SnT 2019
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Calibration of Infrasound Sensors in a Long-Term Field Study

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Abstract

A long-term field study is being performed at Sandia National Laboratories (SNL) Facility for Acceptance, Calibration, and Testing (FACT) to compare the performance of five infrasound sensors in active use. The goal of this study, which was initiated at the beginning of 2018 and is continuing into 2019, is to evaluate the relative performance of the sensors in a field environment in which the sensors are subject to dynamic environmental conditions and to evaluate changes in the sensor's absolute performance under controlled laboratory conditions. The results of the laboratory calibrations, performed at 3-month intervals, are presented here. We examine the laboratory measurements of sensitivity and amplitude and phase response to determine to what extent the sensor performance has changed over the course of the field study.

Testing Methodology

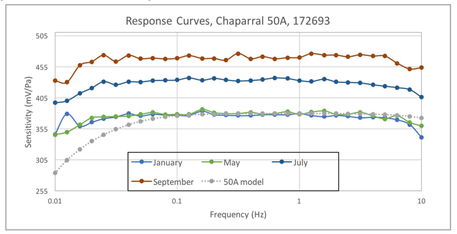
- The sensors were grouped into two equivalent batches, each deployed at a separate field site.
- A batch is brought back for a laboratory calibration as a group and allowed to equilibrate overnight at approximately 23 C.
- The sensors in a batch are calibrated simultaneously against a common reference sensor, ensuring that their relative calibration is very accurate.
- Temperature, barometric pressure, and humidity are monitored during the laboratory calibration

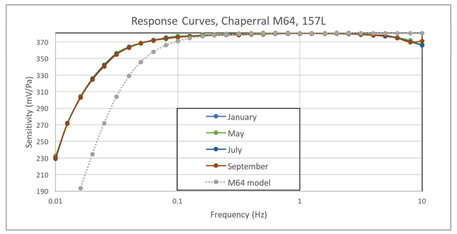
		Jan-18	May-18	Jul-18	Sep-18	Dec-18	Apr-19
Batch 1	Temperature	22.8 C	25.3 C	25.1 C	22.4 C	22.3 C	21.6 C
	Pressure	819 hPa	843 hPa	848 hPa	826 hPa	815 hPa	806 hPa
	Rel. Humidity	18.8 % RH	19.00%	29.20%	43.10%	16.90%	17.10%
Batch 2	Temperature	22.8 C	25.3 C	25.1 C	23.0 C	23.7 C	22.8 C
	Pressure	807 hPa	842 hPa	841 hPa	829 hPa	816 hPa	833 hPa
	Rel. Humidity	18.8 % RH	17.70%	27.50%	36.80%	16.70%	23.50%

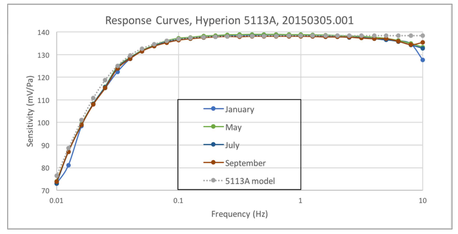
- Changes in the sensor sensitivity are tracked over time and compared to the field data.
- Once the laboratory calibration is completed, the batch is returned to the field site

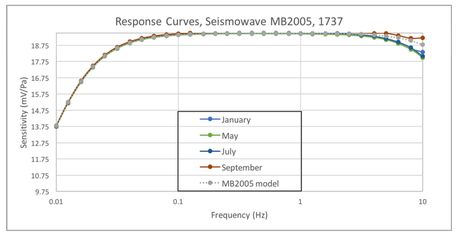
Frequency Response

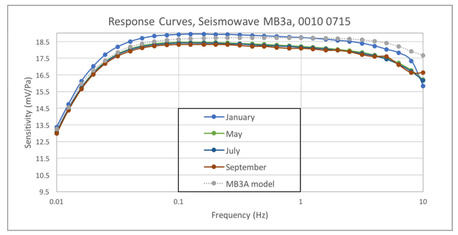
- Calibration signals: sine wave, 4 Pa - 5 Pa peak amplitude, 0.01 Hz to 10 Hz, 1/3 octave intervals.
- Sensors generally matched their nominal response model fairly well, with the exception of:
  - The Chaparral 50A exhibited its amplitude response level shifting with sensitivity, and a significant amount of error in the repeatability at different frequencies.
  - The Chaparral 64 had a lower corner than the nominal response model.
- Phase responses (not shown) matched the nominal models very well and were not observed to change over the duration of the experiment.





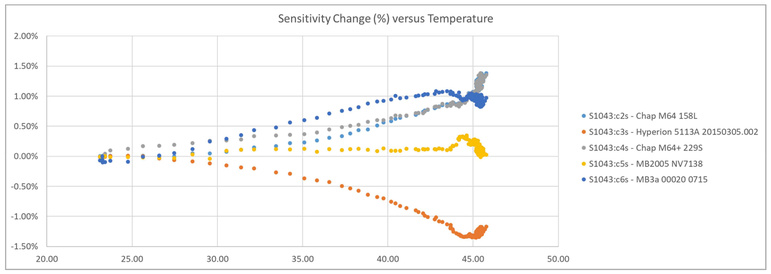






Sensitivity variations with temperature

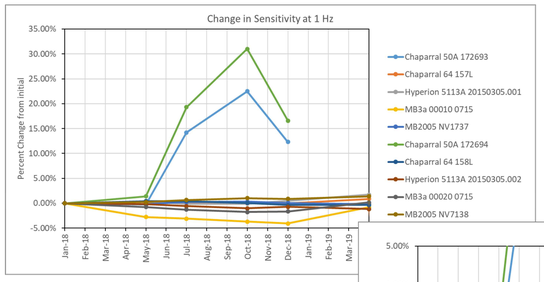
- Relative changes in sensitivity were observed in the field data that appear to be correlated to the operating temperature of the sensors.
- A preliminary attempt at reproducing this measurement in the laboratory was made by adjusting the temperature of the interior of the calibration chamber from 23 C to 45 C.
- The chamber was vented so that pressure did not build up as temperature increased.



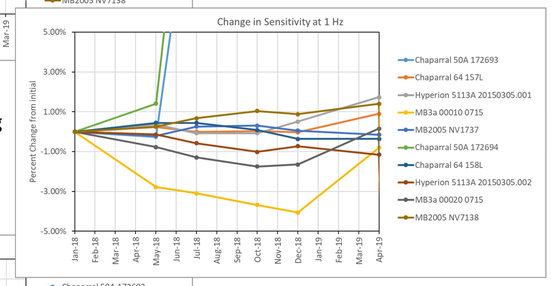
- Note: The reference MB2005 was subjected to the same temperature changes as the sensors under test, the percent change is relative to a reference that may itself be changing.

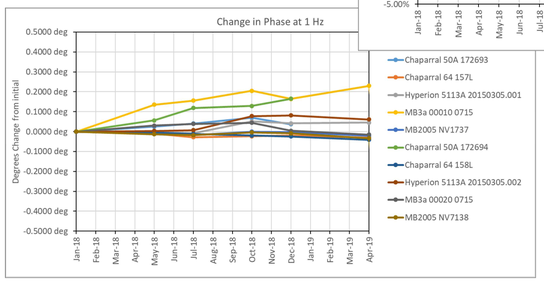
Sensitivity variations under controlled conditions

- Changes in the sensitivity and phase at 1 Hz have been tracked over the past year and a half.



- Both Chaparral 50A sensors were dropped from the study at the end of 2018.
- In April 2019, both MB3a sensors had their bellows re-centered using a updated procedure from CEA, which resulted in their sensitivities reverting to initial values.





- Relative changes in phase response have been very small, under +/- 0.2 degrees.

Model	Serial #	Jan-18	May-18	Jul-18	Sep-18	Dec-18	Apr-19
Chaparral 50A	172693	379.80 mV/Pa	378.80 mV/Pa	433.80 mV/Pa	465.20 mV/Pa	426.60 mV/Pa	
		0.00%	-0.26%	14.22%	22.49%	12.32%	
Chaparral 64	157L	380.20 mV/Pa	381.10 mV/Pa	380.20 mV/Pa	380.30 mV/Pa	380.10 mV/Pa	383.60 mV/Pa
		0.00%	0.24%	0.00%	0.03%	-0.03%	0.89%
Hyperion 5113A	20150305.001	138.30 mV/Pa	138.80 mV/Pa	138.20 mV/Pa	138.20 mV/Pa	139.00 mV/Pa	140.70 mV/Pa
		0.00%	0.36%	-0.07%	-0.07%	0.51%	1.74%
MB3a	00010 0715	18.73 mV/Pa	18.21 mV/Pa	18.15 mV/Pa	18.04 mV/Pa	17.97 mV/Pa	18.58 mV/Pa
		0.00%	-2.78%	-3.10%	-3.68%	-4.06%	-0.80%
MB2005	NV1737	19.49 mV/Pa	19.45 mV/Pa	19.54 mV/Pa	19.55 mV/Pa	19.50 mV/Pa	19.46 mV/Pa
		0.00%	-0.21%	0.26%	0.31%	0.05%	-0.15%
Chaparral M64+	228S						76.58 mV/Pa
							0.00%
Chaparral 50A	172694	391.00 mV/Pa	396.50 mV/Pa	466.40 mV/Pa	512.20 mV/Pa	455.80 mV/Pa	
		0.00%	1.41%	19.28%	31.00%	16.57%	
Chaparral 64	158L	384.00 mV/Pa	385.70 mV/Pa	385.70 mV/Pa	384.30 mV/Pa	382.60 mV/Pa	382.60 mV/Pa
		0.00%	0.44%	0.44%	0.08%	-0.36%	-0.36%
Hyperion 5113A	20150305.002	138.20 mV/Pa	138.00 mV/Pa	137.40 mV/Pa	136.80 mV/Pa	137.20 mV/Pa	136.60 mV/Pa
		0.00%	-0.14%	-0.58%	-1.01%	-0.72%	-1.16%
MB3a	00020 0715	19.40 mV/Pa	19.25 mV/Pa	19.15 mV/Pa	19.06 mV/Pa	19.08 mV/Pa	19.43 mV/Pa
		0.00%	-0.77%	-1.29%	-1.75%	-1.65%	0.15%
MB2005	NV7138	19.32 mV/Pa	19.37 mV/Pa	19.45 mV/Pa	19.52 mV/Pa	19.49 mV/Pa	19.59 mV/Pa
		0.00%	0.26%	0.67%	1.04%	0.88%	1.40%
Chaparral M64+	229S						0.75 mV/Pa
							0.00%

Conclusions and Future Plans

- The long-term field study is continuing for another year, with the removal of the Chaparral 50A from the study and the addition of a Chaparral M64+ and MB3a to each of the two groups.
- Quarterly laboratory calibrations will continue for the study.
- Preliminary field results have identified what are believed to be some dependence in the sensitivity on ambient temperature and pressure.
- Preliminary laboratory testing on temperature dependence have been performed.
- Improved laboratory testing is planned to measure the dependence of sensitivity on ambient pressure and temperatures across -10 C to 40 C with a more stable reference.

PUTTING AN END TO NUCLEAR EXPLOSIONS

This work was supported by the Nuclear Arms Control Technology (NACT) Program at Defense Threat Reduction Agency (DTRA)

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1-mn poster presentation

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Highlight:

- A long-term field study of infrasound sensors is being performed at Sandia National Laboratories.
- As part of the field study, laboratory calibrations are being performed repeatedly over several years to examine changes in sensor performance.
- Measurements of the impact of temperature and barometric pressure on sensitivity are being compared between field and lab environments.

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