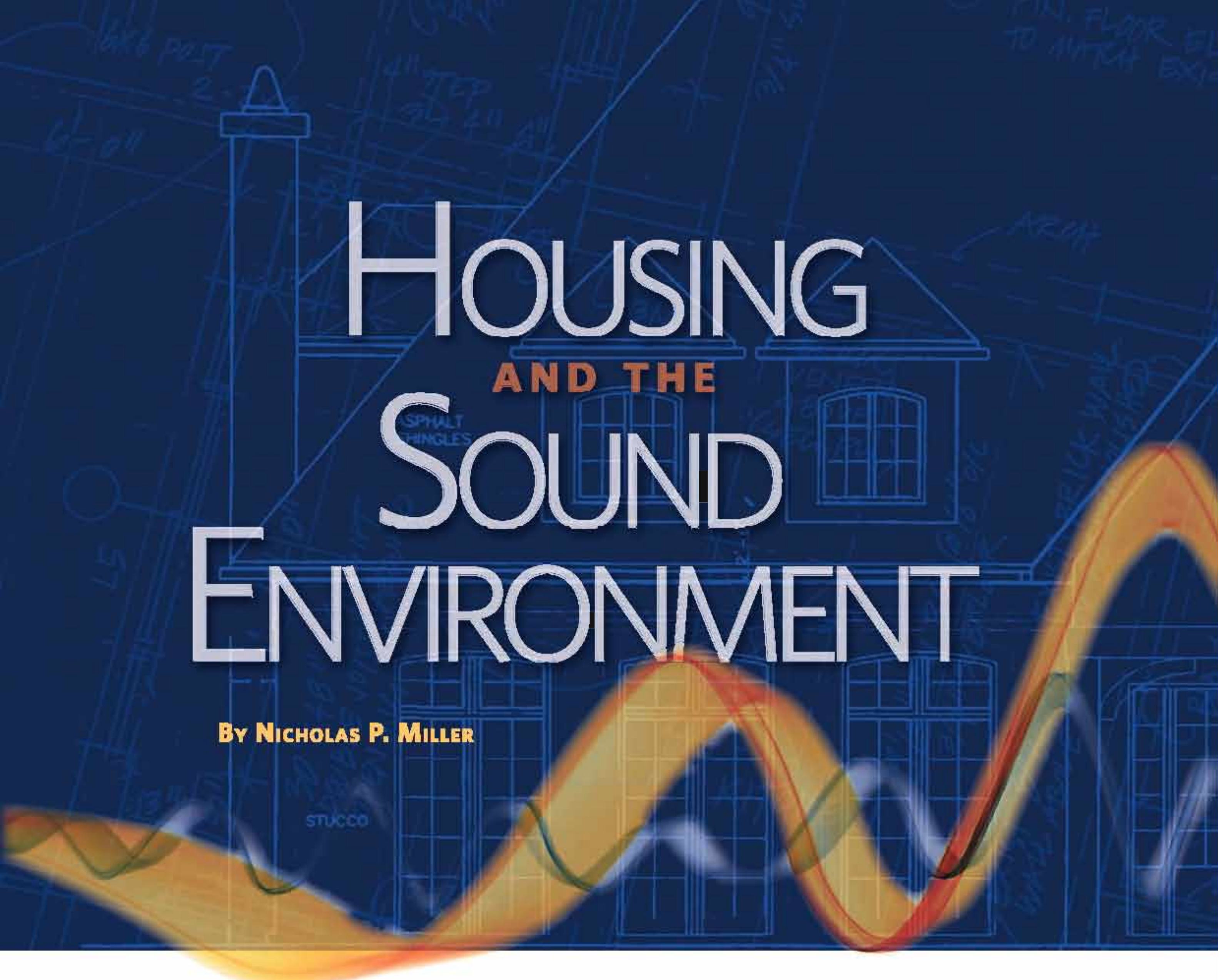

Housing and the Sound Environment

By Nicholas P. Miller

When building in some jurisdictions or near major highways or airports, developers often encounter noise issues. But sound level performance requirements, if they exist, and some commonly used sound metrics rarely help convey an understanding of what a planned neighborhood will sound like or whether the "soundscape" will be satisfactory to the future residents.

In most bylaws and regulations, the metrics are usually "cumulative" measures of sound energy (see sidebar) that are useful for planning purposes but tell little about how a place will sound or how the sound will affect people. This article examines the primary sources of sound that are likely to affect a development and offers guidance to help in site planning and building design. It is intended not as a complete "how to" guide but rather as a means to call attention to possible sound-related problems and potential solutions, particularly in the early planning stages of a development.

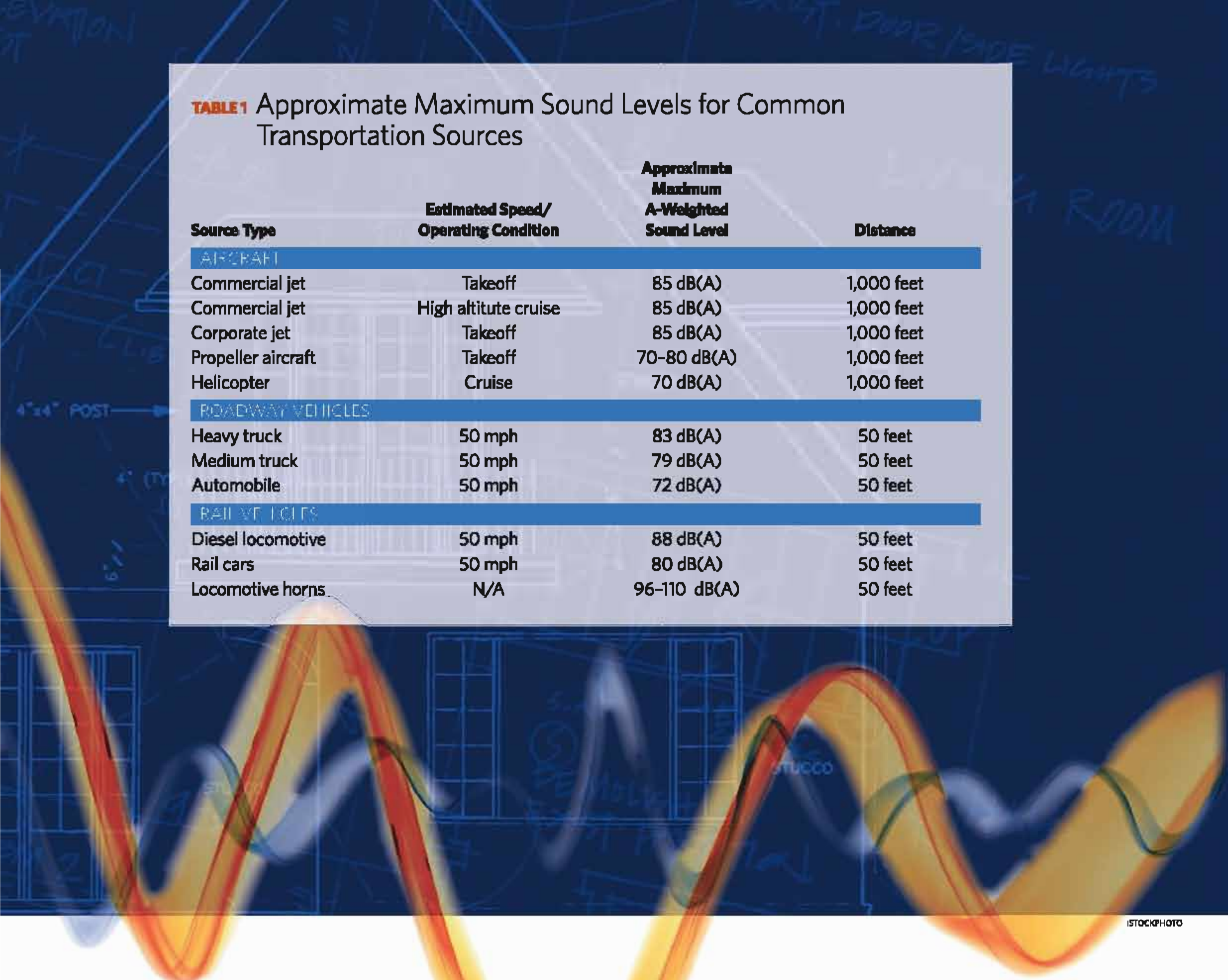

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TABLE 1 Approximate Maximum Sound Levels for Common Transportation Sources

Source Type	Estimated Speed/ Operating Condition	Approximate Maximum A-Weighted Sound Level	Distance
AIRCRAFT			
Commercial jet	Takeoff	85 dB(A)	1,000 feet
Commercial jet	High altitute cruise	85 dB(A)	1,000 feet
Corporate jet	Takeoff	85 dB(A)	1,000 feet
Propeller aircraft	Takeoff	70–80 dB(A)	1,000 feet
Helicopter	Cruise	70 dB(A)	1,000 feet
ROADWAY VEHICLES			
Heavy truck	50 mph	83 dB(A)	50 feet
Medium truck	50 mph	79 dB(A)	50 feet
Automobile	50 mph	72 dB(A)	50 feet
RAIL VEHICLES			
Diesel locomotive	50 mph	88 dB(A)	50 feet
Rail cars	50 mph	80 dB(A)	50 feet
Locomotive horns	N/A	96–110 dB(A)	50 feet

How Easy to Converse or Listen?

Perhaps the easiest way to understand sound levels is to know at what level and in what locations an intruding sound will start to make speech difficult. Ease of conversation depends on the voice level, the background sound level, and, outdoors, the distance between the people engaged in conversation. In general, conversing people in the United States tend to stand about three feet apart. Outdoors, if they speak in a normal conversational voice, they experience speech interference when intruding sound levels rise above 60 to 65 A-weighted decibels [dB(A)]. Indoors, we use more relaxed voice levels and generally expect to understand virtually everything said. Therefore, intruding sounds that start to exceed 45 dB(A) indoors can produce speech interference. Indoors, however, distance between talkers is less important because the sound level of speech tends to be fairly consistent throughout the room.

What Are the Sound Levels of Common Sources?

Sound levels must be associated with a specific source, with the way the source operates, and with a specific location on the ground or at a distance from the source. Table 1 provides estimates of the maximum sound levels produced by common types of vehicles. It is important to note that the aircraft levels assume that the listener is 1,000 feet from the aircraft and that the ground transportation sources assume a distance of 50 feet. In reality, the sound levels of these sources at different distances depend on many factors, such as type of ground surface, weather conditions, intervening buildings, and so forth.

Figures 1 and 2 provide a generalized picture of how the sound levels could drop with increasing distance. Figure 1 shows the decrease in maximum sound levels with distance from a highway carrying moderately heavy truck traffic. Figure 2 shows similar information for an aircraft that is nearly overhead not off toward the horizon. The gold line in both figures reflects the assumption that there are no obstructions between the source (roadway or aircraft) and the location on the ground. In Figure 1, the blue line shows how a 15-foot-high noise barrier (or earth berm or long building) located about 100 feet from the roadway would affect the sound levels behind it. With a little effort, the figures can be used to estimate how the sound levels of other sources listed in Table 1 would decrease with increasing distance. For instance, the roadway level changes from about 83 dB(A) at 50 feet to about 55 dB(A) at 500 feet; a decrease of 28 dB. Hence, the level of a medium truck at 500 feet may be estimated to be 79 dB(A) minus 28 dB or about 51 dB(A). (This method is not exact, but it can give a reasonable estimate of the levels.)

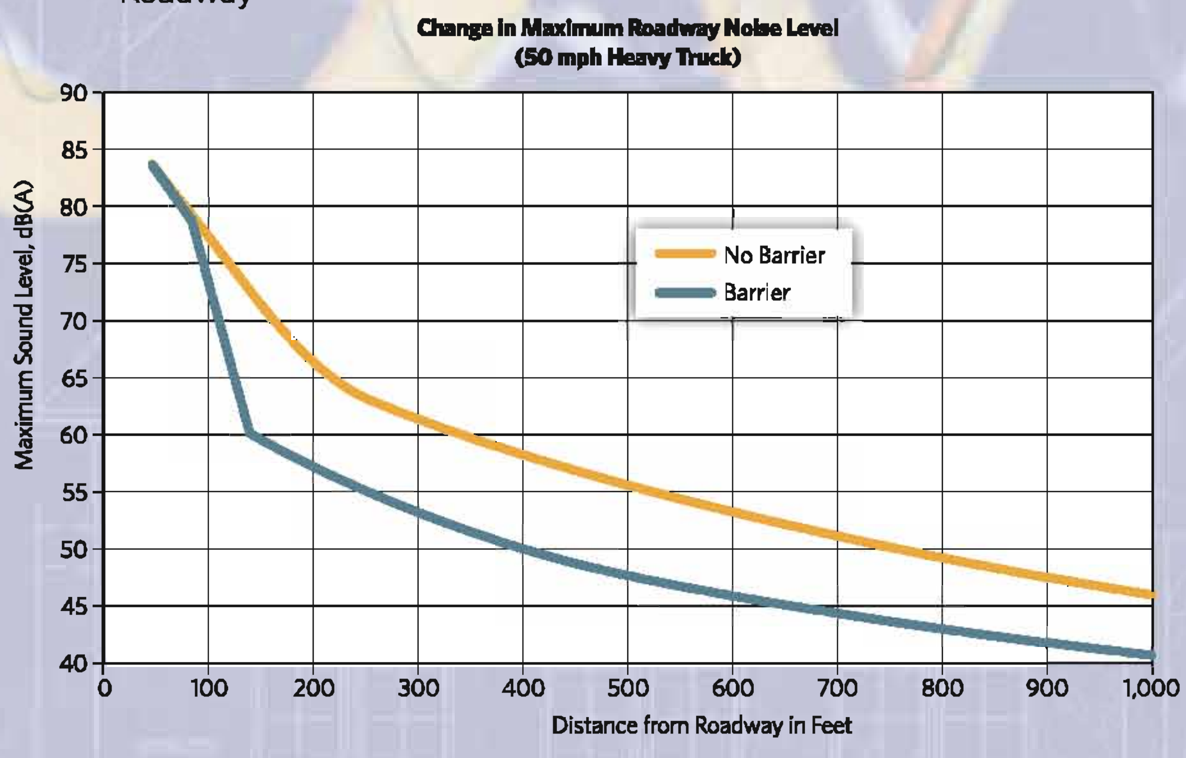
The information in Table 1 helps indicate when sound from transportation sources should be considered in planning residential land use. For example, along roadways with heavy trucks, dwellings closer than about 300 feet with a clear view of the road may have outdoor areas where noise interrupts conversation. The frequency of disruption depends on the number of trucks per hour or per day.

It is also clear why homes near commercial airports, particularly under jet departure flight paths, experience regular disruption of normal outdoor activities. At about three miles from the runway, departing aircraft are often about 2,000 to 3,000 feet above ground level, with maximum sound levels on the ground ranging between 75 dB(A) and 80 dB(A). Indoors, with the windows open, outdoor sound levels are reduced by 10 to 15 dB and outdoor levels of 75 dB(A) drop to about 60 dB(A) indoors—high enough to cause difficulty in hearing all of a conversation at relaxed voice levels. Closing windows produces another 10 dB of reduction, lowering indoor levels to about 50 dB(A), but still producing some interference with relaxed speech.

How to Control Sound Levels?

The federal government has assumed the authority to control the sound level of new vehicles such as trucks, cars, motorcycles, locomotives and aircraft. Therefore, planners must rely on the fundamental concepts of distance or location,

FIGURE 1 Decrease of Maximum Roadway Sound Levels with Distance from Roadway



shielding, sound insulation, and traffic management. Most sound reduction measures are simply a matter of common sense, but they often go overlooked or are infeasible and require some expertise in quantitative analysis to ensure that they will perform as expected.

Increasing distance from noise sources is always desirable, but often not practical. However, if a development is planned to encompass several uses, site planners might be able to incorporate distance buffers or use as noise barriers those buildings whose exposure to noise is relatively less problematic. Planners should be aware that plantings, unless extraordinarily dense and deep (100 feet or more in depth), have virtually no effect on sound levels, though hiding the sound source is in itself often a perceived benefit. Noise barriers or berms can effectively reduce noise levels, primarily at the nearest homes, but they must be fairly high to ensure effectiveness. Some communities have shown they would prefer roadway noise to having high walls at their property lines.

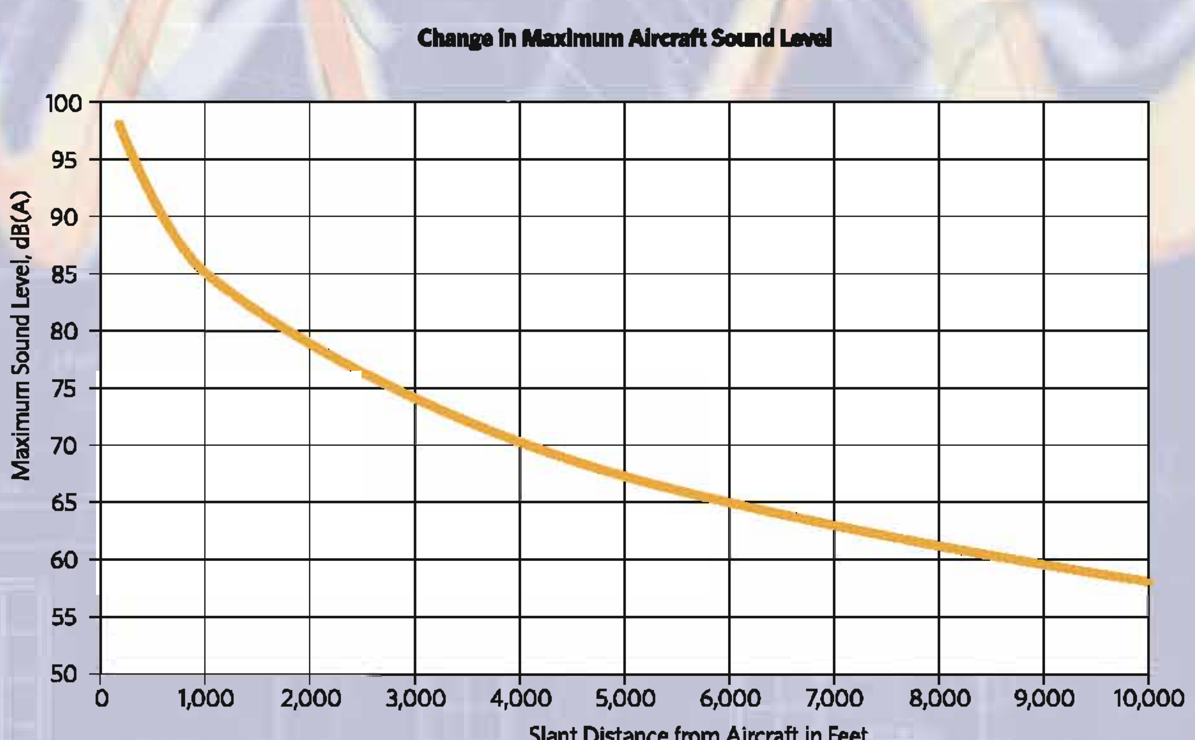
Sound enters homes primarily though windows, doors, vents, and through-the-wall fans or air conditioners. Baffles associated with vents and alternatives to wall-penetrating ventilation can eliminate sound paths, and acoustically rated doors and windows are available from many manufacturers (although, over time, special doors and windows can age and become less effective).

A thorough examination of traffic flows may reveal that, especially if a roadway system is part of a development, alternative routes can be created to divert higher-speed, louder traffic away from the housing areas. Smart growth concepts sometimes include intentional limits on road capacity in order to slow traffic, thereby improving pedestrian safety and reducing vehicle sound levels.

A New Technique for Understanding Future Soundscapes

Recent advances in technology, combined with knowledge of acoustics and noise prediction models, have made possible the creation of Virtual Soundscapes™. By making special audio recordings and adjusting and mixing them together properly, sound technicians can now create an audio presentation of how a proposed development will sound. The

FIGURE 2 Decrease of Jet Aircraft Maximum Level with Distance from Aircraft



Sound Metrics and Criteria

SOUND IS QUANTIFIED IN SEVERAL WAYS, usually either as a total accumulation of sound energy over a given period of time or as a measure of a single event. First, almost all environmental sound is quantified in A-weighted decibels, dB(A) or dBA. A-weighting is a means of summing sound levels across frequencies, de-emphasizing the levels at different frequencies to correspond to the way we hear.

The total accumulation metrics are termed "equivalent levels" usually for either a period of one hour, symbolized as LAeq,H (or simply Leq if the time period is clear), or a 24-hour period as Day-Night Average Sound Level, symbolized as DNL or often as Ldn. DNL includes a weighting or penalty of 10 dB for sound occurring between 10 p.m. and 7 a.m.

Single events may be quantified in many ways. The most common ones are an accumulation of sound energy over the duration of the event, termed Sound Exposure Level, SEL; a maximum level, Lmax; or a length of time that the sound from the event exceeded a specified "threshold" level, or Time Above or TA.

Several organizations have identified levels of cumulative sound exposure below which there should be little risk of adverse effects on human health and little annoyance. The U.S. Environmental Protection Agency (EPA) identified a value of 55 dB DNL as such a level. Figure A shows typical values of DNL for various locations and identifies the EPA level and the U.S. Department of Hous-

FIGURE A Typical Values of DNL

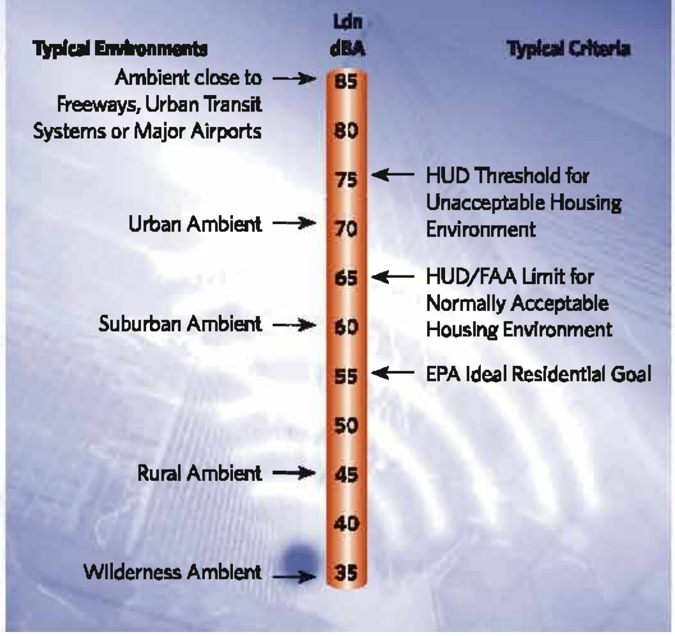
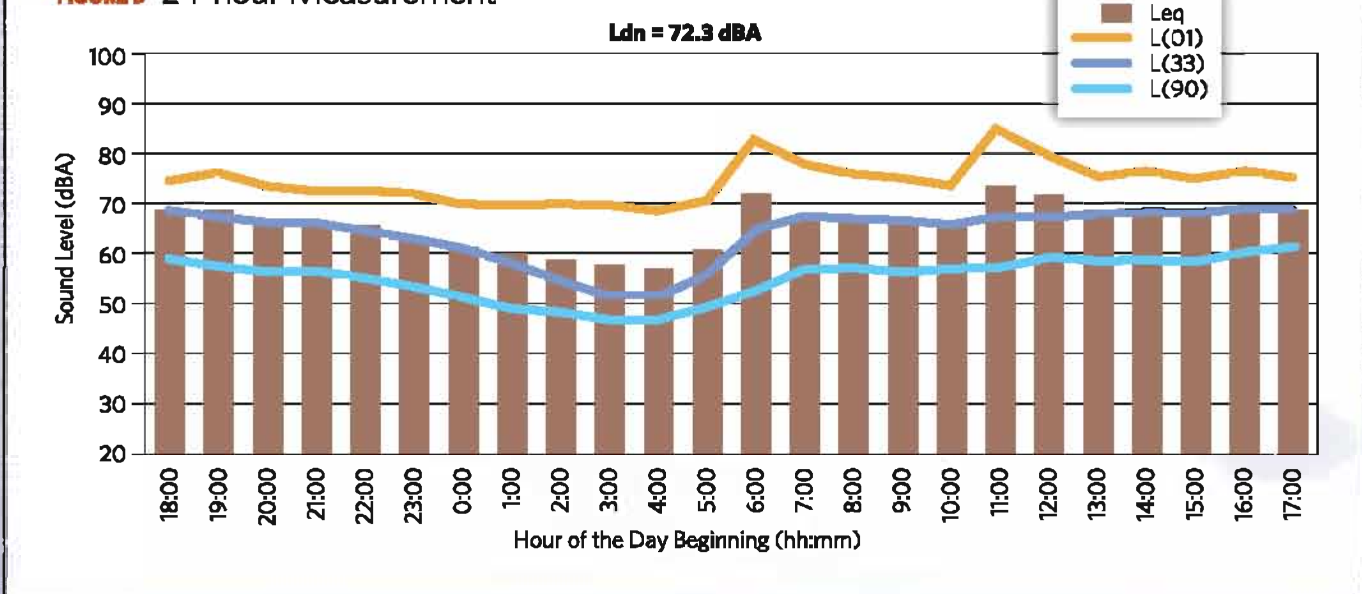


FIGURE B 24-hour Measurement



audio presentation, heard through stereo headphones, places the listener in a realistic, surrounding soundscape.

It is possible, for example, to listen to the traffic sounds in a proposed development adjacent to a highway and to demonstrate the effect of different-height noise barriers on those sounds. It is also possible to simulate the audible effects of being indoors with the windows open or closed. The technology can answer questions about how the soundscape will sound if traffic speeds are reduced; if houses are built under a flight corridor; if high performance acoustic windows and doors are installed; and if a park is developed to provide a buffer between a roadway and housing. Almost any combination of outdoor sounds and the effects on those sounds of various controls can be created and heard.

Points to Remember

■ Soundscapes can affect the quality of life and should be considered early in the ing and Urban Development (HUD) and the Federal Aviation Administration (FAA) levels for purposes of making agency decisions regarding funding assistance for certain types of projects and situations.

As suggested by Figure A, federal agencies responsible for transportation noise have established criteria (or standards or guidelines) that identify when "impact" occurs and when an increase in sound is "substantial." When either an impact or a substantial increase is projected to result from a federally funded project, federal law requires specific actions including detailed analysis and usually examination of means to reduce the noise. Under specified conditions, noise reduction methods and actions can be supported with federal funds. Generally, the reductions must meet minimum goals, and the methods or actions must be technically and economically feasible.

Hourly equivalent levels contribute to the value of DNL for the 24-hour period and Figure B shows the measured levels at one site. The location showed little variation from hour to hour, except in the middle of the night. L(01), L(33) and L(90) are the levels exceeded for 1 percent, 33 percent, and 90 percent of the hour, respectively.

Figure C shows how the sound level of a single event might look, including the maximum level and the time above. Figure D provides some typical maximum sound levels.

The Sound Exposure Level is generally 5 to 10 dB higher than the maximum since it is the summation of all the sound energy in the single event. Though the maximum level is easier to imagine and understand, the SEL provides a more complete estimate of the disruptive or annoying quality of the event because the duration of a sound—how long we can hear it—factors into how bothersome we consider the event.

FIGURE C Single-Event Time History

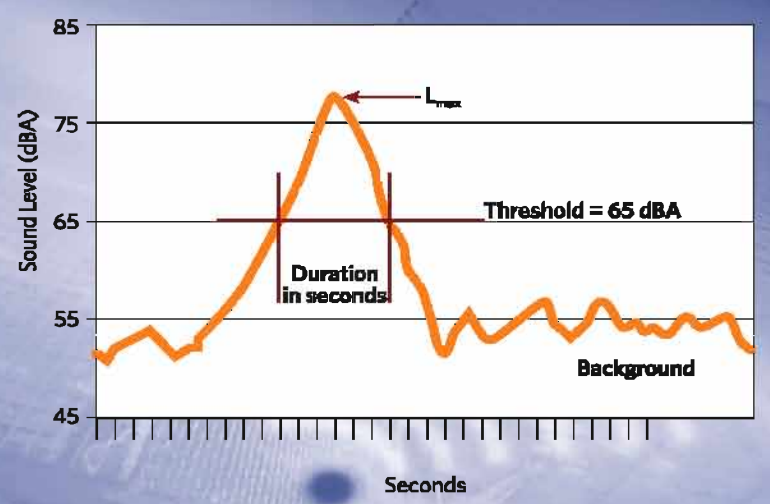
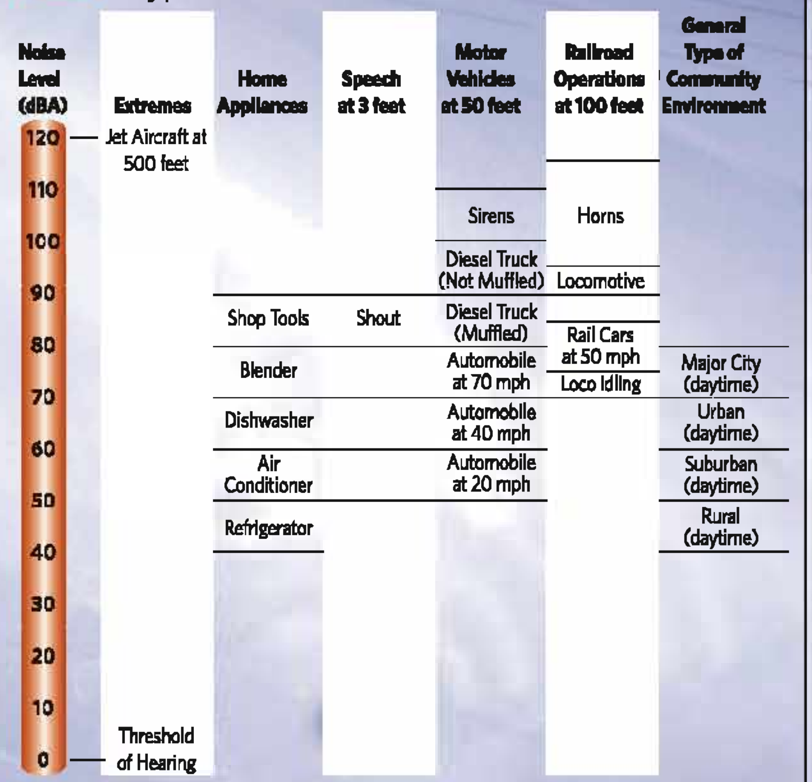


FIGURE D Typical Maximum Sound Levels



planning process.

- The sound levels produced by most common sources are well known and can be estimated for different locations and conditions.
- Sound control measures are available for many situations and may be easier to implement and more effective if designed and incorporated into the planning process at its earliest stages and then onward.
- The soundscapes likely to affect a development can be predicted and considered both quantitatively with decibels, speech interference, and "impacts" (see sidebar) and qualitatively with, for example, Virtual Soundscapes.™ LD

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