

Boston University
Electrical & Computer Engineering

EC464 Senior Design Project

Final Test Report

OBSIDAS

On-Board Sound Intensity Data-Acquisition System

by

Team 8 / Team Volpe
(Client: U.S. DOT Volpe Center, Cambridge, MA)

Team Members

Muhammed Abdalla (muhabda@bu.edu)
Aurojit Chakraborty (aurojit@bu.edu)
Daniel Cardosi (dcardosi@bu.edu)
Javier González Santamaría (javiergs@bu.edu)
Joseph Lucatorto III (jlucator@bu.edu)

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1 Required Materials

Hardware:

Personal computer (Lenovo-Windows)

Desktop computer (located in PHO113)

iPhone

Volpe-provided input-chain apparatus:

1. GRAS 26AK preamplifiers (x2)
2. GRAS 40AI externally polarized paired microphones (x2; i.e, 1 pair)
3. GRAS 12AQ 2-channel power modules (x1)
4. Brüel and Kjær 4231 calibrator (x1)
5. GRAS 7-pin LEMO 10-meter extension cables (x2)
6. BNC 25-foot extension cables (x2)
7. Native Instruments USB-4431 4-input data-acquisition device (x1)

Software:

Microsoft Windows (Desktop ECE-SD-T08)

LabVIEW 2017 (Desktop ECE-SD-T08)

Sound and Vibration Toolkit

NI-DAQmx 20.7

Sonic (iPhone)

2 Set up

The purpose of this test was to ensure the complete functionality of OBSIDAS' three basic functions: calibration, which entails the user-editability of sensitivity parameters independently for each microphone; measurement and computation, which entails the user-definability of measurement-trial duration, the user-initiability of individual measurement trials, and the automation calculation after each trial of on-board sound intensity via a variety of metrics; and data export, which entails the formatting and packaging of the computed data into a locally saved, timestamped *.csv file on the machine operating OBSIDAS. An additional focus was the functionality of the user interface and its various graphical data-display features. All aspects of the set-up followed the previously written test plan, reproduced in the paragraphs hereafter:

As regards software, no set up is required beyond the placement of the OBSIDAS executable (of extension *.exe) and dynamic-link library (of extension *.dll) in the same hard-drive location and the prior installment of LabVIEW 2017 along with the related NI Add-Ons and drivers listed above in the previous section.

As regards hardware, the Volpe-proved components listed above should be configured to provide two channels of external-sound input (via the USB-4431) to the machine operating OBSIDAS, the B&K calibrator being active and affixed to a single microphone and the iPhone (playing via Sonic a pure tone substantially above 1 kHz) positioned against the other microphone. The microphones should be connected to the 'AI 0' and 'AI 1' input channels of the

USB 4431 so as to match the configuration of the ‘leading’ probe as opposed to a configuration with single microphones in each of the two different probes.

3 Testing Procedure

The testing steps for OBSIDAS are as follows:

1. Run the executable.
2. Fix the measurement-trial duration at 3 seconds.
3. Run a single trial, and examine the generated *.csv to verify the correctness of all computed values.
4. Edit the default sensitivity parameters of the two connected microphones (one to be lower, and the other to be higher)
5. Run another trial, and examine the generated *.csv as above.
6. Change the measurement-trial duration to 60 seconds.
7. Run a final trial, and again examine the generated *.csv as in (3) and (5).
8. Examine the data-display plots on the front panel, verifying their agreement with the values in the outputted *.csv.

4 Measurable Criteria

The criteria for the outputted numerical results are as follows:

1. Each of the single-band and entire-spectrum dB(SPL) values should be nonnegative and bounded above by 194 dB.
2. Each of the subband magnitude-squared-coherence values should be between 0 and 1.
3. Each maximum value of the third-octave-level arrays should be ≥ 10 dB greater than the value of either adjacent element (given the pure-tone stimuli presented).

The criteria for the exported data file are as follows:

1. The file must have the extension *.csv.
2. The file must show the correct timestamp.
3. The file must contain all numerical data intended for export, being the following:

*In 1/3-octave bands, with centers from 250–5040 Hz
(quantities are of 14-element arrays, each element corresponding to a single 1/3-octave band)*

- i. Single-microphone sound pressure levels (x4)
- ii. Single-probe sound pressure levels (x2), each probe being a pair of colocated microphones
- iii. Overall (all-microphone) sound pressure levels (x2)
- iv. Inter-microphone (single-probe) magnitude-squared coherences (x2)

For the entire frequency spectrum

- v. Single-probe sound pressure levels (x2)
- vi. Overall sound pressure levels (x1)
- vii. A-weighted versions of (v) and (vi) above

5 Results

Due to an initially incorrect setup, in which a number of input-path cables were misconnected and in which the OBSIDAS executable had been configured to read simulated input data in place of real data as gathered from the USB-4431, the first attempted tests yielded unreasonable graphs and SPL values. Upon correcting the setup, our team was able to demonstrate the program's functionality of computing the Volpe-specified metrics (*q.v.* section 4 above), all with the desired precisions, in the required *.csv format, and also demonstrated was the editability of both the individual microphone sensitivities (each of which altered the computed metrics appropriately) and the measurement-trial duration, the range of possible values for the latter spanning those to be used by Volpe.

As regards the graphical data-display features developed additionally to Volpe's requirements, the test revealed an unintended addition of the four inputs prior to all forms of display thereof as well as an improper range of numerical axis bounds for the displayed sections of the FFT results. These mistakes, at the time of this report's composition, are completely fixed; Fig. 1 shows the front panel of the updated OBSIDAS executable, which also implements the recommendation received during testing to utilize four separate sets of axes in the plotting of individual-microphone data rather than grouping all such data into a single plot.

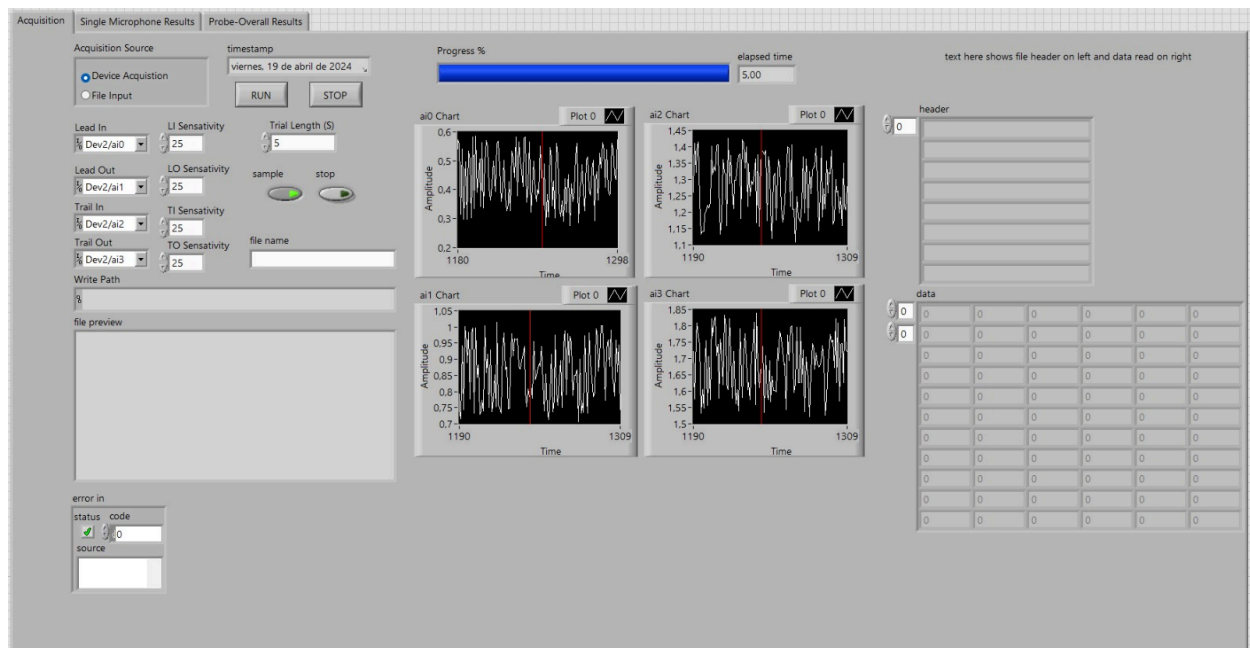


Figure 1. Front panel of OBSIDAS.

6 Conclusions

As regards the requirements specified by Volpe, the final test was completely successful in verifying the functionality of the OBSIDAS executable to interface with the hardware input chain to record sound, automatically compute each of the desired acoustically significant metrics, and export the results of such computations into a readable *.csv file. As regards the additional functionality of graphically displaying the measured data, the test was constructive in its exposure of errors within the program's configuration (all of which have now been addressed).

The current OBSIDAS executable is thus ready to be delivered to Volpe and employed thereafter, in tandem with their USB-4431-connected microphone array, to perform On-Board Sound Intensity computations on recorded tire-pavement noise.