**Overview and Situation**

The impact of aircraft noise on a “community” is well-regulated by the [Federal Aviation Administration](https://www.faa.gov/about/office_org/headquarters_offices/apl/noise_emissions/airport_aircraft_noise_issues/) (FAA). Aircraft manufacturers such as Airbus and Boeing must demonstrate adherence to these standards for all new or derivative aircraft models which includes flight testing of prototype aircraft. Community noise flight tests consist of instrumenting one end of a runway of a remote airport with acoustic recording devices and recording the acoustic signatures as the test plane is flown over the instrumentation for many conditions as required by the Federal regulations. To avoid costly and time consuming repetitions of flight conditions or non-compliance, the surround acoustic environment should cause no undue noise contamination on the acoustic recordings that could cause elevated aircraft noise levels. Sources of contamination can include but are not limited to: bird chirps, wildlife/livestock vocalizations, insect noises, traffic noises, and aircraft noises borne from aircraft besides the target test flight. Current testing procedures use extensive equipment and human labor to detect, assess, and remedy any environmental noise contamination to ensure the recorded acoustic signatures are solely from the test aircraft.

This project is a feasibility study into using automated procedures for detecting and assessing environmental noise contamination. The goal is to monitor, detect, and classify the presence of environmental noise in real-time. The scope of the classification should be sufficient to guide test engineers on the necessary recourse. For example, whether the flight condition need be redone or what type(s) of contaminant noise sources need to be removed from the testing site. Human labor designated for these tasks, while reasonably effective, is taxing and not cost-efficient. Thus, the proposed signal processing and machine learning-based system for this problem.

**Target Audience**

The target audience of the noise contamination detector is an aircraft manufacturer, the sponsor Boeing Test & Evaluation (BT&E). This project could remove the need for multiple on-site work stations and operators and could lead to significant cost reductions for BT&E. The performance of the system could increase the accuracy and repeatability of the detection, further streamlining regulatory noise testing by BT&E.

**Constraints and Requirements**

The project, its models, its software code, and data must not limit the commercial use by The Boeing Company. Furthermore, all software code must be executable in MATLAB, the preferred computational platform for the BT&E noise testing division.

**Deliverables:**

* A trained algorithm, an explanation of its selection, and theoretical background, for detecting audio signals contaminated by environmental noise sources.
* Measures of the algorithm’s performance when deployed in various “environments” – i.e. for a wide spectrum of noisy audio signals and contamination sources.
* Well-documented process for algorithm retraining and overall project reproducibility.
* A list of algorithms investigated detailing each one’s limitations and advantages.

**Information Required From the Sponsor**

We require that the example training data (acoustic signals with/without contamination) must be labeled/classified.

**Proposal**

We seek to research, develop and implement a signal processing into machine-learning pipeline for automating the detection of environmental noise contamination contained in acoustic measurements. A proposed methodology for achieving such results could be:

1. The data from the sponsor BT&E will be of the .wav file format (audio signal). The first step will be to extract features from these signals. This portion of the project will require research and implementation of novel audio signal processing techniques in MATLAB. Signal filtering, Fourier analysis, signal-to-noise ratio/signal energy spectrum methods, wavelet transforms and other time-series transient signal classification methods are potential methods for this purpose.
2. Given a set of features/covariates from (1) above, we will develop classification algorithms using the training data. These machine-learning (ML) algorithms will range from basic to complex: i.e. from softmax multi-classification and multi-layer perceptrons, to recurrent neural networks. Because we plan on delivering an automated system *for real-time* analysis by on-site engineers, the algorithm must be efficient and not require heavy computational resources. The algorithm(s) also must be deployable in MATLAB.
3. Steps (1) and (2) will be continuously re-evaluated according to model performance(s). It is plausible that the features engineered in (1) are not sufficient to result in accurate classification and different signal processing techniques must be researched and deployed. This is also applicable for the ML portion in (2).
4. To assist in the prior steps, we may augment the data set from the sponsor with other examples of environmental noise that allow for unrestricted commercial use, such as data from the [United States National Park Service](https://www.nps.gov/subjects/sound/gallery.htm).
5. Once satisfied with the performance of the pipeline, we will provide robust documentation to retrain the algorithm(s) and reproduce and/or adapt our project for BT&E.