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PRELIMINARY THOUGHTS ON AN ACOUSTIC METRIC FOR THE WILDERNESS AIRCRAFT OVERFLIGHT STUDY

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This paper (erroneously referenced as ref. 1 in its companion paper, U.S. Forest Service and National Park Service Wilderness Aircraft Overflight Study: Sociological Background and Study Plan) presents some preliminary thoughts on acoustic metrics which may be appropriate for the measurement of sound caused by aircraft overflights of wilderness areas. The reader may wish to consult the companion paper for general background and a discussion of some of the human issues regarding aircraft impact on the dispersed wildland recreationist.

It could be argued that, by definition, wilderness areas contain very few people and thus the aggregate impact on populations using the wilderness is small. However, wilderness is very important to a large number of people, and "wilderness experience" has proven to be a very precious commodity. Our agencies, the National Park Service and the U.S. Forest Service are mandated by law to manage wilderness to the best of our ability, and to maintain the unspoiled character of this significant land area.

Differences between the wilderness situation and the much better studied airport-community situation include the very low background sound that exists in wilderness areas. Measurements of L_{50} = 20 dBA in desert and sparsely wooded areas, and 30-40 dBA in coniferous forests, are representative. Further, background sounds are highly variable as a function of time, wind, and the presence of water.

Limited, informal studies by your authors have shown that the dominant background sound for most users of wilderness areas, at least in terms of amplitude, is self-generated noise. Conversation, brushing through vegetation, footfalls, etc., are by far the loudest sounds encountered by most wilderness visitors.

Another variation between the community noise and the wilderness noise situation is that, in wilderness, populations are transient. Hartmann, (see companion paper for citations) has documented the average wilderness stay to be somewhat less than a day. This contrasts sharply with the community noise situation.

Finally, alluded to above, is the statutory scheme. Wilderness areas are declared and established by Congress, with somewhat arbitrary boundaries, to be land where lasting signs of man are excluded, or at least minimized.

As mentioned above, a dose response relationship is sought. How to characterize this dose is the task at hand.

At first thought, the parameter detectability, d' would seem to be the obvious candidate; d' is really the measure of an energy flattened signal plus noise to noise ratio, in third octave bands, corrected for the efficiency of the observer. For a discussion of the technical aspects of d', see ref. 1.One reason to recommend d'is that it considers the background. (We assume that impact on a human observer is a function of the background sound as well as the intruding sound.) This metric is currently used by land managers to site recreation facilities. The methodology proposed by the Forest Service (see ref. 9 of the companion paper) assumes that for areas which present the most primitive recreation opportunities, a very low d' is appropriate. As the recreation opportunity becomes less "wilderness", a higher d', that is, a greater "intrusion", is acceptable. This method has only anecdotal support; it has been successfully used in a number of locations, as reported by the managers of those locations. No systematic study of its efficacy has been published to the authors' knowledge.

The use of d' is not without its problems. Perhaps the greatest of these is that the current state of the art provides no "d' meter". The only way to determine d' is to tape record intrusive sounds and background sounds on an instrumentation tape recorder, return them to the laboratory, and using a rather sophisticated computerized frequency analysis and computational scheme, develop d's in a number of slices of time. Since it is impossible to separate the signal from the noise, d' can be calculated only retrospectively. Further, the definition of d' includes an observer efficiency, and this observer efficiency has been shown to depend strongly on _a priori_ information that the listener possesses and the risk associated with detection that the listener faces. For a further discussion of this point, see ref. 2.

As mentioned above, the literature does not contain controlled studies relating d' of various levels to various visitor responses. However, there is good data correlating d' with annoyance of low level sounds. (See ref. 3.)

A further disadvantage of the d' scheme is that the unit is not familiar to even knowledgeable professionals, much less the general public. The experience of the authors in explaining measurements made in decibels A to managers without strong technical backgrounds confirms this disadvantage.

The second metric which comes to mind is some variant of the "time above" scheme. Features which recommend such a metric are that it is very easy to understand, i.e., preliminary work (ref. 4) indicates that for approximately one-half the time, helicopter noise is "clearly audible" at Grand Canyon National Park. However, this assumes either a particular sound level, or a particular d', defines the threshold of audibility. As mentioned above, the observer efficiency in the d' definition is difficult to quantify and probably depends on many variables personal to the listener. There seems to be no sound level, either A weighted or linear, which defines audibility or a threshold of annoyance under outdoor conditions. So, the same problems which argue against the selection of d' for a metric argue against "time above" as a metric.

A third thought, perhaps called "back to basics", suggests itself. CNEL, or PNL, or L_{eq24} have served well in community noise measurements. Some modifications of these schemes, perhaps with extra penalties for a slow or very fast onset rate, or longer than "average" durations, could correlate with impact as well as more sophisticated measures. In their favor, such methods are widely recognized and well accepted. The negatives are obvious in that they do not consider background. Further, there is no support in the literature that we have found for the hypothesized corrections under wilderness or national park conditions.

The issue of onset rate deserves further discussion. Anecdotal information indicates that startle, particularly to pack stock, has caused some safety problems under some park and forest conditions. This is the type of onset that is found under military training routes, where high speed, low altitude tactical aircraft are flying.

On the other hand, very slow onset rates, such as observed with tour helicopters in the Grand Canyon, suggest to the listener the question, "When will it end?" The subjective impression of your authors is that the very long onset is as extra annoying as the startle.

Conclusion

We are faced with the following uncertainties:

1. Is the background as important in determining the impact of a given aircraft overflight sound as has been hypothesized? This is an issue which we consider crucial, and it will be studied early on in the program.

2. How can we decide which metric to use? Our current test plans call for continuous tape recording, with very high fidelity instrumentation, at-ear, ear level, and ground level sounds, including background and intrusion, for a broad assortment of different ecotypes; then, as many of the methods above as can economically be calculated will be.

3. This raises a third very interesting question, and that is, how does the visitor distinguish between aircraft noise and "wilderness noise"? In other words, is it possible to develop an aircraft detection algorithm? Certainly the human ear incorporates such an algorithm, and the authors' experience in wilderness areas substantiates that focused listening by a sophisticated human observer can detect aircraft acoustically at extremely low levels.

We speculate that background sound is poorly correlated across frequency as a function of time and also poorly correlated spatially. The overall levels change only slowly, but levels in each third octave band change rapidly and independently of each other. Aircraft sound, on the other hand, is well correlated across both frequency and spatial domains. Using this knowledge, we believe it is possible to develop a small microprocessor-based package which will detect the presence of an aircraft acoustic signal. If this can be done, it can be combined with a package which can be worn by a hiker and will query him automatically when an aircraft is detected. This raises the intriguing possibility of an interactive system in which visitor response and visitor stimulus are measured simultaneously.

As mentioned above, our work in this largely uncharted area is just beginning. We earnestly solicit your ideas and criticism.

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