Feature Articles

THE QUEST FOR QUIET

California Researchers Explore Reduction of Highway Noise for NCHRP

Black smoke belching from a factory smokestack; a brown pall of smog hanging over the towers of a large city; rivers clouded by industrial waste, feeding into dying lakes: These are the mental images conjured up in the mind of the average person by the word "pollution."

But, paradoxically, a silent partner in the pollution picture is noise—silent inasmuch as it is rarely mentioned or discussed as a pollutant. Nontheless, the level of environmental noise has risen steadily until it poses a definite threat to health in today's urban environment.

By far the greatest source of urban noise is traffic, and studies in several major American and European cities have shown that, despite the noise produced by aircraft, the predominant and most widespread source of noise is surface traffic, such as automobiles, buses, trucks, and motorcycles.

In the early 1960s, before the problem reached its peak, the National Cooperative Highway Research Program was alerted to its seriousness. Since then, a series of research projects administered by NCHRP uncovered a great deal of useful information on the nature of traffic noise and resulted in the publication of several manuals, design guides, and reports that are helping highway designers, engineers, and land use planners in the fight against traffic noise.

Four such projects have been carried out for NCHRP by Bolt Beranek and Newman, Inc., from the company's regional office in Canoga Park, California. With headquarters in Cambridge, Massachusetts, the firm was organized in 1948 to offer consulting in the fields of theoretical and applied acoustics. Interest and activity in these areas have continued, but the broad research interests of BBNs scientific staff and the increased demands for applied research and consultation in other fields have led the firm to gradually expand its original activities.

BBN has carried out noise measurements and analyses of aircraft, trains, helicopters, specialized industrial facilities, and various other types of motor vehicles. The company's highway noise studies, independent of the NCHRP projects, have ranged from Seattle to Baltimore, from Los Angeles to Atlanta, and from Hawaii to Detroit.

The alliance between NCHRP and BBN in the noise war began in 1964, when the California firm was awarded a $150,000 contract to develop a computer simulation program for the prediction of noise from freely flowing highway traffic; to determine the effects of traffic flow variables such as speed, flow rate, and vehicle mix and of roadway configurations such as elevation or depression on highway noise levels; and to recommend methods of measuring vehicle noises objectively, based on analysis of existing subjective tests and experience. As part of the project, the researchers interviewed residents living near highways and freeways in the Los Angeles area to assess their reactions to traffic noise.

The person-to-person interviews were conducted in several Los Angeles areas, ranging from high-priced neighborhoods to poorer districts where interpreters had to be used. Seventy percent of the richer residents living in an area where there was little freeway noise expressed annoyance, but only half of the residents of the poorer areas were disturbed by the noise, which in their case was 4 times greater!

Later analysis of the statistics showed that residents judge their living situation from the standpoints of convenience, attractiveness, intrusion (including odor and vibration, as well as noise), and the need for handling the increased traffic volume. According to NCHRP Report

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1 Senior consultant B. Andrew Kugler (left) examines 16-mm footage from sound film being produced by senior scientist Sanford Fidell (seated) as part of NCHRP Project 3-7.

2 Four tape recorders linked up to microphones at various heights and distances from the highway were used to record traffic noise. Four sound meters in left foreground were used to balance sound to a known level.

3 Microphones were raised to 25 feet to assess traffic noise from the Michigan freeway that runs behind these houses.

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4 Researchers verify the noise level from the freeway in the background as it affects the residents of these homes in Michigan.

5 Charting the possible noise effects of a proposed new freeway are (from left) William J. Galloway and Allen G. Piersol.

78, which carries the research results, it is the total situation, including attitudes toward highways and freeways in general, that leads to expressed annoyance with noise.

Armed with these facts, the BBN team moved ahead with phase 2 of the research and devised a "cookbook" type of manual with which a designer can feed in the various criteria and get a reliable estimate of the impact of highway-generated noise on the community. This was issued as NCHRP Report 117, which was accompanied by an illustrative tape recording to help engineers understand how different noise levels are heard, what the significance is of changing noise levels by various amounts, and how motor vehicle noise varies with traffic flow conditions.

This design guide was based partially on theory; and theory is only as good as its practical applications. The next step—and the next phase of the project—was to field test some of the procedures recommended in the design guide and modify them as necessary. (Details of the findings are published in the NCHRP News Briefs section of this issue of Transportation Research News.—Ed.)

Eighteen months ago the final and most ambitious phase of the research got under way at the Canoga Park Laboratories. Emphasis on previous studies had been placed on the way sound was conducted and received, but little emphasis had been placed on the source of the noise. Now the researchers were to summarize existing noise level information on the characteristics of motor vehicle noise sources, including trucks, motorcycles, and automobiles, summarize the present state of the art in noise control for motor vehicle sources, and show how existing technology is expected to cope with the problem. They were charged with improving the prediction techniques for traffic noise propagation in urban areas and with documenting the acoustic and nonacoustic aspects of traffic noise reduction measures, both through highway design and by land use planning. They were to evaluate the economic trade-off considerations of curing the highway noise problem through control at the source and at its destination rather than exclusively through highway design. Finally, they were to develop improved recommendations for highway noise level design criteria based on improved knowledge of the effects of time-varying noise in terms of annoyance, speech interference, and sleep interference.

"The project looks far beyond noise control for highway design," says B. Andrew Kugler, BBNs senior consultant who headed the research team. "It has a dual role in helping the highway engineer to choose from a number of alternatives and in helping the highway official to influence legislation on highway noise.

"Noise reduction is a public education process as well as a technical one," says Kugler. "As we noted in our person-to-person interviews, some people do not understand that noise interferes with their verbal communication, affects their sleep, and is generally annoying. But just like the vacuum cleaner that didn't sell because it was too quiet, noise reduction programs aren't always understood.

"The most effective course is to go straight to the source and legislate for quieter trucks and automobiles," he adds.

What causes traffic noise? Generally, it comes from the various components of vehicles such as the engine intake, casing, and exhaust and from tires, cooling fans, transmissions, and aerodynamic sources. The resulting noise is controlled to a great extent by the number of vehicles on the highway, the average speed and rate of flow, the road surface, and the proportion of automobiles and trucks.

"Trucks generate about 14 decibels more than cars," says Kugler. "It takes about 25 cars to make as much noise as one truck."

Surprisingly, vehicle noise can be attributed as much to the action between the tires and the roadway as it can to the motor and exhaust; the dominating source is a function of vehicle class and average speed of the traffic stream.

6 The noise level from a stationary truck motor is measured by Peter Renz (left) and Larry D. Pope.

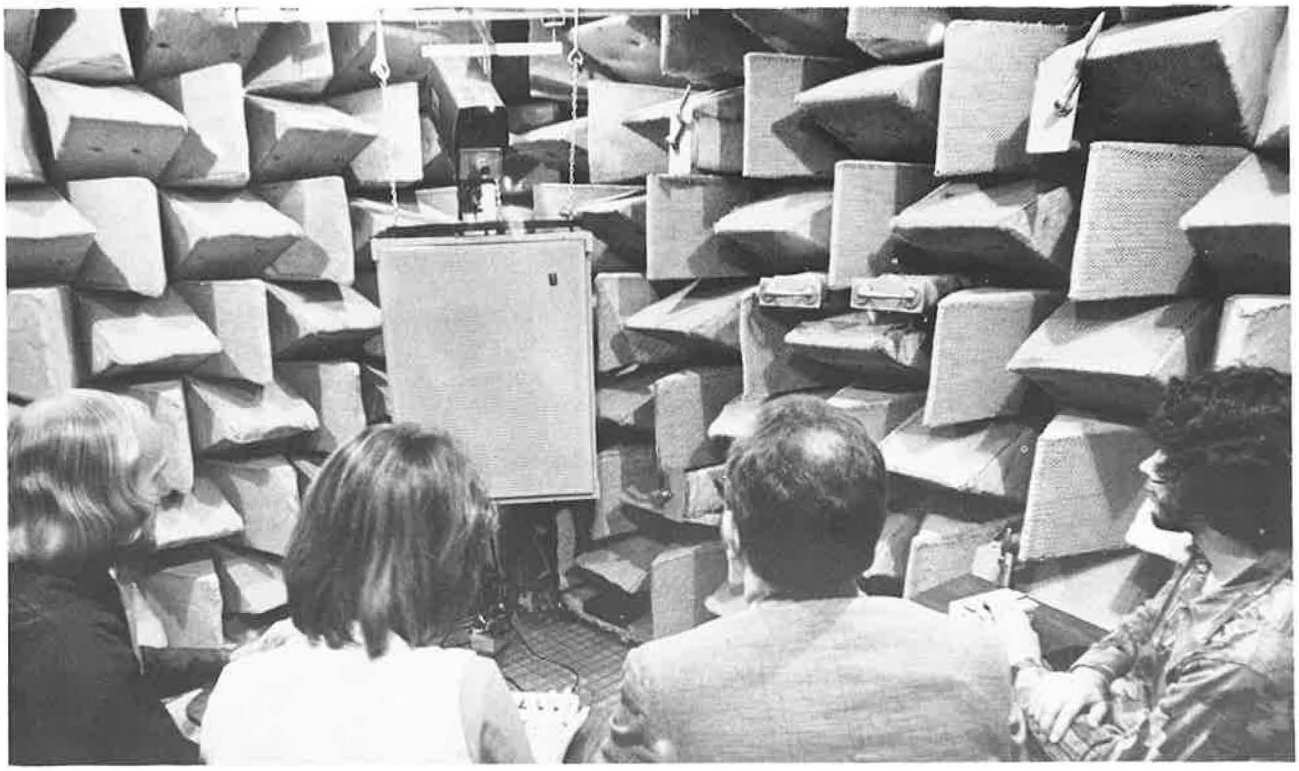
7 The Digital Equipment Corporation PDP 8 computer is the heart of the BBN laboratory. It is equipped with high-speed paper tape equipment and a 32,768-word disc unit for auxiliary storage. Interfaces to various clocks, gates, relays, electronic switches, and amplifiers permit the machine to communicate with most of the analog equipment in the laboratory.

8 Control words, broadcast with a mixture of traffic noise through the loudspeaker in the background, are identified by volunteers to determine the effects of the traffic noise on the human ear. A television camera can record their reactions.

According to the preliminary findings of the final research phase, to reduce the noise of a diesel truck to below the 80-decibel level proposed by California for 1978 would cost $400 to $700. To further reduce the noise to 75 decibels, as scheduled by Chicago and by the Environmental Protection Agency for 1980, would cost at least $1,400 (at current values) per truck. As for the 70-decibel truck proposed by California for 1988, the report points out that this standard will be extremely difficult to meet and cost will be prohibitive.

Although proposed legal limits on highway noise are desirable in the long run, they make the highway engineer's job more difficult today. In the most conservative design, the engineer will be estimating the noise from a highway that may not be in use for 5 to 10 years, based on noise levels produced by unrestricted vehicles now in use. This will usually result in an excessively high noise environment in any area close to the highway. On the other hand, the engineer knows that the various pressures of regional, state, and federal noise control programs can lead to restrictions on vehicle noise for new vehicles that may come into use before his new highway is opened. However, there is little indication of how much lower noise levels can or will be in the future.

The problem is compounded by the fact that even if new, quieter trucks are developed, as they surely will be,



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the older, noisier ones will still be around unless a retrofit law is implemented.

The information gathered by BBN under the NCHRP project will go a long way in alleviating this situation. Six volumes of findings, starting with the modified design guide, are currently being reviewed by NCHRP staff and advisory panels prior to publication of the final report in 1975.

An interesting product of the research was a 16-mm motion picture designed to illustrate some of the problems caused by traffic noise and to spell out possible solutions. Sanford Fidell, a one-time radio announcer and producer, and Prichard H. White, documentary film producer, both of whom are now senior scientists at BBN, were responsible for the production of the film, which will be available on loan from NCHRP at a later date.

Reduction of traffic noise at the source can only be carried out to the limits imposed by economics and technology. How do we cope with the noise that's left? According to BBN, where buildings and highways are already in place, the noise can be baffled to a certain extent by sound barriers erected beside the highway. Sound insulation of buildings can cut down the sound even further. Various methods of insulation and designs of barriers have been investigated in depth as part of the NCHRP study.

The most effective measures can be taken at the design stages. Depression or elevation of a new urban highway can sharply reduce the noise in adjacent buildings, but an intelligent land use program is even more effective. Setting houses well back from the highway and having commercial or industrial facilities, where the traffic noise is acceptable, act as a buffer between the homes and highway are the best solution. Properly shielded and insulated high-rise apartment buildings are also useful as noise barriers between the highway and single-occupancy homes.

The 55-mph speed limit imposed on a nationwide basis as a result of the energy crisis has had beneficial side effects in noise reduction. "Tests show a definite drop in the noise level," says Kugler.

Other BBN researchers involved in the NCHRP project include William J. Galloway, principal consultant; Allan G. Piersol, Peter E. Rentz, Larry D. Pope, and Karl K. Pearsons, senior scientists; and Grant S. Anderson, Dwight E. Bishop, Daniel E. Commins, Nicolaas H. Reddingins, and Salvatore D. Pecora, senior consultants.

A decade of effort is coming to fruition with the development of a universally accepted methodology for noise measurement and a design guide, representing a degree of standardization unknown in any other transportation mode.

Traffic noise represents a big problem in a big country. The United States has 134 million people living in urban areas, and 37 million of these will be affected sooner or later by traffic noise. NCHRP, with the expertise of such organizations as Bolt Beranek and Newman, Inc., will continue to provide the ammunition for the highway engineer and designer to use in the continuing war against noise.