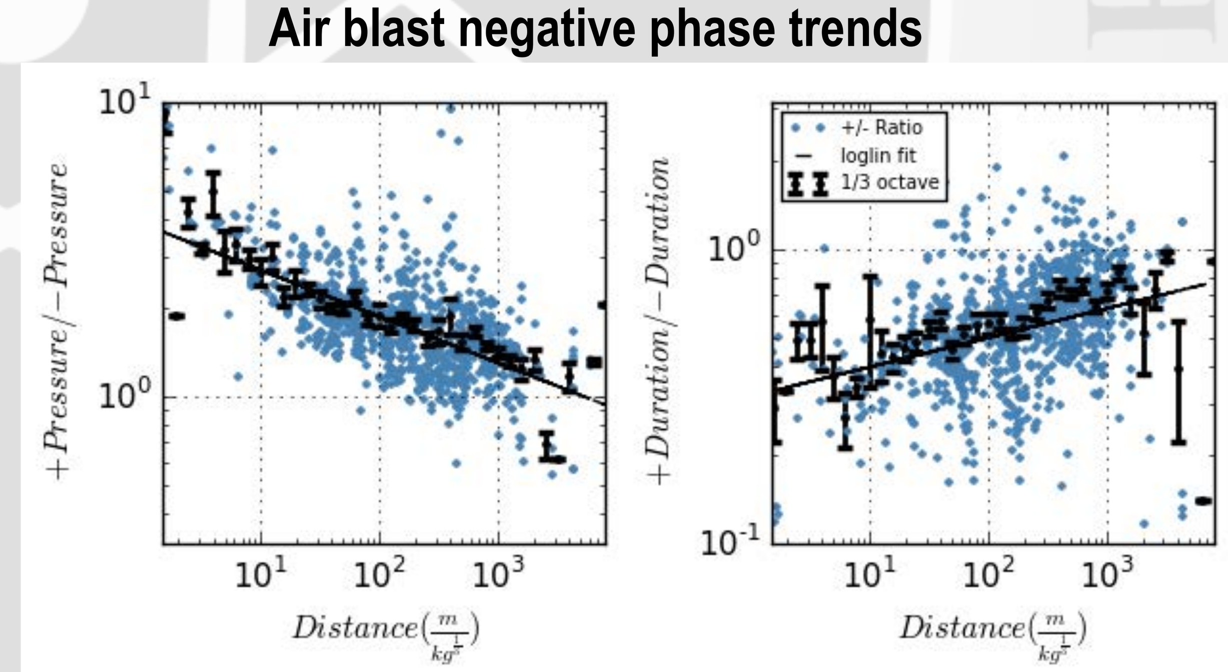


Figure 5. Air-blast positive to negative phase ratios. These previously overlooked negative phase features could contribute to improving the accuracy of yield estimates.

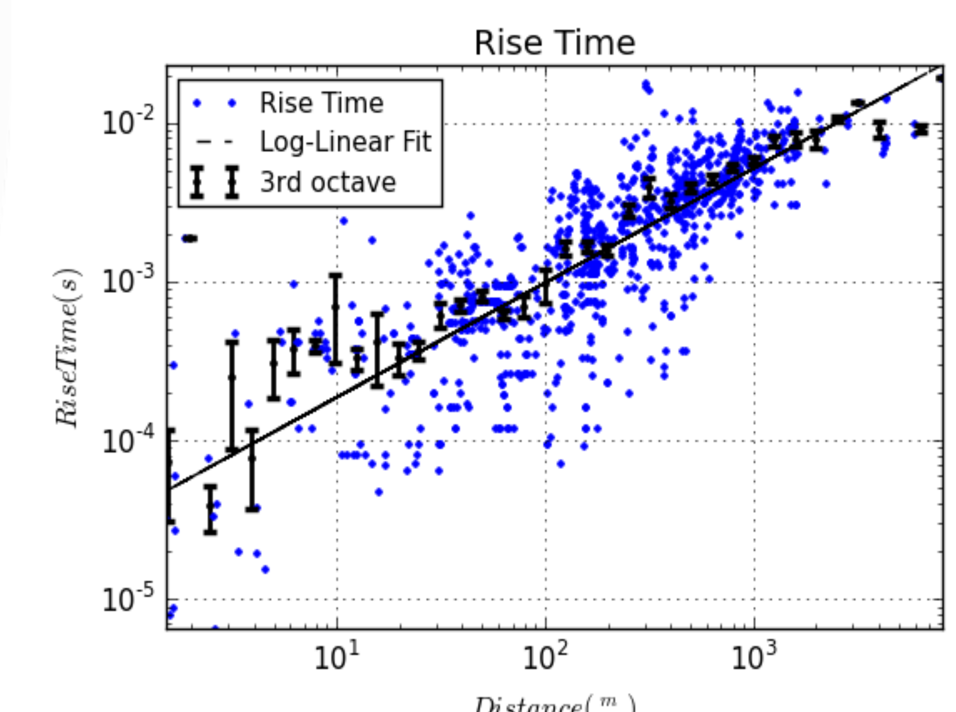


Figure 6. Air-blast rise time vs. range. The positive linear trend contributes to the assessment of frequency content as a function of propagation

4. Conclusions and Future Work

- We have validated the response model for the next-generation MB3d infrasound sensor in the 0.02 – 4 Hz pass band.
- We have developed improved impulse models for air-blast measurements and proposed the incorporation of rise time and negative phase parameters in future air-blast modeling

*Contact information: kasmar@hawaii.edu

National Nuclear Security Administration

This work was funded in-part by the Consortium for Verification Technology under Department of Energy National Nuclear Security Administration award number DE-NA0002534