Community Noise Monitoring Program

by ARNOLD G. KONHEIM, *Office of Noise Abatement and Control, U. S. Environmental Protection Agency, Washington, D. C.*

ABSTRACT.—There are numerous questions in regard to methods, instrumentation, and human and agency resources for community noise monitoring. The U. S. Environmental Protection Agency is currently in the process of seeking answers to these questions through research within the agency and by cooperation with other organizations, including the Department of Defense and the National Bureau of Standards. EPA hopes to have an acceptable protocol for community noise monitoring by July 1977, but there will still exist a long-term requirement for developing more meaningful and efficient techniques.

LISTENING TO MY COLLEAGUES who preceded me, one might infer that environmental noise monitoring is such a well-explored field that its challenges lie only within deep acoustic crevices. I am sure that they would be the first to admit that this is not the case.

At EPA, we are asking some basic questions concerning noise monitoring, and it is to this phase of our activity that my remarks are addressed. It is hoped that the considerations raised here will contribute to this conference in the following manner:

1. By familiarizing you with the problems of community noise-monitoring.
2. By encouraging greater participation in the search for solutions to these problems.

WHY MONITOR?

EPA is currently in the midst of developing an environmental noise-monitoring and assessment program to satisfy the following needs:

1. Develop an environmental noise baseline to asses future trends.
2. Identify populations at risk in terms of public health and welfare from the standpoint of exposure to noise sources and mixes.
3. Establish standard methods to assure quality assurance in the area of data collection and processing.
4. Provide technical assistance to state and local governments in the characterization of their environments.
5. Collect noise data to support EPA's standards and regulatory activities.

To meet these needs we are in the process of developing a protocol to answer three basic questions:

1. How shall we monitor (i.e., what is our methodology) ?
2. What are our instrumentation requirements?
3. What are our resource requirements?

We are committed to seeking answers to all three questions. However, as this program is only in its initial stages, emphasis has been placed on solving the first two questions.

APPROACH

One can categorize monitoring in several ways. A first breakdown might be to separate an assessment based upon the physical collection of data from that based upon a social or attitudinal approach. Monitoring can also be looked at in terms of focus. Are we seeking to obtain an integrated community measurement, merely examine specific sources, or determine the exposure experienced by persons of different lifestyle's throughout their daily activities?

Based upon the above, it appears that one can investigate six combinations of monitoring approaches; in fact, these reduce to three. All of the social techniques are based upon interviews with community residents: only the questions vary. Physical personal monitoring is effected by instrumenting an individual with a personal noise-exposure meter or dosimeter which he wears for a particular period. The other physical techniques, i.e. integrated community and source specific, consist of instrumenting the community. While we are approaching monitoring from all of these directions, I will direct my remarks only to the physical integrated community and physical source-specific measurements.

SPECIFIC AREAS OF INVESTIGATION

The first area of investigation is the methodology for data collection. We are seeking to find solutions to the following questions:

1. How shall we temporally sample?
2. How shall we spatially sample?
3. To what extent and in what way is noise source identification important?
4. What must our monitoring system performance characteristics be?
5. To what extent do indoor and outdoor measurements correlate?

As part of a trend evidenced by instrumentation in general, noise-monitoring systems process data through a digital processing network. Digitization implies a sampling rate. Thus, our first concern, within the temporal domain, is determining a minimum sampling rate, for example 100 samples/s, 1 sample/s, or 0.1 sample/s. Looking at longer time periods, what should be our minimum daily sample (1 hour/day)? How do we treat cyclic and seasonal patterns?

Within the spatial domain, areas of concern are as follows;

1. By what techniques shall we sample (deterministic, stratified)?
2. What criteria shall be used for site selection?
3. How many sites must be selected for a particular criterion?
4. What are the effects of sampling at various heights?

In noise-source identification, what are the problems attendant to and the advantages of identifying sources through human observers, through microsampling, and through signal processing? What are the important output parameters (L_{eq}, L_{dn})? How do we relate indoor to outdoor measurements?

Another methodological area of concern is the processing and assessment of data. Just where is data to be processed and by what means? How can the data best be assessed to accomplish our program objectives, and how can it best be presented so that it is most meaningful to those people who must make decisions?

Our concerns with instrumentation are both systems- and component-oriented. With regards to the system, we are concerned with both its technical capabilities and its ability to perform under field conditions. Thus, we are concerned with such factors as security, weather, ability to withstand vibration, and operating at long periods of time without inspections. We are also concerned with components. What microphone system is suitable for use at long periods of time in the outdoor environment? What kind of windscreen shall be used with this? How can tape mechanisms and computers function in the outdoor environment?

We are concerned with obtaining nonacoustic as well as acoustic information. Nonacoustic data which may be useful are windspeed, temperature, humidity, source to microphone distances, and speeds of transportation sources. Although most monitoring approaches collect and perhaps even partially process information at the site, it is possible to telemeter the information back to a central location. Is telemetry a viable approach; and if so, to what extent is it useful?

IMPLEMENTATION

Our basic philosophy in answering some of the questions that have been raised today has been to consider each of the areas separately with the intention of integrating these as we find solutions applicable to the various areas. To the maximum extent possible, we have limited our own research by applying the results gathered by other investigators. Using EPA regional and headquarters resources, we have field-tested methodologies and instrumentation systems while collecting data valuable to our agency as well as local communities. Our community monitoring has included cities ranging in size from Morgantown, W. Va, to New York City. In the area of monitoring source-specific areas, we investigated the noise associated with railroad yards and along rights-of-way. Presently, we are planning a construction-site monitoring program in which we will study all types and phases of construction activity.

Now let us review some of our approaches to obtaining solutions to these problem areas.

Most of the temporal analysis has been accomplished or is being accomplished through the multiple processing of analog tapes. In October 1974, utilizing our regional resources, we collected over 1,800 hours of digital data during the previously mentioned railroad monitoring. In addition, we gathered approximately 20 hours of analog recordings. We are now processing a selected group of these analog tapes to help us arrive at a proper temporal sampling plan. First, we are interested in determining the effect of various response times on sampling accuracy. Second, we are investigating the accuracy in deriving selected hourly statistics (for example, L_{eg}, L_1) for a range of sampling rates for 45-minute tape segments. Starting with the highest sampling rate (approximately 20 Hz), the rate will be lowered until the levels differ from the original baseline rate of approximately 5 dB. In order to determine the necessity for continuous monitoring, hourly statistics obtained in 5-minute intervals will be compared with that for the entire tape length. A study will be conducted on the effect of changing that point on the tape at which the sampling starts. Finally, the hourly statistics will be determined by using the linear A, C, and D weighting networks for railroad yard noise and train-pass noise to determine the extent to which low-frequency energy contributes to community noise.

Determining the optimal way to sample spatially appears to be a much more difficult problem. Two years ago, when we initiated the noise-monitoring program, we brought to EPA a panel of experts in noise monitoring for a one-day session where we discussed what constituted good monitoring procedures. The area in which we found the least agreement among those experts was on the approach to spatial sampling. Moreover, in fall 1974, at the meeting of the Acoustical Society of America, we presented a paper on spatial sampling. The first part of the investigation was dedicated to a review of previous community noise surveys. We studied these surveys with respect to the following criteria:

1. Number of sampling stages.
2. Sampling technique applied by stage.
3. Spatial criteria used by stage.
4. Total sampling area.
5. Survey length.
6. Total number of measurement sites.
7. Length of measurements made per site.
8. Number of equipment systems and the survey objectives.

We found that there were nearly as many sampling procedures employed as there have been studies performed. Owing to the variability in objectives and other parameters of community noise surveys, it appears that no single sampling procedure is optimal for all community noise surveys. There is a need for a statistical analysis of the relationships of the various proposed spatial criteria to sound descriptors. What we are asking is: which criteria are necessary for characterizing spatial changes in community noise?

We are about to begin an analysis of previously collected data to answer this question. It is intended through application of our regional resources that we can further determine the number of sites per criterion by implementing a program of multiple site monitoring. In the area of three dimensional sampling — i.e., looking at height variations — we have just completed a noise survey at the Crystal City area of Arlington, Va., in which we located monitors above the top of an 11-story building and in various locations on the ground to determine if we can integrate spatially by measuring from above the area. In addition, our regional office in Denver, Colo., has been investigating aerial noise sampling from a balloon suspended approximately 1,300 feet above Boulder, Colo.

Until now, we have hired college students to act as observers so that we might have a record of what noise sources predominated during a monitoring interval. We are, however, looking at other approaches to noise-source identification. We recently purchased microsampling systems to operate in conjunction with our all digital noise-monitoring systems so that we might be able (through time compression) to derive noise-source identification information. Recently we initiated programs to test feasibility of signal processing as a mechanism for noise-source identification. We are looking at techniques such as cross-correlation, which have been used to distinguish among various noise-source generators. Most of the technology for this was developed by the Department of Defense. We are now asking the question: can this technology be transferred at a reasonable cost?

Presently, the U. S. Army's Construction Engineering Research Laboratory is evaluating noise-monitoring systems for us in the field and in the laboratory. We expect the results to be completed within the next month.

The National Bureau of Standards is currently investigating various microphones for application to outdoor noise monitoring. These include condenser, electret, and ceramic microphones, which are being evaluated as a function of temperature (—20° to +50°C) humidity (25 to 95 percent) and frequency (100 to 5,000 Hz). The actual acoustics tests have been completed. NBS will now perform a cost analysis before preparing a final report. In cooperation with the Navy, we are studying the application of telemetry to environmental noise monitoring. Low-cost telemetry and sensor units developed by the Department of Defense show great promise, particularly for systems in which only limited information is brought (e.g., threshold detection).

Another concern is, where shall we process data? We intend to tackle this through an operations-research study scheduled to begin this fall, after which we will concentrate on data assessment and data presentation.

CONCLUSION

While we hope to have answered many of these questions to the point that an acceptable protocol will have evolved by July 1976, there is a long-term requirement for developing more meaningful and more cost-effective techniques.

The multitude of problems we face requires the skills of many disciplines: scientists, engineers, environmentalists, urban planners, social scientists, and statisticians. It is an exciting field. I encourage your participation.