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# NATIONAL SURFACE TRANSPORTATION NOISE STRATEGY

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## MEDIUM AND HEAVY TRUCKS, LIGHT VEHICLES, MOTORCYCLES, AND SNOWMOBILES

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U. S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

# EXECUTIVE SUMMARY

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This surface transportation substrategy is a follow-up to Toward a National Strategy for Noise Control. The strategy document sets forth the extent of the noise problem in the United States and the general framework for its abatement and control. This substrategy identifies the specific noise problems which stem from surface transportation vehicles (excluding railroads), and suggests the noise abatement controls which should be used to halt this growing problem.

In fact, there is no doubt that road noise is growing. By the year 2000, both the noise levels and the number of people exposed to these levels will increase significantly. This is based on the results from a computer model which takes into account traffic flow information, noise level contours around roads, and population density, as well as projections of vehicle growth and population growth. Of course, this projected increase will occur only if nothing is done to prevent it.

Regulations have been promulgated to reduce the noise levels of new trucks and proposed for new motorcycles and buses. The noise emission reduction these regulations will gain have been addressed in the model. However, noise from trucks, buses, and motorcycles will increase even with these regulations. Light vehicle noise will add to the urban noise problem, not only because the vehicle population will grow, but also because both 4-cylinder gasoline engined and diesel engined automobiles are gaining a higher percentage of the automobile market. These types of engines are noisier than the V-8 gasoline engines, which currently make up over half of the auto market. This market share will drop to 18 percent, at the most, by 1985.

Although some noise reduction may occur incidentally from user demand for clutched fans, radial tires, and turbocharged diesel engines in both trucks and cars, the surface transportation noise problem will not be solved. These noise reductions will come about only as a spill-over from a particular user's desire for better performance. A user will not voluntarily bear the cost for noise abatement equipment when it is the community, not the user, who is primarily impacted by the vehicle noise.

On the same note, a profit-maximizing firm will not assume costs to quiet vehicles without legal or economic reasons. So far, regulations for light vehicle noise emission levels have not been addressed. And to repeat, when the community, and not the user, is primarily impacted by the noise, there exists no economic stimulus to either the manufacturer or the user to reduce vehicle noise.

The impact on the community from noise from vehicles is calculated in terms of both the extensiveness (the number of people impacted) and the intensiveness (the severity of the impact). The end result of this calculation is the Level Weighted Population (LWP) for general adverse response. To quantify adverse response more specifically additional descriptors are used. These descriptors are Level Weighted Population for Hearing Loss damage (LWPH), Level Weighted Population for Sleep Interference (LWPS), and Level Weighted Population for Speech Communication Interference (LWPC). These descriptors are used to describe the community noise impact from trucks, buses, motorcycles, and snowmobiles. They are also used to show, through simulations, the effectiveness of various noise abatement controls.

By now it is clear that noise today is a major problem and that it is a growing problem. To provide optimal solutions to every aspect of the noise problem necessitates collecting and analyzing a monumental amount of data. Within time, resource, and available literature constraints, every possible effort has been made to address the data needs. Still, the data are not complete and every data category needs to be strengthened before optimal solutions can be provided.

Nevertheless, there is a sufficient amount of data available on exposure, product noise emission, and attitudes to suggest that surface transportation sources contribute to a noisy environment that jeopardizes the health and welfare of the U.S. population. And while there is not enough information to solve the surface transportation problem in an optimal manner, cost effective for every community, an acceptable mixture of controls is possible.

A continuous effort will be made to fill the relevant data gaps and to fine-tune the national anti-noise activities to arrive at the largest net yield of benefits from noise abatement with minimal adverse impacts. Meanwhile, there is enough data on the growing noise problem to proceed with the Congressionally mandated policy "to promote an environment for all Americans free from noise that jeopardizes their health and welfare."

There is a range of controls available to reduce noise from motor vehicles which reaches operators, passengers, and bystanders. Without regard to cost, reduction of noise at the source is the most effective type of control. Several methods which can be used to do this are: (1) new product emission regulations, which are set to limit noise emitted by new products; (2) in-use controls, which affect use of the product itself; (3) product noise information, to enable the purchaser to consider noise as part of a buying decision; (4) new technology or innovations to directly reduce noise; and (5) other methods, including maintenance programs, retrofitting, and several types of financial incentives and disincentives.

Path controls interfere with the path of the noise. Barriers are the primary path control mechanism for abating vehicle noise. They can be constructed from various types of materials including fill dirt, metal, wood, concrete, plants, trees, and hedges.

Methods at the noise receiver end to abate noise are termed receiver controls. This type of control includes (1) land use or zoning; (2) insulation; (3) hearing protectors; and (4) building design.

These controls can be used in many combinations, and the majority can be used by the private as well as the public sector.

To determine the likely effectiveness of controls with respect to changes in exposure, several scenarios were simulated through surface transportation noise models. However, if the various controls were simulated independently and also time phased and in all combinations, the result would have been an overwhelming array of possibilities at an astronomical cost. Therefore, a less complicated procedure was used which yielded much the same results in terms of isolating controls that could be imposed independently with a relatively high probability of success. Many controls were simulated parametrically to give a range of results depending on the noise emission change of a product and the resulting population noise exposure change. The vehicles considered in the simulations were medium and heavy trucks, light vehicles, buses, motorcycles, and snowmobiles.

The controls were assessed with respect to (1) their effectiveness, taking into consideration the immediate and longer range goals to be achieved; (2) the magnitude of the cost; (3) the incidence of the abatement cost; (4) the number of years before measurable results would be realized, along with the permanency of the effect; (5) the authority imposing controls; and (6) the cost effectiveness of combined controls.

The recommended controls which resulted from the simulations are presented in Table 4. The recommended time phasing of these controls is shown in Figure 6.

Without some government action, community and operator noise exposure will grow significantly. However, the exposure goals cannot be met by only applying the source controls under the purview of EPA. Source controls under the purview of other Federal agencies and especially State and local governments must be used intensively to give significant noise exposure relief.

In addition, even if source controls were used to a reasonable level, a significant amount of noise exposure would remain. Portions of this remaining exposure can be eliminated through path controls, and receiver controls, including avoidance actions. Thus, it is clear that to solve the noise problem everyone must participate. Action is needed from the Federal Government, State and local governments, industry, and the population as a whole.

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# INTRODUCTION

## INTRODUCTION

The goals of this surface transportation substrategy are:

- To demonstrate that surface transportation noise is a major problem of national concern, and
- To suggest the methods/controls that should be employed nationally to mitigate the problem.

In order to attain these goals, this substrategy is organized into three parts. Part I presents a compilation of various primary and secondary data to demonstrate the contention that noise, especially surface transportation noise, is a problem today. This judgment is based on descriptors ranging from neighborhood characteristics perceived to be undesirable by people nationally, to the noise levels associated with various surface transportation vehicles. Moreover, it will be shown that the problem will grow in magnitude unless some controls are utilized to halt the expansion of noise exposure linked to surface transportation vehicles.

In Part II various controls are simulated to arrive at an array of controls which, when employed, are likely to be effective in terms of significant reduction, halting or reversing projected increases in noise exposure associated with surface transportation vehicles. In Part III an array of controls is developed and a methodology is presented and used that can be employed to select controls that should be given national preference.

# I. THE NATURE AND SCOPE OF THE U.S. NOISE PROBLEM

# I. THE NATURE AND SCOPE OF THE U.S. NOISE PROBLEM

In 1977 the U.S. Environmental Protection Agency in a document entitled Toward a National Strategy for Noise Control[1] demonstrated the extent of the U.S. noise problem by highlighting some of the effects associated with noise exposure. Noise effects that are well documented include: damage to the inner ear resulting in permanent hearing loss, spoken communication interference, sleep disturbance, and general annoyance.

Other indicated effects that are not yet quantitatively documented include: nonauditory health effects, effects of noise in combination with the effects of other pollutants, and learning and task performance consequences.

It was estimated in the national strategy document that 14.7 million American workers are exposed to an Leq(8)* of 75 decibels (dB) or greater. Workers exposed to this level risk incurring noise-induced hearing loss. In addition, it was estimated that about 13.5 million people in the U.S. are exposed to Leq(8) of 75 dB or greater from transportation vehicles including recreational vehicles.**[2]

Noise exposure is both an indoor and outdoor problem and affects operators, passengers, bystanders, and residents. The extent to which these respective groups will fare for better or worse with respect to noise in the future depends on a host of variables among which are population growth, changes in lifestyles, energy availability, and environmental constraints. Even if these and other variables should not change in the future to make the noise exposure worse, the present situation warrants concern.

The aforementioned noise exposure estimates directly identify surface transportation as a problem today. Other indicators not only point to surface transportation as a problem today, but also indicate that surface transportation noise will continue to be a problem in the future.

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* Leq, equivalent sound level, is the average energy level of sound over a given period of time. The period of time is shown in parenthesis; in this case, eight (8) hours.

** This statistic includes community noise exposure plus driver/operator exposure.

1. BUREAU OF CENSUS SURVEY

Three Bureau of the Census housing surveys of owners and renters of dwellings rated noise as the most undesirable condition among all street conditions. Table I-1 provides data from these surveys which indicate that over 31 million, 34 million, and 36 million undesirable street conditions related to noise were reported in the 1973, 1974, and 1975 surveys respectively. As a percent of undesirable street conditions, noise ranked highest by 62.0%, 63.6%, and 66.3% of total undesirable conditions in 1973, 1974, and 1975, respectively. Compared to crime, noise in any one of these years was mentioned at least twice as frequently. (See Figure I-1.) These statistics also reveal that in absolute terms and relative to all undesirable conditions, the number of noise related undesirable characteristics increased by more than 15 percent in three years.

2. THE URBAN NOISE SURVEY

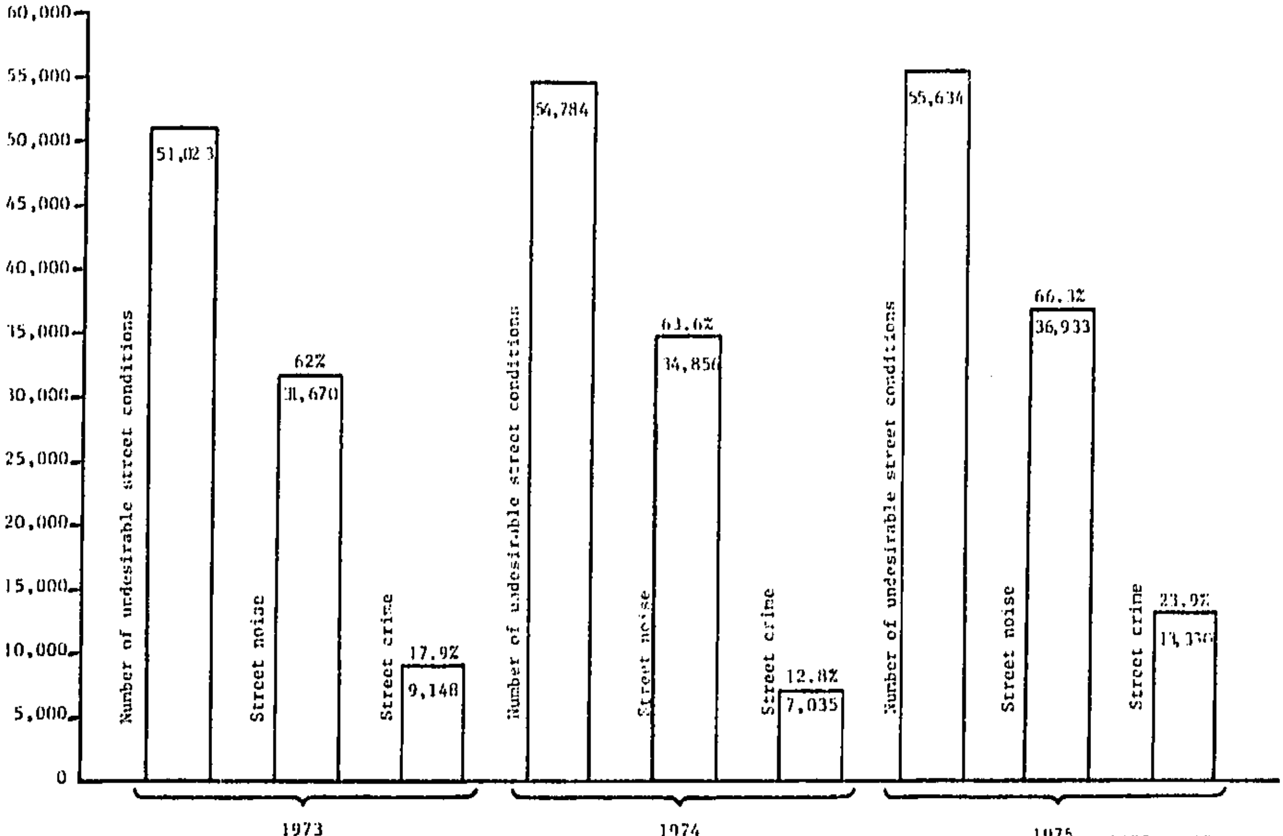
According to a recent EPA urban noise survey, among various mechanical noise sources perceived to be annoying, surface transportation vehicles generally head the list. Specifically, these vehicles are motorcycles, large trucks, autos, sports cars, small trucks, and buses. When numbers of vehicles are considered along with numbers of people exposed to various levels of noise (Ldn), the maximum noise levels at 50 feet ($L_A$ at 50 feet), the operator level ($L_A$ operator), the energy-weighted product distribution, and the Level Weighted Population (LWP) (associated with general adverse response, hearing loss, sleep interference, and speech interference impacts), it is easy to see why the urban noise survey found surface transportation sources so annoying.

3. NOISE EXPOSURE

The current surface transportation noise problem, measured in terms of community noise exposure to the various Ldn levels mentioned in the National Strategy, i.e., Ldn* 55 dB, Ldn 65 dB, and Ldn 75 dB, is expected to grow significantly unless outside controls are exerted. Assuming no additional surface transportation vehicle regulations besides those in force for medium and heavy trucks are promulgated by EPA, and that State and local governments do not launch major new

* Ldn, day-night sound level, is the energy-averaged equivalent level (Leq) for 24 hours adjusted to include a 10 dB penalty for noise exposures during nighttime hours (10 p.m. to 6 a.m.).

Figure I-1
UNDESIRABLE STREET CONDITIONS
Noise vs. Crime 1973-1975
(in thousands)




Source: U.S. Department of Commerce, Bureau of the Census, Annual Housing Survey; 1973, p.8; 1974, p.8; 1975, p.12, Washington, D.C.

Table I-1
UNDESIRABLE NEIGHBORHOOD CHARACTERISTICS

| | 1973 | 1974 | 1975 |
|---|---|---|---|
| Number of undesirable conditions | 51,023 | 54,784 | 55,634 |
| Noise conditions | 31,670 | 34,856 | 36,933 |
| Crime conditions | 9,148 | 7,035 | 13,330 |
| Noise percent of all street conditions | 62.0 | 63.6 | 66.3 |
| Crime percent of all street conditions | 17.9 | 12.8 | 23.9 |

Source: Compiled from data in U.S. Department of Commerce, Bureau of the Census, Annual Housing Survey: 1973, p. 8; 1974, p. 8; 1975, p. 12, Washington, D.C.

surface transportation noise abatement initiatives, it was conservatively estimated that the number of people exposed to Ldn 75 dB and above in urban areas will increase from about .78 million people in 1977 to about 1.3 million people in the year 2000--a 65% increase (Figure I-2). The number of people exposed to Ldn 65 dB and above is projected to increase from 17.7 million in 1977 to about 21.6 million in the year 2000--a 22% increase* (Figure I-3). The number of people exposed to Ldn 55 dB and above from surface transportation vehicles is estimated to be about 94 million in 1977, growing to about 128 million by the year 2000. The model takes into consideration traffic flow information, noise level contours around roads, and population density.

Different exposure numbers are likely to be derived from a more encompassing approach currently being developed by EPA. It considers recent Department of Transportation data which actually accounts for all roads, not just a sample of roadways in a few cities. In accounting for all roadways in the U.S. and functionally categorizing them in terms of use, location relative to population areas, speed, traffic flow, and traffic mix, a more accurate and precise model has evolved. Vehicles are also separated into 14 different categories based upon use or noise emission characteristics in four operating modes. Results from this exercise will be introduced later in this paper. At this point our objective is only to point out that a growing noise problem does exist in the U.S.

The number of people exposed to highway noise at levels of Ldn 65 dB and above (assuming that the percentage of cars with 4-cylinder and diesel engines will increase in the future), is projected to increase from around 17 million in 1977 to over 24 million by the year 2000** (Figure I-3). It must be noted at this point that Ldn 65 dB and

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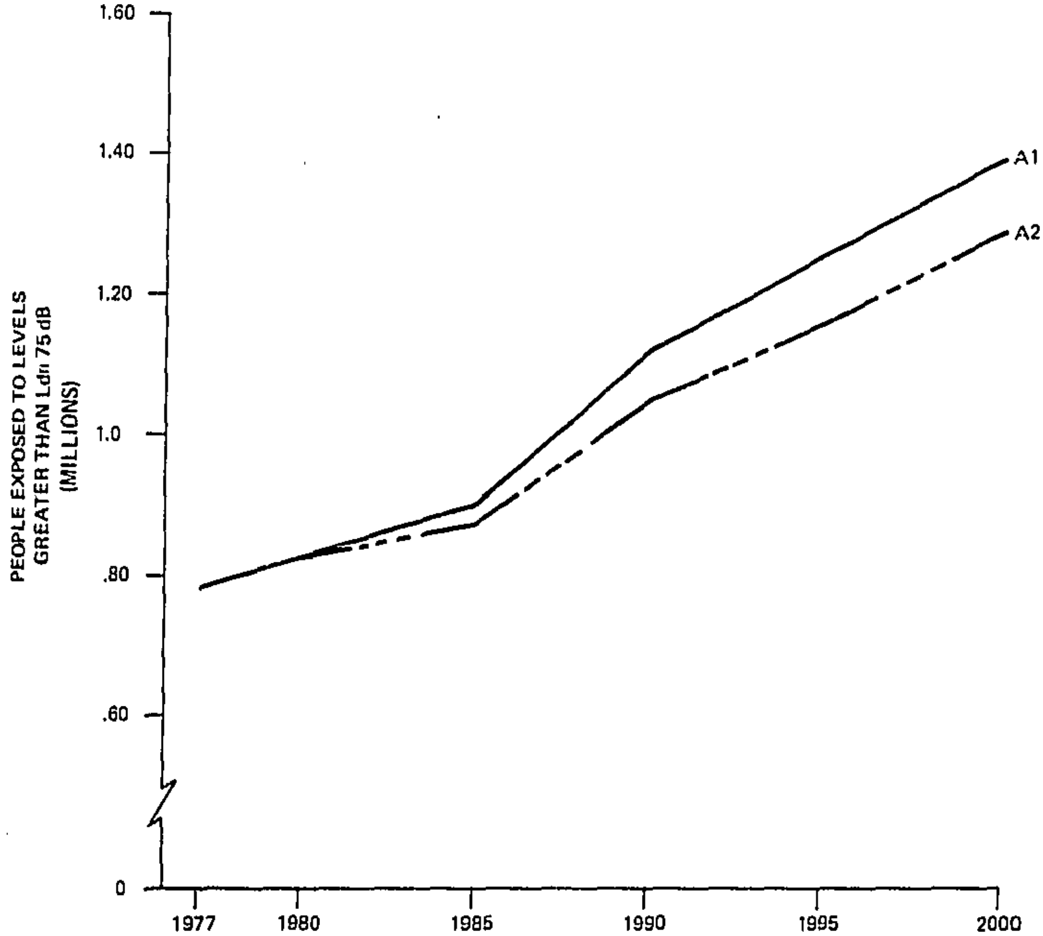
* The Wyle Laboratories' "REGIM" model was used, since at the time the simulations were processed this was the most up-to-date model available for simulation purposes. This conservative estimate implies that noise emitted from light vehicles in the year 2000 will be like levels currently emitted, except for vehicle population growth adjustments. Due to increased sales of vehicles with 4-cylinder and diesel engines, noise emissions could increase so that the number of people exposed to Ldn 65 dB and over could increase by as much as 41% between 1978 and the year 2000.

** Projections using the Wyle Laboratories' "REGIM" model. See discussion above regarding a more refined EPA model now under development.

Figure I-2
NOISE EXPOSURE TO HIGHWAY VEHICLES
(Over $L_{dn}$ 75 dB)

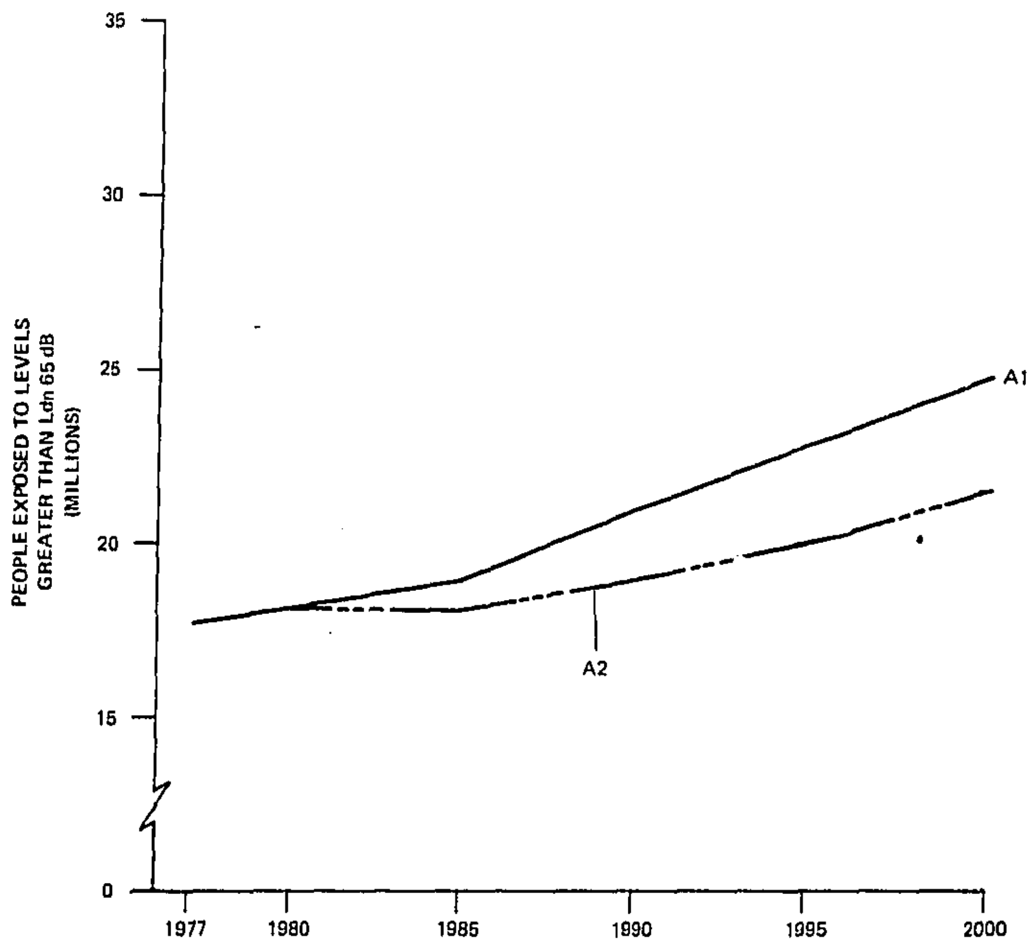



SOURCE: WYLE LABORATORIES (PLOTKIN 12/1/77)

——— A1 – BASELINE FOR ALL HIGHWAY VEHICLES WITH GM SCENARIO, WITHOUT 1985 75 dB TRUCK REGULATIONS

– – – A2 – BASELINE FOR ALL HIGHWAY VEHICLES WITH LIGHT VEHICLE (LV) FROZEN MIX AND LEVELS

Figure I-3
NOISE EXPOSURE FROM HIGHWAY VEHICLES
(Over $L_{dn}$ 65 dB)




SOURCE: WYLE LABORATORIES (PLOTKIN 12/1/77)

A1 – BASELINE FOR ALL HIGHWAY VEHICLES WITH GM SCENARIO, WITHOUT 1985 75 dB TRUCK REGULATIONS

A2 – BASELINE FOR ALL HIGHWAY VEHICLES WITH LIGHT VEHICLE (LV) FROZEN MIX AND LEVELS

Ldn 75 dB are used throughout this study to exemplify noise exposure trends and to test the effectiveness of particular noise abatement controls. This approach conforms with the following quantified initial goals listed in the National Strategy:

- To take all practical steps to eliminate hearing loss resulting from noise exposure
- To reduce environmental noise exposure to an Ldn of no more than 75 dB immediately
- To reduce noise exposure levels to Ldn 65 dB by vigorous regulatory and planning actions
- To strive for an eventual reduction of noise levels to an Ldn of noise levels to an Ldn of 55 dB.

These goals should not, however, be construed as levels satisfactory to EPA. The Levels Document[4] explicitly states that indoor activities can be disrupted by noise levels in excess of Ldn 45 dB. Consequently, the LWP is merely an indicator.

## 4. NUMBER OF VEHICLES

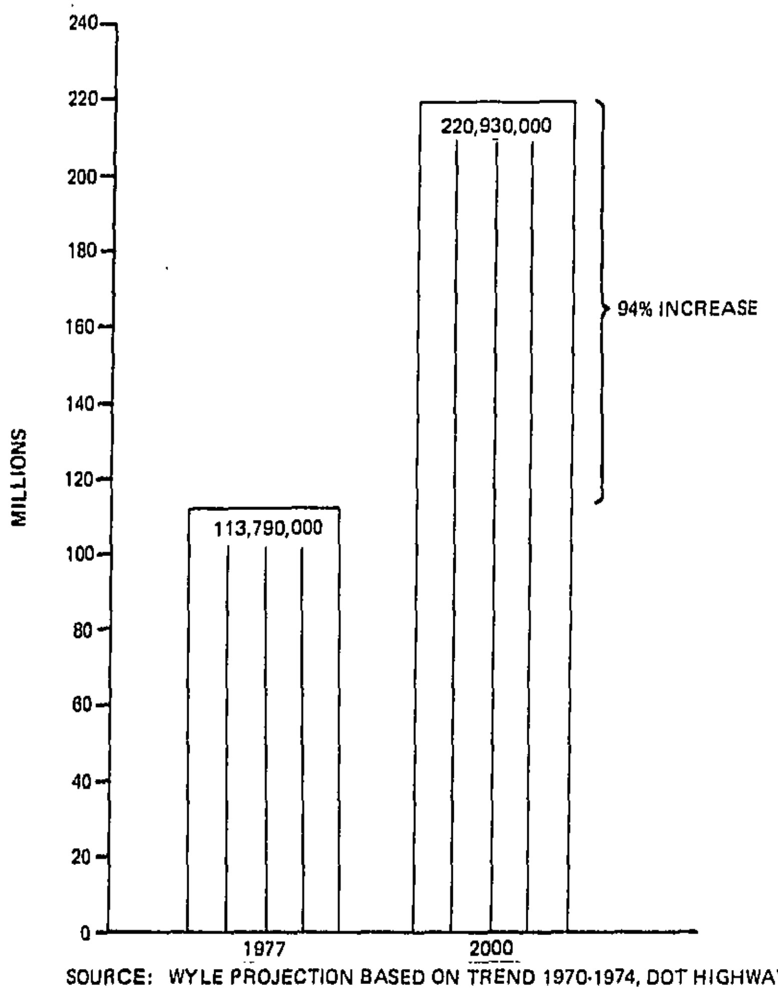
In addition to population growth, an important factor substantially contributing to increased population noise exposure is the anticipated growth in the number of vehicles. As shown in Figure I-4, light vehicles are expected to increase by about 94 percent between 1977 and 2000, from over 113 million to over 220 million units. Medium and heavy duty trucks are expected to increase from over 5 million to over 7 million (about 36 percent) (Figure I-5). The number of buses produced is projected to increase by about 40 percent between 1977 and the year 2000. This figure includes school, transit, and intercity buses. Motorcycles, which exceed 5 million today, are expected to more than double by the year 2000.* Snowmobiles are expected to increase only slightly from the estimated 1.5 million in 1977.

## 5. VEHICLE NOISE EMISSION

There are few economic reasons why producers of either trucks or light vehicles would reduce noise emission. A user might demand clutched fans, radial tires, and turbocharged diesel engines instead of

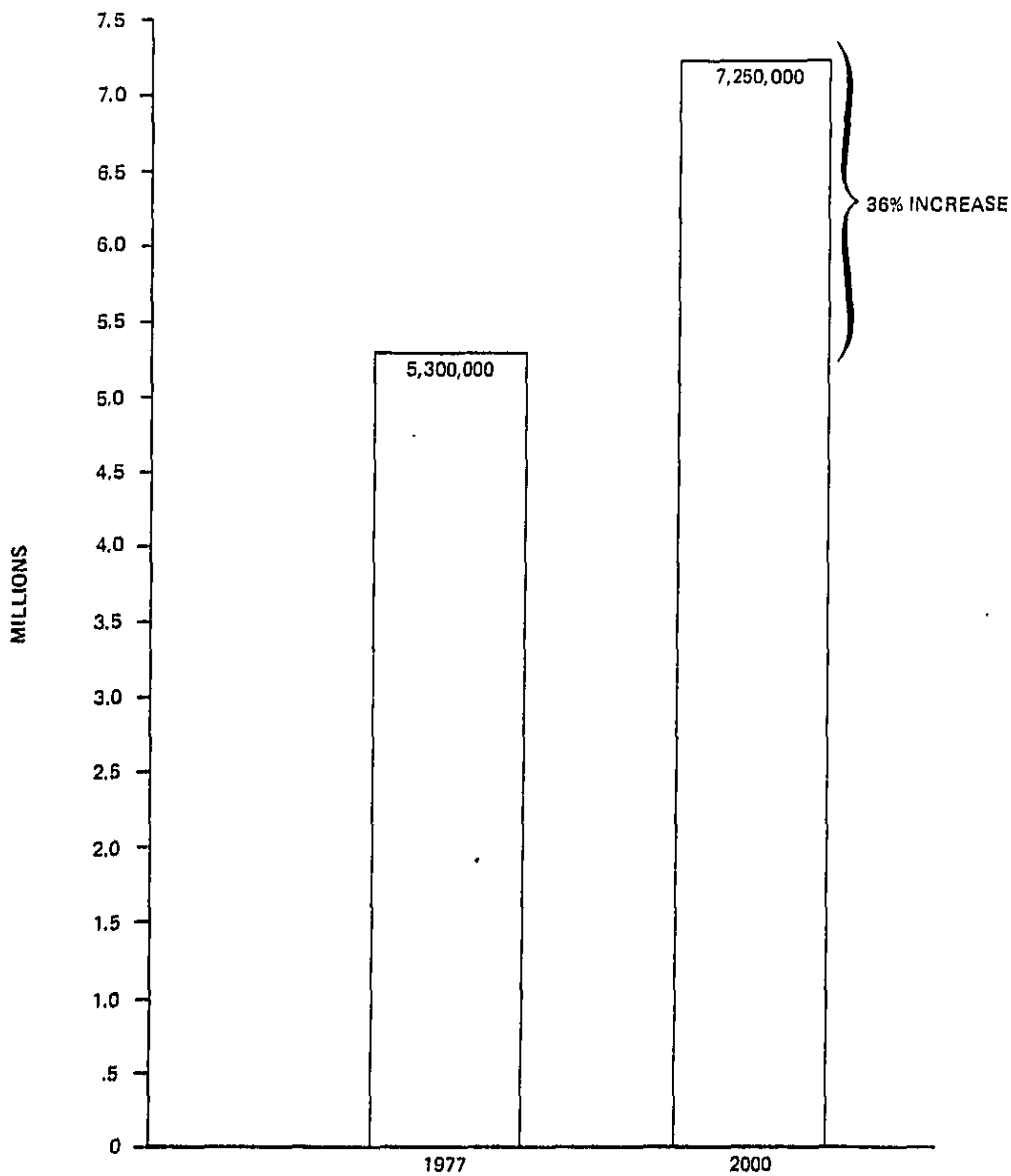
* Wyle Laboratories estimates based on motorcycle registration trends.

Figure I-4
CURRENT AND PROJECTED NUMBER
of LIGHT VEHICLES




SOURCE: WYLE PROJECTION BASED ON TREND 1970-1974, DOT HIGHWAY STATISTICS.

Figure I-5
CURRENT AND PROJECTED NUMBER
OF MEDIUM AND HEAVY TRUCKS




SOURCE: WYLE PROJECTIONS BASED ON 1970-1974 DOT HIGHWAY STATISTICS.

naturally aspirated diesel engines in order to reduce fuel consumption, which might incidentally lower noise emissions of vehicles so equipped. But the surface transportation noise problem will not be solved in this manner. Many modifications to lower noise would require that the costs be borne by the user, whereas for the most part bystanders suffer the costs. The community, not the owners, are primarily impacted. Moreover, there is no logical reason why a profit-maximizing firm would assume costs to quiet vehicles when it can avoid them.

Current vehicle sound levels range between 86.8 dB for modified motorcycles (energy-average over acceleration, cruise, deceleration, and idle) to 63.4 dB for light vehicles. Regulations to reduce the noise levels of new trucks have been promulgated and regulations to reduce the noise levels of new motorcycles and buses are in the process of being promulgated. These reductions set levels for trucks, motorcycles, and buses under full throttle test procedures at 80 dB, 78 dB, and 77 dB respectively.

The light vehicle noise problem has not, however, been addressed in this manner although State and local government in-use controls have had some success. But the urban noise problem associated with this noise source is, nevertheless, expected to be exacerbated. Among other reasons, V-8 gasoline engine equipped cars are expected to drop from the current 56% of the automobile market to between 18 and 0 percent of the market by 1985. Noisier 4-cylinder gasoline engined automobiles are expected to increase from the current 25% of the automobile market to about 50% of the market and diesel engined automobiles may increase from the current insignificant number to as much as 25% of the market.

Appendix B indicates that the medium and heavy truck drivers' noise dose* in 1977 ranged from 75 dB to 95 dB, with the mode in the 85 to 88 dB range. The mode will also be in the 85 to 88 dB range by the year 2000, with the number of operators in this category increasing from 849,000 in 1977 to over 1,465,000 in year 2000. Even with full compliance to the Bureau of Motor Carrier Safety interior noise standards assumed, the mode and number of operators within this noise interval remains unchanged, and over half a million operators will be exposed to a noise dose of 90 dB or more.

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* The interior level is measured at a standard position adjacent to the driver's right ear, while Leq represents the average of left- and right-ear positions. Truck drivers are allowed to drive 10 hours per day, so that the noise exposure must be based on 10 hours. The noise dose, i.e., the energy-equivalent level over 8 hours which gives the same exposure as the actual Leq over 10 hours, is:

$$\begin{aligned}\text{Noise Dose} &= \text{Leq}(8) + 10 \log_{10} (10/8) \\ &= \text{Leq}(8) + 1 \text{ dB}\end{aligned}$$

Moreover, over 3.4 million drivers/operators will be exposed to a noise dose in excess of 75 dB.[8] Similar shifts are expected in the light truck market. Current 4-cylinder and diesel engined light vehicles are, respectively, approximately 5 db and 7 db noisier during typical part throttle acceleration and 1 dB and 3 dB noiser during cruise than the average current V-8 gasoline engined automobile.[9]

## 6. OPERATOR NOISE EXPOSURE

Today, the average noise exposure level for all bus operators is approximately 84 dB. With regulations proposed by the U.S. EPA, it is expected to drop to about 80 dB by the year 2000.[10] Noise exposure for motorcycle operators is about 90 dB today and expected to drop to 85 dB by the year 2000.[11] Snowmobile operators are currently exposed to between 85 dB and 110 dB.[12] Under existing State and local government regulations the average level of operator exposure is expected to fall as old models are replaced by new ones.

## 7. ENERGY-WEIGHTED PRODUCT DISTRIBUTION (E at 50'; kwh/day)

The national (not urban) energy-weighted product distribution (E),* takes into consideration the number of units, the average hours per day of usage, and the approximate A-weighted noise power (watts). In 1977 medium and heavy trucks ranked first. Although the percent drops in the year 2000, trucks will still remain in first place, while light vehicles' share is expected to increase. (See Appendix A.) Motorcycles will drop in importance along with the bus share. The snowmobile share, however, is expected to remain relatively stable.**

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* $E = 10^{-13} N \cdot T \cdot W_a$
E = Kilowatt hours/day

where N = total hours of units
T = average hours per day usage
$W_a$ = approximate A-weighted noise power, watts

$$10 \log \frac{W_a}{10^{-13}} = L_A + 20 \log R_o + 7.5 \text{ dB ref } 10^{-13} \text{ watts}$$

Where $L_A$ = typical A-weighted noise level in db(A) @ reference distance $R_o$ (ft)

** Computations based on data developed for the $L_A$ @ 50' (previously covered) and from Wyle Laboratories data.

8. LEVEL WEIGHTED POPULATION (LWP) FOR GENERAL ADVERSE RESPONSE

The impact of noise may be described in terms of both extensiveness (the number of people impacted) and intensiveness (the severity of impact). The fractional impact method explicity accounts for both the extent and severity of impact.

Noise exposure may be expressed in terms of Fractional Impact (FI). A FI of 1.0 represents an impact of 100 percent, in accordance with the following formula:

$$FI = .05\ (L-55) \quad \text{for } L > 55$$

$$FI = 0 \quad \text{for } L \leq 55$$

where L is the observed or measured Ldn for the environmental noise. Note that FI can exceed unity for exposures greater than Ldn = 75 dB.

The Level Weighted Population (LWP) associated with a given level of noise (Ldn) may be assessed by multiplying the number of people exposed to that level of noise by the fractional impact associated with the level as follows:

$$LWP = (FI)P$$

where LWP is the magnitude of the impact on the population exposed to the noise (Ldn) and is numerically equal to the number of people who would be 100 percent impacted. FI is the fractional impact associated with the level of (Ldn) and P is the population exposed to this level of noise. To illustrate this concept, if there are 1000 people living in an area where the noise level exceeds the criterion level by 5 dB (and are thus considered to be 25 percent impacted, FI = 0.25), the level weighted population for this group is the same as for 250 people who are 100 percent impacted (1000 X 25% = 250 X 100%).[14]

The value of Ldn for each exposed population depends on the geometry and it is calculated from a model. Other parameters which influence the LWP are usage of the product and those products around it. For instance, motor vehicles are part of a traffic noise mix which consists of trucks, light vehicles, buses, and motorcycles. For the purpose of strategy formulation, the LWP reduction directly attributable to a specific control is isolated. This is done by determining the LWP with the product present in the traffic mix and subtracting from it the LWP after the control is imposed.

The Wyle Laboratories' "REGIM" model, referenced earlier, projected the LWP for highway vehicles, of which medium and heavy trucks are the most significant contributors. The LWP attributable to trucks was about 33.3 million in 1977. With existing regulations it would increase to over 45.7 million in the year 2000—a 37% increase. (See Appendix C.) This higher projection takes into consideration population growth and a fleet mix containing more small cars, discussed earlier. It does not consider all details incorporated into the EPA model presently under review. Without the change in fleet mix, the "REGIM" model predicted a low-range LWP growth from 33.3 million in 1977 to only 40.7 million in the year 2000—a 22.2% increase. The actual change in LWP between 1977 and 2000 is likely to be between the 22.2% (low estimate) and the 37.2%, tending toward the high estimate if the light vehicle mix changes as discussed earlier. The EPA model starts at a higher (41.77 million) LWP level in 1977 for reasons elaborated in the previous discussion, and predicts a 29.7% change between 1985 and 2000. The percent change corresponds closely to the estimates derived from the "REGIM" model for that time period—27.7%.

The surface transportation substrategy is primarily concerned with simulating the effectiveness of noise abatement controls in order to select an array of effective controls to be analyzed with respect to various selection criteria (contained in Section III of this paper). In many instances it would not matter which model is used. The "REGIM" model is in place and has been used in the preliminary stages of the substrategy work, which makes it attractive for continued use. When the EPA model is finalized and when particular noise controls are simulated that would require the kind of details provided by the EPA model, an effort will be made to utilize it. To limit the costs of modeling we would not plan routine duplication of the results shown here, once the EPA model is finalized. We plan to use it instead for detailed analysis of some problem areas where the more complex model will have advantages. Likewise, it should suffice to use the high baseline estimates of the "REGIM" model when the relative effectiveness of a control is appraised.

The LWP descriptor is augmented by several variations because the LWP for general adverse response does not describe the harmful effects of noise adequately under certain situations. For example, people are exposed to bus noise in a variety of situations—inside a home or office, around the home (outside), as a pedestrian, as a bus operator, or as a bus passenger. The equivalent noise level measured by Ldn and converted to LWP does not adequately describe the annoyance perceived by bus passengers. Annoyance frequently depends on the activity and location of the individual and the equivalent noise level tends to average out the disruptive and annoying peak noise levels experienced by a single bus passby. The LWP attributed to buses presently amounts to less than one million per day and is expected to remain below one million to the year 2000.[15] Therefore, additional descriptors are needed to quantify the undesirable effects of intruding bus passby noise levels. Such noises may be evaluated in terms of community sleep disturbance, speech interference, and community and operator/rider hearing loss.

Generally the same applies to motorcycles and snowmobiles. Nevertheless, the general annoyance LWP is relatively substantial for motorcycles—almost 3 million in 1977 and over 4 million projected for the year 2000.[16] For snowmobiles it was less than one million in 1977; it is not expected to exceed one million by the year 2000.*[17,18]

## 9. LEVEL WEIGHTED POPULATION FOR HEARING LOSS DAMAGE (LWPH)

The measure of the amount (extent and severity) of hearing loss suffered by the public as a result of a given product is the level weighted population for hearing loss. Each unit of LWPH represents one person undergoing a 1 dB hearing loss (Noise Induced Permanent Threshold Shift) over a 40-year exposure period, averaged over the 500, 1000, 2000, and 4000 Hertz frequency bands--a person-decibel of hearing loss. If a population (P) is exposed to an annualized equivalent noise level of Leq(24) every day, then their LWP is found from

$$LWPH = 0.025\ (Leq(24) - 70)^2\ P.$$

In determining LWPH for each product, a mathematical model is used to derive the number of people exposed and the respective noise levels.** The LWPH for medium and heavy trucks and light vehicles, excluding operator/rider exposure, approximated 1.9 million in 1977 and is expected to reach about 3 million in the year 2000.*** With driver/operator exposure the numbers increase about five-fold.[19] (See Appendix B for details.)

Without considering population and product growth the hearing loss LWPH for buses is estimated between 3 and 4 million in 1977 as well as in the year 2000. Including population growth considerations, the hearing loss LWP from buses is estimated to increase only slightly.†

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* Note that all LWP's are underestimating the potential effects because these calculations do not provide for product population and people growth. In this manner, the sensitivity of controls can be simulated without introducing the uncertain population growth (product and people) factors.

** Calculations from data in EPA's Proposed Bus Noise Emission Regulation.

*** Computed by applying LWPH formula to data collected with the Wyle "REGIM" model. For details of assumptions see earlier discussion regarding the "REGIM" model.

† Calculated from data in U.S. EPA's Proposed Bus Noise Emission Regulation, Sec. 6.

For motorcycles the hearing loss LWP including operator/rider exposure without population growth considerations was estimated to be between 15 and 16 million LWP in 1977 and to hold steady toward the year 2000. If population growth were also considered, the hearing loss LWP would increase from 15 to about 18 million.[20]

The hearing loss LWP for snowmobiles is expected to fall from about 5 million in 1977 to around 3 million in the year 2000, including operator/rider exposure because new snowmobiles are made quieter.[21]

The LWP estimates are used here only to indicate the severity of the noise problem. In order to simulate the effectiveness of controls, however, the LWP for general adverse response will be used in the remainder of this paper (along with the number of people exposed to Ldn over 55 dB, 65 dB, and 75 dB) unless the control is aimed directly toward operator/passenger noise abatement.

## 10. LEVEL WEIGHTED POPULATION FOR SLEEP INTERFERENCE (LWPS)

The LWP for sleep interference represents the equivalent number of potential sleep awakenings per night due to the product. Calculation of this LWPS is accomplished using a model which portrays the usage pattern of the product at night and its proximity to the people being awakened. Other key parameters are the sound level and duration of the product's noise signature.

The sleep interference LWP for buses remains between 30 and 31 million in the time period covering 1977 to the year 2000, given no increases in the population. If we include population growth, the sleep interference LWP is estimated to be around 36 million.*

The motorcycle sleep interference LWP is expected to remain at less than one million for the entire 1977-2000 time period, assuming no population growth. If population growth were included, it would not be altered significantly.*

For snowmobiles the sleep interference LWP today (on a daily basis) is negligible and is expected to remain so by the year 2000.[22]

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* Computed by applying LWPH formula to data calculated with the Wyle "REGIM" model. For details of assumptions see earlier discussion regarding the "REGIM" model.

11. LEVEL WEIGHTED POPULATION FOR SPEECH COMMUNICATION INTERFERENCE (LWPC)

Noise often disturbs people when they are engaged in conversation, watching television, or listening to music. In addition to disturbances in their homes, speech interference occurs when people are in their yards or walking along the street. Those noise occurrences which cause speech interference are similar to one causing sleep interferences, but the speech interference events occur primarily during the day. The appropriate noise metric for speech interference is calculated in a manner similar to that for general adverse response and it represents the equivalent number of potential disruptions of speech per day due to the noise source.

The speech interference LWP from buses between 1977 and the year 2000 is expected to hover around the 15 to 16 million mark, assuming no population growth. Including population growth, the respective LWPC is expected to increase from this level to over 17 million.**

The speech interference LWP for motorcycles is expected to hover between 1 and 2 million LWPC, during the 1977-2000 time frame when no population growth is introduced into the calculations. When population growth is included in the calculations, the respective LWPC is expected to increase to slightly above 2 million by the year 2000.***

The speech interference LWP for snowmobiles, on a daily basis with and without the population grwoth scenario, is negligible.[23]

12. U.S. SURFACE TRANSPORTATION PROBLEM: SUMMARY COMMENT

The preceding discussion clearly demonstrated that noise associated with the operation of surface vehicles is a problem now and will continue to be a problem by the year 2000. In fact, the problem will increase between now and the year 2000.

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* Calculated from data in U.S. EPA's Proposed Bus Noise Emission Regulations, Sec. 6.

** Computed by applying LWPH formula to data collected with the Wyle "REGIM" model. For details of assumptions see earlier discussion regarding the "REGIM" model.

*** Calculated from data in EPA's Proposed Bus Noise Emission Regulations, Sec. 6.

In the next section of this paper, Section II, an attempt will be made to seek out controls that could be employed to address this growing problem. In Section III of this paper these controls will be subjected to a range of criteria in order to choose the preferred controls.

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6 U.S. Environmental Protection Agency, State and Municipal Noise Control Activities, 1973-1974, January 1976, pp. 9-19.

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10. Wyle Laboratories, Noise Emission Standard for Buses, Report No. WR 76-21 for U.S. Environmental Protection Agency, October 1976.

11. U.S. Environmental Protection Agency, Proposed Motorcycle Noise Emission Regulations—Background Document, EPA 550/9-77-203, November 1977, pp. 5-80.

12. Cambridge Collaborative, Technology Study of Snowmobile Noise, for U.S. Environmental Protection Agency, July 1977, p. 28.

13. Wyle Laboratories, Transporation Noise and Noise from Equipment Powered by Combustion Engine, for U.S. Environmental Protection Agency, No. NTID 300.13, December 1971.

14. U.S. Environmental Protection Agency, Information in Support of the Proposed Regulation for Truck-Mounted Solid Waste Compactors, EPA 550/9-77-204, August 1977, pp. 5-31.

15. U.S. Environmental Protection Agency, Proposed Bus Noise Emissions Regulations, August 1977, Section 6.

16. Proposed Motorcycle Noise Emission Regulations: Background Document, Chapter 5.

17. Ibid.

18. Richard E. Burke, Health and Welfare Impact of Snowmobile Noise, Wyle Laboratories, July 1977.

19. Plotkin memorandum.

20. Proposed Motorcycle Noise Emission Regulations: Background Document, Chapter 5.

21. Cambridge Collaborative, Technology Study of Snowmobile Noise at the Operator's Ear, for U.S. Environmental Protection Agency, July 1977.

22. Richard E. Burke, Health and Welfare Impacts of Snowmobile Noise Regulation, Wyle Laboratories for U.S. Environmental Protection Agency, July 1977.

23. Ibid.

## II. CONTROL CHOICES

# II. CONTROL CHOICES

This section of the surface transportation substrategy consists of four parts. Part 1 discusses the availability of data and the effect it has on isolating effective controls. Part 2 is devoted to a discussion of a range of controls that will be considered. Part 3 discusses the methodology employed to isolate effective controls. Part 4 presents the results of simulations, using the methodology described in Part 3.

## 1. DATA DISCUSSION

To address the U.S. noise problem at all it is necessary to have minimum amounts of relevant data. Additional data would be helpful in choosing the more effective controls from among the many possibilities.

To answer the main question, "Why bother to abate noise?" it should be ascertained whether or not noise adversely affects the well-being of the population. That noise today is a major problem and that it will be a growing problem in future years with respect to the number of people adversely impacted has been demonstrated.

Will the noise problem go away if we ignore it? Our best indications to date are that the answer is no. Among the reasons are:

- The U.S. populations is expected to continue to grow.
- The U.S. population concentration is expected to grow.
- The product population emitting the noise is expected to grow.
- Insufficient incentives exist to reduce exposure, especially since "bystanders" suffer the primary impact.
- In the absence of government intervention incentives are strong for some products to become noiser.
- The U.S. population is not adequately informed regarding the physical and nonphysical effects of noise, including mental, economic, and social.
- The U.S population is inadequately informed regarding the options open to them in dealing with excessive noise, specifically source controls, path controls, and receiver controls.

Concluding that solutions to the noise problem have to be initiated somehow and somewhere, the question remains how, where, and when. To methodically answer these questions so that "optimal" solutions to the noise problem can be formulated necessitates a host of data. These data are present in various states of completion. Other data need to be accumulated. None of the data described below are in such stage of refinement that no additional data is desirable. Data is sought in the following areas (see Figure II-1) in order to complete an analysis of noise exposure:

- Current and projected product population information associated with noise. In the surface transportation area we should include:
  - Medium/Heavy Trucks
  - Light Vehicles
  - Buses
  - Motorcycles
  - Snowmobiles
  - Other Vehicles
- The relative contribution of specific products to the overall sound energy emitted
- The total daily exposure of individuals by occupations, general activity patterns, geographic locations, specific tasks, etc.
- The portion of total exposure attributed to particular sources of noise
- The type of exposure:
  - Ambient
  - Single event
- Particular health effects associated with noise exposure, such as stress
- Source information on:
  - Sound levels
  - Operational cycles
  - Ambient noise environment
  - Available technology for noise abatement

FIG

DATA VOIDS AND AREAS OF APPLICAT

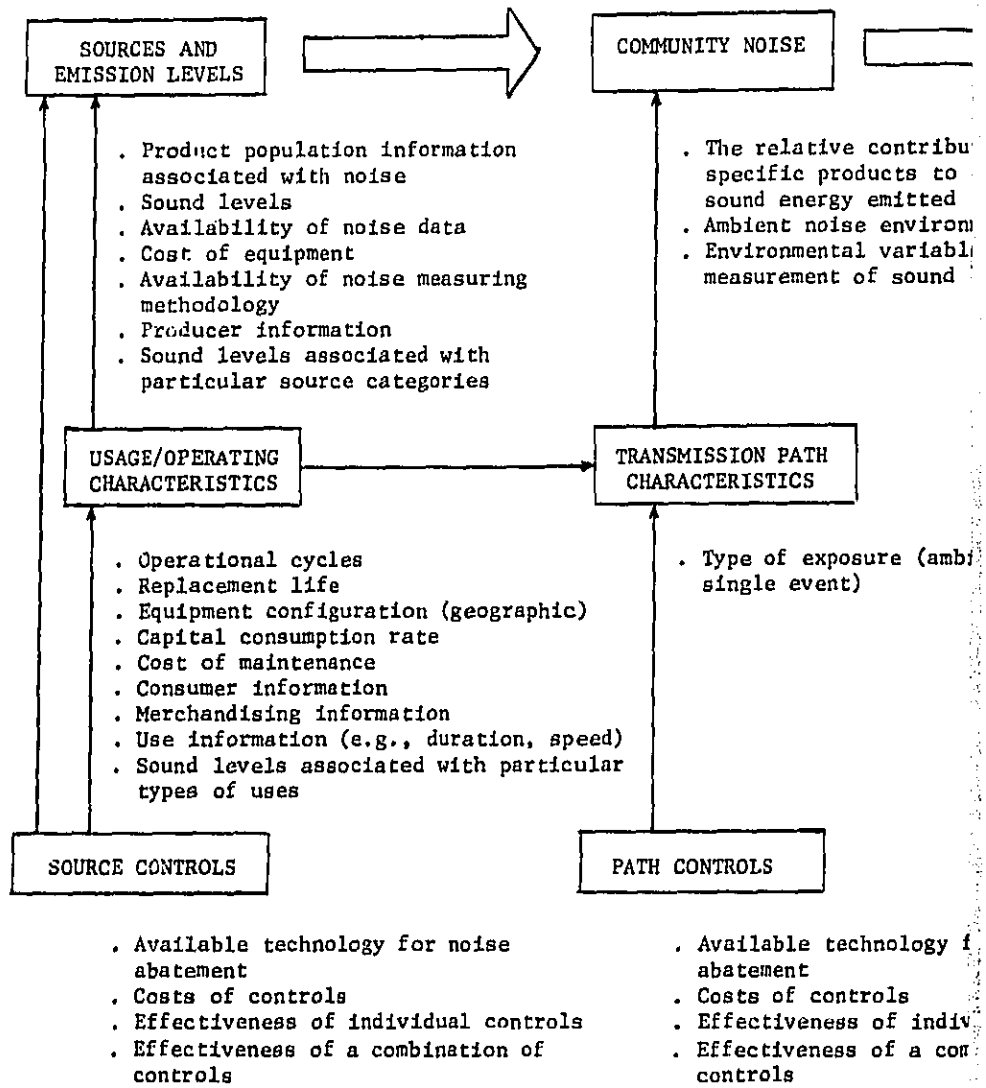
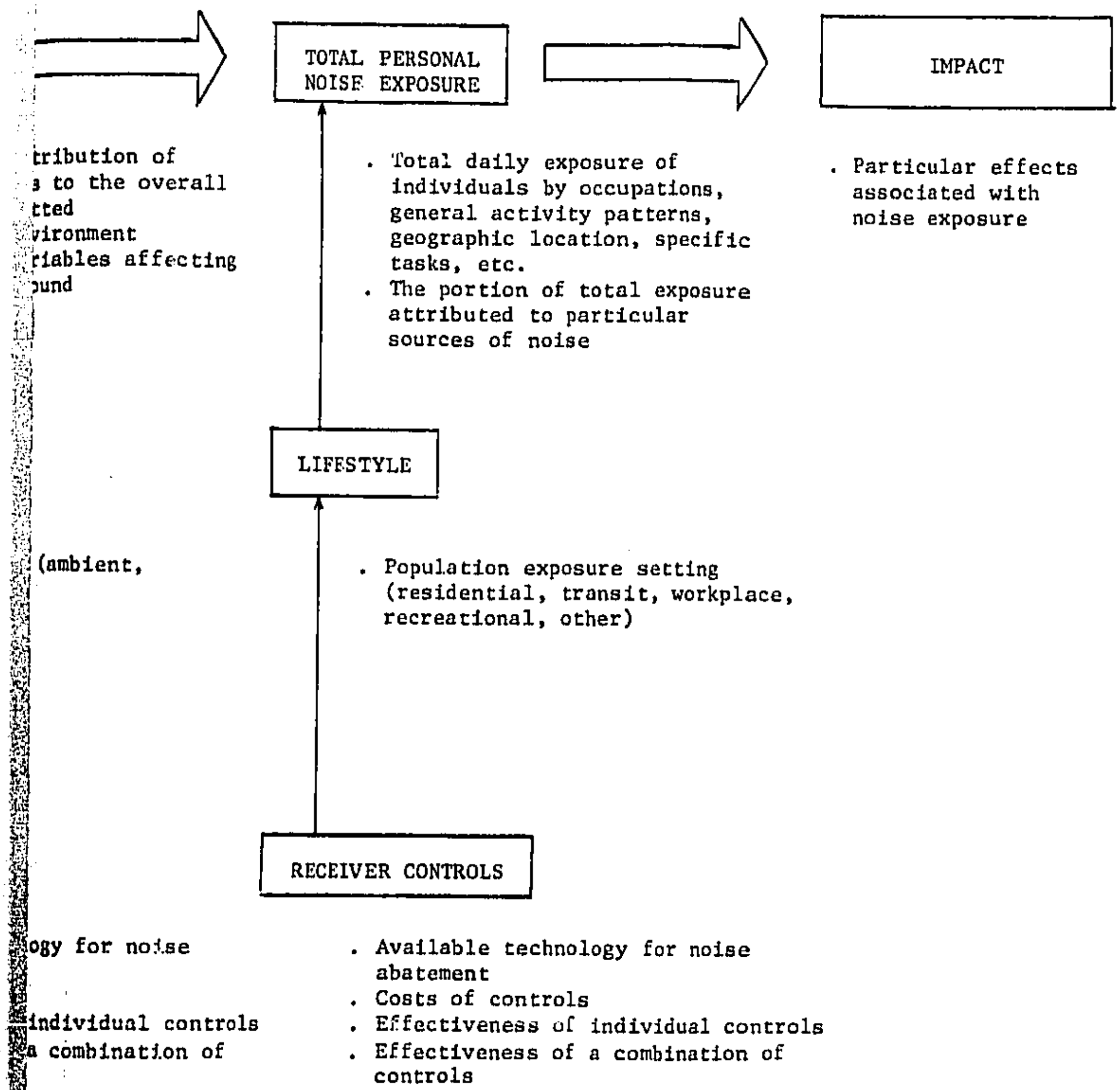


FIGURE II-1

LICATION BETWEEN NOISE SOURCES AND IMPACTS



- Replacement life
- Equipment configuration (geographic)
- Capital consumption rate
- Cost of equipment and maintenance
- Noise measuring methodology
- Consumer demand
- Producer supply and market structure
- Merchandising information
- Use information (ranging from duration to speed)
- Sound levels associated with particular source classes
- Sound levels associated with particular types of use (for example, with regard to surface transportation, information regarding the type of roadway, speeds, road surface, stop/go patterns, acceleration/deceleration, and geographic areas)
- Environmental variables affecting measurement of sound

. Population exposure setting

  - Residential
  - Transit
  - Workplace
  - Recreational
  - Other settings

. Effectiveness of selective controls designed to reduce noise

. Noise reduction effectiveness of a combination of controls

. Cost of individual controls and combinations of controls.

EPA's noise program is relatively new, started formally by the "Noise Control Act of 1972." Consequently, data needs listed here are not complete. However, within time-, resource-, and available literature-constraints, every attempt has been made to address the data needs. Nevertheless, every data category in the preceding discussion needs to be strengthened.

The question to be answered at this point is, "Do we have a sufficient amount of data available to suggest products that should be considered for noise abatement by the U.S. population?" The answer to this question is yes. There is sufficient exposure, product noise emission, and attitudinal data available to suggest that surface transportation sources contribute to a noisy environment that jeopardizes the health and welfare of the U.S. population. This was specified in the Levels Document.[1]

The next question, however, which cannot be answered affirmatively, is, "Do we have enough information to solve the surface transportation problem in an optimal manner, with respect to cost effectiveness, for every community?" The data is incomplete.

Should we proceed to control noise despite the incompleteness of data, or should we refrain from doing anything about noise until all data gaps are filled? Before answering this question we should again point out that if the U.S. population fails to address the noise problem, the number of people exposed to unacceptably high levels of noise will continue to increase. On the other hand, even without complete information, it is possible that a suboptimal mixture of controls could be utilized. We must proceed with a noise abatement plan despite limited data. The "Noise Control Act of 1972" states that "Congress declares that it is the policy of the United States to promote an environment for all Americans free from noise that jeopardizes their health and welfare."[2] It does not specify that the approach to noise abatement must be optimal. It is the intent of the U.S. EPA, however, to constantly consider cost with respect to benefits (cost effectiveness) and to avoid unnecessary costs. Alternatively stated, any control that does not yield benefits to cover the dissatisfaction of the associated money costs should not be instituted. To encourage the latter, Federal Government regulatory actions require that public hearings be held. In fact, the Noise Control Act of 1972 specifies that:

> "Any regulation prescribed under subsection (a) or (b) of this section (and any revision thereof) respecting a product shall include a noise emission standard which shall set limits on noise emissions from such product and shall be a standard which in the Administrator's judgment, based on criteria published under section 5, is requisite to protect the public health and welfare, taking into account the magnitude and conditions of use of such product (alone or in combination with other noise sources), the degree of noise reduction achievable through the application of the best available technology, and the cost of compliance."[3]

Likewise, on the State and local government level similar considerations are necessary in the rulemaking process.

It is felt, however, that a continuous effort should be made to fill the relevant data voids so that the national anti-noise activities can be fine-tuned in order to arrive at the largest net yield—benefits from noise abatement vs. adverse impacts resulting from such activities. If this implies major directional changes, national programs should be flexible enough to adjust accordingly. For example, if it becomes evident that the private sector can take care of a noise problem and that government intervention is no longer required, assuming no significant cost changes per unit of benefits, respective government agencies should be prepared to bow out and the private sector should be prepared to act. Conversely, when warranted, any sector in the nation (including the public sector) should be prepared to commit its resources and talents toward reducing noise when necessary.

## 2. RANGE OF CONTROLS

Noise that reaches the operators and passengers of motor vehicles, as well as "bystanders" (people other than operators and passengers), can in many cases be reduced by:

- Source Controls—addressing the source of the noise directly
- Path Controls—interfering with the path of the noise
- Receiver Controls—methods at the receiver end to avoid exposure
- A combination of these approaches.

If costs to quiet sources were zero, and path control and receiver control methods did not have negative costs, the source control method would be most attractive on equity grounds. Unfortunately, this is not the likely case. Consequently, to maximize the cost effectiveness of "controls," source controls, path controls, and receiver controls must all be considered.

### (1) Source Controls

To reduce noise from current levels at the source, the country has several options available. Some examples are:

- New product emission regulations
- In-use controls

- Noise emission information (incuding labeling and other types of consumer and producer noise information)
- Noise reduction innovations (technology)
- Other methods, including financial incentives and disincentives.

### 1. New Product Emission Regulations

New product emission regulations are currently utilized by all levels of government—local, State, and Federal. Federal regulations are generally uniformly applicable, while State and local regulations may vary at any one time from jurisdiction to jurisdiction. With respect to reducing the increase in noise exposure in a timely manner, regulations aimed at the manufacturing level are especially effective when the product is replaced before the noise reduction devices of the products deteriorate, the fleet is replaced in a relatively short period of time, few economic and noneconomic incentives exist to tamper with regulated products, and the regulation applies to replacement parts that influence the noise signature of the product in which they are incorporated. This type of control is difficult to enforce by the private sector—nongovernment manufacturers, users, middlemen (and organizations of the same)—even though trade associations and labor unions, among others, could exercise a regulatory type of control. The incentives to do so are not strong, however, or are even lacking, especially if government regulations are preemptive.

### 2. In-Use Controls

Within limits of a "not to exceed regulation," noise exposure of people can be mitigated by in-use controls exercised by the private and public sector. Private sector options include user acceleration and deceleration choices, shifting and RPM options, tire pressure, hours of operation, rerouting, speed options, lane options, in-vehicle entertainment choices, and alternate vehicle use options.

The public sector (Federal, State, local and foreign governments) can, to some extent, require some of the above options and with proper enforcement assure a high degree of compliance with mandatory in-use controls. All levels of government can assist in motivating operators to utilize available in-use controls. Moreover, governments at all levels operate or fund the operation of a multitude of vehicles that can be subjected to in-use controls. In addition, other quieter systems alternatives such as mass transit can be encouraged by the private sector.

Several options that directly or indirectly facilitate in-use controls can generally be employed by the public sector. Direct options include public road and road surface modifications, zoning ordinances, required lane use, speed limits, and traffic flow controls. Options indirectly affecting in-use controls include, among other things, emission charges (assessing the user directly through licensing fees or through taxing new vehicles according to the environmental damage they are expected to cause). Another alternative is to incorporate charges into State-approved insurance rate structures and auto finance interest rates.

3. <u>Product Noise Information</u>

Information regarding the noise characteristics of products can be made available to the purchaser with or without government involvement, so that the purchaser is afforded the opportunity to incorporate noise into his demand decisions. Noise information without government involvement can be made available by producers, sellers, or trade associations in print or by voice, with information attached or detached from the product. Such information might also be combined with cost data and health impact data. Likewise, government at all levels can either require that this information be provided or provide the information independently. Another alternative would be for the government, at any level, to provide assistance, ranging from technical information to guidelines or even standards, in the dissemination of such information.

4. Technology/Innovations

Applied technology—innovations—can likewise be utilized by the private or the public sector to reduce the noise emitted from particular products. When profitable, the private sector will apply quieting technology without government intervention, as is the case with quieting the interiors of cars. When the impact of noise affects primarily third parties, such profit motivation will generally be lacking and government intervention might be the only solution to the problem.

Government can intervene indirectly by providing fiscal incentives for innovations like EPA's Low Noise Emission Products (LNEP) Program, tax credits, special capital consumption allowances, or emission charges. More direct forms of intervention include basic research carried out by government, the installation of mechanisms to transform inventions into innovations, government procurement policies providing for best current and/or available technology, government dissemination of technical/economic information and technical assistance, or earmarking grants and other government assistance with noise specifications.

5. Other Methods

The private and public sectors can use a host of other source control methods. Examples of those that could be used by the private sector are: noise oriented maintenance programs, retrofitting of equipment as new technology becomes available, choosing quieter equipment when a range of choices exists, choosing quiet processes when alternatives are available, installation of temporary noise abatement devices when equipment is used where it would likely affect a large number of people, administrative controls (hours of operation), etc.

Government at all levels also has a variety of source control methods available. Some, like tax incentives and the LNEP program, were already mentioned under specific source controls, but they are also applicable as more general source control methods. In other words, the LNEP program may stimulate the application of technology, but at the same time the program could be used to stress the use of current low noise technology. Specifically, the Federal Government, as well as State and local governments, could consider noise signatures of equipment when setting use fees and road use taxes. Moreover, workman's compensation insurance premium rates for employers using noisy equipment could be adjusted in accordance with actual compensation for hearing loss claims related to noise.

Governments at all levels could also assist one another by exchanging source control information and disseminating it to the public.

(2) Path Controls

Barriers are the primary path control mechanisms. They can, of course, be constructed by both the private and the public sectors. An example of public sector construction would be a noise barrier constructed along a highway on government right-of-way. Examples of private sector construction would be a barrier installed by a railroad company near retarders in a switching yard and when area residents organize to construct berms.*

Barriers are constructed of various types of materials including fill dirt (including recessed highways), metal, wood, concrete, plants, trees, and hedges.[5,6]

While other methods of controlling noise could be considered path controls, like land use and home insulation, they are discussed under receiver controls because the receiver has the opportunity to institute the controls and they are generally physically closer to the receiver than the source.

(3) Receiver Controls

1. Land Use

Land use is generally associated with zoning and path controls, but insofar as it involves discretionary use within a particular zone, the private sector can determine land use along with the public sector.

When the noise is relatively site specific, land use can be employed by various levels of government to minimize citizen complaints and/or noise exposure. One of the ways of doing this is to prohibit "encroachment" of residential dwellings through local zoning ordinances. For example, the area around a railroad switching facility might be zoned industrial only. Consequently, no residential dwellings, hospitals, or other dwellings inhabitated by individuals who are most sensitive to noise would be built in such areas.

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* A recent experiment along I-75 in troy, Michigan revealed that 65 homeowners paid between $200 and $1,000 per family to lower highway noise by 7 dB, or about $140 per dB on the average.[4]

Within particular zones, the private sector can make land use decisions that would reduce exposure to noise. For example, rather than building a commercial dwelling next to a highway with a parking lot in the rear, the parking lot could be located in front of the building. The extra distance between the noise source and the dwelling, all other things being equal, would result in lower noise exposure.

2. Insulation

When noise penetrates, or is expected to penetrate, an inhabitated dwelling, insulation can be used to reduce such exposure. Such a program could simply entail the installation of storm windows, or could involve designing a newer structure with wall-, ceiling-, window-, door-, and duct-insulation. Such insulation could be required by local building codes, or it could be voluntary, or it could be encouraged by any government level through methods ranging from fiscal incentives and disincentives to public education.

3. Hearing Protectors

In some instances, hearing protectors (including ear plugs) might be the only method to mitigate noise exposure. This could be voluntary or be required by governmental bodies concerned with health and safety, such as the U.S. Occupational Safety and Health Administration (OSHA).

4. Other Methods

Other methods can be used to lower noise exposure. Buildings can be designed with most windows and doors facing away from outside noise sources. Likewise, outside areas such as patios can be shielded by fences or other devices.

The above mentioned examples of controls could very well be carried out by either the private sector or the public sector. Unless restrained by zoning ordinances, the private sector could exercise most noise isolation options. The public sector could either require adoption of noise path interruptions via building codes or other laws or ordinances, or provide information for the public to act independently. Alternatives to present modes of transportation, like a switch from cars to subways or from trucks to barges, can also be exercised by the public and private sectors.

(4) Concluding Comments on General Control Methods

The aforementioned controls merely constitute a list of major control options. The private sector could exercise the majority of these options, making government intervention, for the most part, unnecessary. If for any reason, ranging from lack of knowledge about the ill effects of noise to the desire not to incur any explicit cost, the private sector does not solve the noise problem, the public sector may be called upon to assist in solving the problem. Before discussing the public and private sector subject further (including the probability that the private sector will not take the initiative), the overall effectiveness of each major control will be analyzed.

## 3. METHODOLOGY TO ISOLATE EFFECTIVE CONTROLS

In order to select a batch of controls that conceivably will retard, halt, or reverse the increase in noise exposures, several scenarios will be simulated with the help of surface transportation noise models in order to indicate the likely effectiveness of selective controls with respect to changes in exposure (using Ldn and LWP descriptors). From the number and types of controls discussed earlier, it can be seen that the number of simulations that could be processed is almost endless. After simulating each control independently we could use various controls in combination with one another and also time phase individual controls and combinations of controls. The final result would be an overwhelming array of possibilities. The cost of such an academic excercise would be astronomical.

A less complicated procedure which should yield much the same in terms of eliminating controls that are relatively ineffective would be to isolate controls that could be imposed with a relatively high probability of success. For example, a control calling for the introduction of a 65 dB heavy truck in 1979 would not be simulated since the likelihood that available technology could be employed is very slim.

The effectiveness of some controls can be approximated easier than others. For example, to assess a new product regulation on a product that does not degrade with respect to sound is relatively easy. Effectiveness appraisal for other controls is more difficult. A case in point is State and local government in-use controls. They have been in use and highly touted as being effective. Many jurisdictions in which they were used second that belief with qualitative case history support. Unfortunately, to date little quantitative work has been done to evaluate and aggregate the exposure benefits. Several projects are currently underway and planned to fill this void. Meanwhile, it would be improper to categorically dismiss as inappropriate in-use controls or other mechanisms for which little empirical data is available. Controls like these will be considered parametrically by simulating the noise emission change of a product, within relevant limits, as well as the resulting population noise exposure change. In this manner some of the controls which may be effective with respect to attaining the goals of the Strategy can be sorted out.

The explicit goals outlined earlier do not specify acceptable standards for single noise events, such as when one motorcycle drives through a relatively quiet neighborhood at 3 a.m. One cannot, however, ignore sources emitting this kind of noise in terms of their overall contribution to outdoor noise (measured with Ldn), even though they are overshadowed by trucks and light vehicles. For example, motorcycles rank highest in percent of urban population highly annoyed,[7] even though they contribute little in terms of the Ldn descriptor, with buses ranking tenth.

If we are to attain a community noise exposure of Ldn less than 65 dB or even Ldn less than 55 dB and an operator/rider exposure of Leq less than 75 dB, we must eliminate noise sources above these levels, including excess noise from motorcycles, buses, and snowmobiles.

(1) Individual Control Simulations

In the proceeding discussion, several of the previously described major noise controls will be simulated with respect to their impact on Ldn (and LWP). With respect to noise sources, the following surface transportation vehicles will be covered separately: medium and heavy trucks, light vehicles, buses, motorcycles, and snowmobiles. It should be noted at this point that a snowmobile is a noise source causing a great deal of concern,[8] even though it is not generally thought of as an urban vehicle (except during snow emergencies). Moreover, operators of these vehicles are exposed to noise at high levels.[9] While the snowmobile is considered by some people as a recreational vehicle, it is considered by others as a major surface transportation mode. Consequently, it will be considered in the surface transportation substrategy.

(2) Regulations

The Noise Control Act of 1972 enabled the Administrator of the U.S. EPA to regulate transportation equipment.[10] This does not necessarily mean that all transportation equipment should be identified for regulatory purposes. To date medium and heavy trucks, buses, and motorcycles have been identified. For medium and heavy trucks a regulation has been promulgated under Section 6 of the Noise Control Act and an in-use regulation under Section 18. The questions that should be raised are: (1) Is the medium and heavy truck regulation (under Section 6) strong enough, or should EPA take another look at the levels with the view of strengthening it? (2) Should EPA proceed with the bus and motorcycle regulations as proposed? (3) Should the snowmobile be considered as a candidate for a new product regulation?

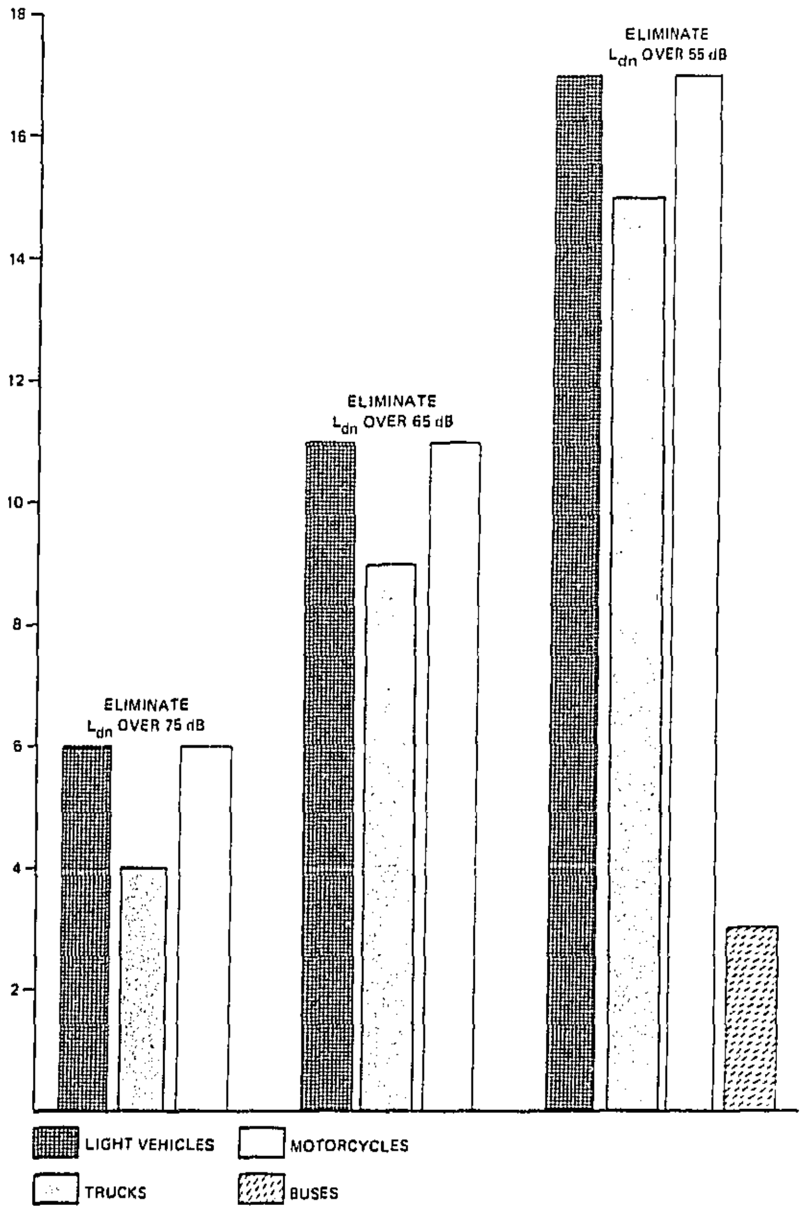
To answer these questions we need, among other things, information regarding the potential effectiveness of various regulatory options as well as the feasibility of attaining various levels. The "other things" will be introduced in Section III of this paper to sift out the most desired controls.

1. Medium and Heavy Truck Regulations

Results of simulations* indicate that (1) new product regulations presently in force on medium and heavy trucks will slow the noise exposure growth from surface transportation; (2) the impact on noise exposure is slow due in part to the long life of trucks; (3) the results, given proper enforcement, are relatively certain; (4) the growth in surface transportation vehicles, given the projected noise signatures and the growth in the U.S. population, will result in an increase between now and the year 2000 in environmental noise exposure, measured at Ldn 55 dB, 65 dB, and 75 dB and LWP (Figure 5-A); and (5) in order to avoid this increase at the Ldn 75 and 65 dB levels by the year 2000, given that trucks were to carry the total burden, a 70 dB medium and heavy truck regulation effective in 1985 would be necessary. Regulatory levels below 70 dB would lower the number of people exposed for each respective Ldn category. Since a great portion of the exposure growth in the Ldn 55 dB or more category is attributed to light vehicles, this regulatory control will not suffice to eliminate noise exposure growth in this category (Figure II-2).

* The "REGIM" model and the EPA model support the same general conclusions.

Figure II-2
FLEET LEVEL REDUCTIONS
TO MEET VARIOUS GOALS




SOURCE: BOOZ, ALLEN AND HAMILTON, WASHINGTON, D.C., JULY, 1978

The regulatory control of medium and heavy trucks must be considered further (see Section III) as a preferred candidate. However, it must be noted that technology constraints make it impossible to attain the goal of eliminating noise exposure to Ldn over 55 dB, 65 dB, and 75 dB by the year 2000, even if we were to assume a 70 dB heavy truck regulation effective in 1985, along with a 60 dB medium truck regulation and a 55 dB light vehicle regulation. In fact, even with these stringent regulations the baseline 1977 exposure is hardly altered (Figure 4).

At the present time we know little about the relationship between external and in-cab truck noise levels. Limited information available[11] indicates that they are associated, raising the possibility of in-cab spillovers from external noise level reductions arising from regulations.

## 2. Light Vehicle Regulations

Regulations applied to light vehicles have the following characteristics:

- They have a minimal effect, at any reasonable regulatory level, on the number of people exposed to environmental noise of Ldn greater than 65 dB or 75 dB.
- The major effect is with regard to the number of people exposed to below Ldn 65 dB, which is often the ambient noise level set by light vehicles.
- The replacement cycle of light vehicles is shorter than for trucks.
- Aftermarket exhaust component replacement options are more numerous than for trucks.

Exposure to Ldn over 75 dB, 65 dB, and 55 dB cannot be eliminated by relying only on light vehicle standards. In fact, one can remove all light vehicles from the traffic stream and still have noise exposures in these categories.

If light vehicles were regulated at the 1977 levels, the difference in the number of people exposed to Ldn over 75 dB in the year 2000 would be negligible, but it would be about 15 percent less at Ldn over 65 and 55 dB. A regulation lowering the expected light vehicle noise levels by 3 dB effective in 1985 would likewise have a negligible effect on the number of people exposed to Ldn over 75 dB. It would, however, decrease the number of people exposed to Ldn over 65 and 55 dB by about 25 percent. (See Appendix C.)

A strong light vehicle regulation used in conjunction with a strong medium and heavy truck regulation would yield larger benefits. For example, a 65 dB light vehicle regulation effective in 1985 would, by the year 2000, have a negligible effect on exposures of Ldn over 75 and 65 dB. Combined with a 70 dB medium and heavy truck regulation effective in 1985, exposure reduction in the Ldn over 65 dB category would drop by about 25 percent. The effect on the Ldn over 75 dB category would drop to zero from low speed vehicles and drop negligibly from high speed vehicles. Given the above simulation results, regulation of light vehicles should be retained as a control option.

Little data is available on driver/rider exposure to light vehicle noise or on the contribution of light vehicle noise to the individual's total exposure. Since representative external sound levels are not in excess of 75 dB, it is assumed that Leq(8) 77 dB exposure by itself from the light vehicle source is not a problem, but as it adds to other noise exposures, i.e., the workplace, we should be concerned with it. Until further concrete data is developed, we will assume that as exterior noise levels are lowered there are positive spillovers to the rider/operator. At this time, however, we will not quantify these benefits.

3. Motorcycles

Community noise exposure above 75 dB and 65 dB attributed to highway vehicles cannot be eliminated unless noisy motorcycles are quieted along with other vehicles (Figure 4). If motorcycles were completely eliminated from the traffic mix, the year 2000 baseline for Ldn over 75 dB and 65 dB exposures would be lowered by about 5 and 10 percent, respectively, while exposures to Ldn over 55 dB would not be significantly altered.

If we should promulgate the motorcycle regulations as proposed by EPA—with street motorcycles at 83 dB in 1980, 80 dB in 1982, and 78 dB in 1985 (along with the anti-tampering provisions and the acoustical assurance period)—the number of people exposed to Ldn over 75 dB, 65 dB, and 55 dB would decline by about 0.1 million, 1 million, and 0.7 million, respectively. In addition to community noise being abated, operator exposure will also be reduced by more than 50%, measured in terms of LWPH, by the year 2000.

Given the above findings, motorcycle regulations will be retained as a control option for further analysis.

### 4. Buses

Bus noise does not appear to measurably influence community noise exposure to Ldn over 75 and 65 dB. Theoretically, we could achieve the Ldn below 75 and 65 dB goals by addressing noise from medium and heavy trucks, light vehicles, and motorcycles only. When trying to abate the Ldn over 55 dB exposures bus noise has to be addressed.

Buses are responsible for a host of single event disturbances, measured in LWP for sleep and speech. The bus regulation as promulgated would reduce LWP for sleep and LWP for speech by 40% and 50% respectively from the year 2000 baseline. Therefore, the regulatory option for buses will be retained for further analysis.

The relationship between operator/rider noise exposure from buses and external noise levels has not been established. Therefore, the impact of an exterior new product regulation on operator/rider noise exposure is uncertain. Generally it can be stated, however, that as external noise is reduced, interior noise is not likely to increase and would be expected to decline. Controls other than regulatory will be applied to simulate the possible effect on operator/rider exposure. Meanwhile, it will be assumed that the above-described regulatory controls will likely have routine spillovers for operator/rider exposure.

### 5. Snowmobiles

Since the snowmobile industry is seriously addressing community noise problems from snowmobiles as discussed in Part I, new product regulations at this time are not considered a practical option.

(3) In-Use Controls

The range of in-use controls can be used by themselves or in conjunction with other controls. For example, if regulations do not reduce noise levels to the satisfaction of a local community, there are various controls it can institute. It can ban traffic, as is currently done in some parts of U.S. and Canadian cities. It can institute passby controls such as curbline noise standards (the City of Galena, Illinois, is a case in point), or it can crack down on modified, defective, or inadequate exhausts.

Alternatively, States and localities can proceed without outside assistance with respect to controlling vehicle noise. They can regulate: (a) non-preempted new vehicle noise emissions, (b) the traffic mix, (c) in-use noise levels, (d) the manner in which vehicles are operated, (e) traffic routing, and (f) limitations on the number of various vehicles within the mix. Notwithstanding the establishment of some pedestrian malls, truck routes, speed limits, property line standards, curb line standards, and new product noise emission regulations, most State and local noise enforcement emphasis has been directed toward noisy exhausts.*

According to State of California enforcement data,[12] in 1977 about 1.0 percent of all light vehicles tested were in violation of the State vehicle noise codes because of modified exhausts, defective exhausts, or inadequate exhausts. Since 1975, when 2.3% of screened light vehicles were found to have defective exhausts, there has been a significant improvement in compliance with the noise code.**

The same holds true for motorcycles. In 1975 about 14% of all motorcycles screened failed to comply with the California vehicle noise code. In 1977 only 8.8% failed due to faulty or modified exhausts.

Overall, heavy trucks have a better record. In 1975 only 1% were noncompliant while in 1977 the percentage dropped to 0.6%.

* It should be noted that many State and local noise programs lack enforcement and/or funding.

** Noise limit 76 dBA at 50 feet at 35 mph or less.[13]

It is general knowledge that a 100% degraded exhaust can increase vehicle noise emissions by as much as 25 dB under full throttle conditions. Various stages of degradation (or modification) below a 100% muffling loss would naturally result in a lower noise exposure.

If we were to assume that States which currently have no in-use noise enforcement program and are not expected to have one by the year 2000 were to adopt one as effective as California's by the year 2000, noise exposure would decline. The 1% of 1,904,677 estimated medium and heavy trucks (Appendix D-1) that would be expected to be in violation of any reasonable noise code due to ineffective exhausts would decline to 0.6%. Likewise, the light vehicle exhaust violations would decline from 2.3% of 58,317,000 to 0.9%. Motorcycle noncompliance would change from 13.9% of 3,230,143 to 8.8%.

Assuming that exhausts were merely degraded by 5 dB, an in-use enforcement program would yield negligible benefits to people exposed to Ldn over 75 dB or 65 dB. If we were to assume a 25 dB degradation, the number of people exposed to Ldn over 75 dB and 65 dB would decline by approximately 40 percent. It should be pointed out that this can be achieved much quicker than with other programs, including new product regulations. Consequently, this control should be maintained as a viable option. It could, of course, be strengthened by other in-use enforcement controls. (See Appendix F.)

Other in-use controls can take over where new product regulations leave off. It was demonstrated, for example, that without significant technological innovations the Ldn over 55 community noise exposure goal cannot be attained with new product noise emission regulations. By controlling the absolute numbers of vehicles, the traffic mix, routing of traffic, and the manner in which vehicles are operated, the highway vehicle noise level can be reduced, theoretically, to the background ambient noise level—the level that would exist without surface transportation vehicles. With less stringent State and local government in-use controls, desired levels between the ambient and existing or expected levels can be attained. For example, vehicles like trucks and motorcycles could be excluded from parts of the traffic flow by establishing truck routes through areas where community noise above a certain Ldn level would not result. Speed limits could be lowered to reduce tire noise. The use of snow tires during the spring, summer, and fall could be prohibited. Trucks and motorcycles could be prevented from using curb lanes and restricted to inside lanes only. Also, State and local governments could restrict the overall number of vehicles in operation by limiting State vehicle registrations or city and county stickers.

(4) <u>Noise Emission Information</u>

Noise emission information by itself, whether in the form of a label attached to the vehicle or its components or in the form of a separate booklet or other printed matter, will not reduce noise emission or noise exposure. Only insofar as it persuades purchasers to purchase quieter products, convinces producers to produce quieter products, and warns the noise receiver to avoid noisy sources, will noise exposure be lowered. The consumer might demand a less noisy product because he derives more utility from a less noisy product. Information regarding noise from surface transportation would make it possible for the consumer to make a well-informed decision. This could result in a total product mix that is less noisy. If consumer desires for quieter products were transmitted back to the producer via the price system, the producer would concentrate on the quiet product demanded and perhaps still quieter products.

If the consumer did not prefer less noisy products, possibly because he was not willing to pay anything for noise reduction or because the community, and not the driver/rider, is primarily impacted, obviously there would be no signal sent to the producer to produce or develop quiet products. Noise information would, nevertheless, be useful in the battle to lower noise because it would assist State and local noise enforcement when noise codes are based on new product noise levels.

Unfortunately, we have no data available to determine the effectiveness of noise emission information for any of the possibilities we have covered. Consequently, we have to consider the sensitivity parametrically, i.e., by considering values within the relevant range. In the very short run the maximum effect of noise information is obviously limited by current technology—quieting technology presently incorporated into the product. In the intermediate time span the maximum benefits are limited by available technology, whereas in the long run, the maximum effectiveness of noise emission programs is limited by future technology. In this respect the maximum effect of noise emission information control is like the new product regulation control. But the probability of attaining a given level with the information control is less because of lack of enforcement possibilities, lack of acoustical assurance periods, and considerations other than noise which affect the demand for surface transportation vehicles, i.e., income, safety, etc. On the other hand, there would unquestionably be some impact on vehicle purchases if this information were disseminated. An EPA survey found that the overwhelming majority of consumers queried felt that if a noise label were provided they would be likely to use the information in their purchase decision. In fact, the survey indicated that many consumers would be willing to pay more for less noisy products if they had to.[14] However, we do not know whether such users as trucking firms and taxi companies would pay more for quieter vehicles. EPA is currently researching the potential effectiveness of this control and results will be supplied as soon as they become available. Since the maximum effect of this control is limited by technology as with source regulations, and since source regulations have measurable effects, this control will be retained for further analysis. (See parametric treatment of the control in Appendix F.)

1. Medium and Heavy Trucks and Light Vehicles

There is little chance that truck owners or operators would stand in line to purchase the quietest trucks available if noise information were supplied to them, so long as the regulatory levels were met by all new trucks. Profitability of one vehicle compared to another vehicle for specific uses would probably be the overriding decision-making factor. Profitability can be influenced by local ordinances limiting the operational flexibility of trucks. In this case noise information could persuade purchasers to buy quieter vehicles.

The exact response to noise information for light vehicles is not known. The information in EPA Noise Labeling: General Audience Survey[14] indicates that because of the general consumer good characteristics inherent in light vehicles, noise information disseminated to consumers would likely yield a quieter fleet. If only 50% of the people were to switch to the quietest vehicles available, both trucks' and light vehicles' year 2000 exposure could be reduced by as much as 30% in the Ldn over 65 dB group. This control would do little for the Ldn over 75 dB exposure category. It should be noted that the possible effect of a light vehicle labeling action by itself is equal to or larger than the effect of a new product regulation set at 70 or 65 dB. That ceiling would likely encourage manufacturers of some products below those levels to move up to the maximum rather than to continue to engineer quieter cars. (See Appendix C for additional information.)

2. Buses

On major capital outlays like buses, the purchasers are presumably astute enough to take disturbing community noise into consideration when purchasing new vehicles. Moreover, since public bus fleets are subsidized by the Federal Government, it would be relatively easy to specify interior and exterior noise levels as a condition for funding. With respect to interior noise, however, labeling might induce rider noise avoidance patterns and reduce noise exposure. By labeling the representative noise levels per row and indicating the health effects hazards associated with noise exposure levels, riders might choose quieter seats or the driver might instruct them to do so. Possible exposure reductions could be around one million LWPH by merely getting a portion of the people to sit as far removed from the engine as possible.

3. Motorcycles

Noise information by itself might have counter-productive effects on lowering motorcycle noise because some consumers are likely to prefer noisier models. A label or other information would direct those users to the noisier products. With in-use enforcement and a new product regulation (specifying an acoustical assurance period and containing anti-tampering provisions) to accompany the noise information on the vehicle and parts, benefits realized could be as demonstrated under the regulation portion of this section. In addition, when labels and other information media explain ill effects from noise, consumer demand might shift toward quiet products below the regulatory noise ceiling. To what extent this would occur is unknown at this point.

4. Snowmobiles

Snowmobile operators/riders, as opposed to the community, suffer the most injurious exposure from snowmobiles. By pointing out to users what some of the ill effects of noise are and that quieter vehicles are available, consumer demand could be changed in favor of quieter vehicles. This would speed the transformation already underway to a quieter fleet. Moreover, the operator armed with this knowledge is more likely to protect his ears and employ other voluntary noise avoidance techniques such as hearing protectors. The LWPH could, for example, be reduced by about one million by the year 2000 if 50% of new snowmobile purchasers bought the quietest model available.

(5) Retrofitting

New product regulations are relatively effective on products with a large existing stock composed of vehicles lasting for a long time, as is the case with trucks, buses, automobiles, and to a lesser extent, motorcycles and snowmobiles. To increase the rate of noise abatement generally, or to realize a particular geographic noise goal, retrofitting noisy vehicles could be considered. An example of attaining particular geographic goals is when a locality establishes a pedestrian mall and the only vehicles permitted in the mall are city transit buses. It may very well be that the community desires (or demands) quiet buses and is willing to retrofit them accordingly. Likewise, communities could demand that other vehicles become quieter. Measurable effects can be achieved, as can be seen with simple logic. For example, measurable effects can be attained with new product regulations. Since retrofitting can instill like or even more pronounced benefits, this control is effective. (See Appendix C for more information.)

1. Medium and Heavy Trucks

As profit seekers, most truck owners will be prompted to retrofit trucks primarily if (1) they can save money, and (2) they cannot earn money otherwise. Examples of the latter are: (a) when noisy trucks would not be licensed, or (b) if they were ticketed by the Bureau of Motor Carrier Safety (BMCS) for violating the exterior or interior truck regulations. An example of the former is when truckers switch to quieter temperature-modulated fans or radial tires because fuel savings exceed retrofit costs. Other possible retrofits with noise implications are energy saving conventional fans, truly round tires, aerodynamic roof modifications, weight reduction, height reduction, streamlining, turbocharging engines, derating engines, governing maximum engine speeds, and modifying engine-, transmission-, axle-combinations.* The noise characteristics associated with these retrofits are not exactly known, nor do we have an indication of the extent to which these modifications will be made. One optimistic example is to imagine that 50% of the trucks were immediately retrofitted such that medium trucks met a passby test level of 75 dB and heavy trucks met a passby level of 80 dB. This could result in a 25% reduction in the number of people exposed to over 75 Ldn, 15% to over 65 Ldn, and 5% to over 55 Ldn.

* For additional information see Federal Energy Administration, Truckers Guide to Fuel Savings, March 1976.

2. Light Vehicles

The owners of light vehicles, like truck owners, are not expected to rush to the nearest gas station to have their vehicles retrofitted as a good neighborly gesture. Many owners are expected to do so, however, to conform to State and local government noise codes or in order to realize personal utility and monetary savings.

Motivation for retrofitting defective exhaust systems can be rendered by State and local enforcement. Likewise, noise problems associated with light vehicles, such as warning devices, tires, and basic engine noise, can for the most part be brought into compliance through retrofitting, given the state of current State and local laws and ordinances. The expected exposure benefits are especially pronounced in the Ldn over 55 and 65 dB ranges. (See Appendix F, in-use control section for more detail.)

3. Buses

For buses retrofitting would not lead to substantial exposure reductions. If all buses were equipped with present technology retrofit packages, the number of people exposed to Ldn over 75 dB and Ldn over 65 dB would not be materially reduced even if other vehicles in the traffic mix were quieted.

Retrofitting would, however, have a substantial effect on reducing hearing loss exposure to drivers and passengers. If an 80 dB interior noise regulation were instituted in 1985 and 75% of the buses were retrofitted to 78 dB interior, operator/rider noise exposures to potential hearing loss levels could be essentially eliminated by the year 2000. LWPH would decrease from 4 million to less than one million. In addition, the annoyance due to the intrusive nature of noise would likely be mitigated.

Since a good part of the national bus fleet is government owned or controlled, there is no doubt about the ability of government at all levels to reduce exposure from bus noise using retrofitting techniques. School and intracity buses could be addressed immediately by States and localities, or in the longer run by Federal funding pressures, while intracity transit buses could be handled by the appropriate regulatory and funding agencies.

4. Motorcycles

A retrofit program for motorcycles would have to be initiated by government, preferably at the State and local level, because it is unlikely that operators/riders would voluntarily undertake this task. The results obtained for community and operator/rider exposure reductions could be as high as those for in-use controls since we are primarily dealing with exhausts. This control would be very ineffective if a one time retrofit without any follow-up were the only requirement. Consequently, continuous retrofitting of loud exhausts must be required. (See In-use Enforcement Section for parametric simulation results.)

5. Snowmobiles

The life of a snowmobile is relatively short, and the newer models are becoming quieter. Since the primary noise exposure from snowmobiles is to the operator/rider, not to the community, the benefits of a retrofit program to the general community would be marginal.

(6) Innovations (Technology)

It is clear from computer simulations, using various models, that current technology limitations will not permit us to attain the strategy goals by employing source controls alone. In fact, even when employing reasonable path controls like barriers, in-use controls, and land use mechanisms, the goals cannot be attained without changes in current technology.

Given the large number of road vehicles now and the significant growth predicted between now and the year 2000, the speed with which quiet product technology can be introduced is important. The later the date, the less chance that quiet technology can be transferred into innovation to assist us in attaining the Strategy goals or even to offset noise exposure growth resulting from vehicle population and population growth. Significant improvements in current technology are necessary if we are to attain the Strategy goals (Figure II-2). Current noise emission levels have to be lowered to such an extent that despite the most optimistic projections, source controls will not permit us to achieve the Strategy exposure goals. Technology (including tires, road surface, engine noise, etc.) can, however, evolve to assist us toward these goals. Moreover, technology innovations to produce exposure reductions at lower cost per unit of benefit than other controls, can relieve economic pressure. (See Appendices H and I for selective experiences.)

(7) Other Controls (Financial Incentives and Disincentives)

Under "Other Controls" the main control, in terms of predictable noise exposure reductions, is effluent charges of various sorts. As indicated earlier, these charges could be used in conjunction with other controls like labeling. They could also be effective when used by themselves.

The nature of road vehicles with their availability of substitute products, luxury aspects, wide range of noise signatures, availability of substitute transportation modes, significant prices compared to income, etc., is such that effluent charges can be used to encourage or force, if high enough, consumers to demand quieter vehicles. Moreover, the structure of the industry (control over engineering designs, foreign competition, potential diseconomies of scale, etc.) causes industry to be sensitive to effluent charges and to draw on available technology.

The most effective place to originate these charges would probably be on the State and local level, because industry lobbying costs against such actions are more likely to exceed the cost of introducing quieting innovations. (Some research along these lines is proposed, and if results become available, they will be distributed.)

Other financial controls with probable noise abatement benefits include paying premiums for government procurements of quiet products (LNEP program mentioned earlier, among others), incorporating a quality of life component into revenue sharing formulas, tying noise stipulations to general grants, earmarking road taxes, lowering Federal excise taxes (as on tires) for quiet products, reducing fines when a violator can demonstrate a below-new-vehicle-level retrofit of a noisy vehicle, etc.

(8) Barriers

Theoretically, the elimination of exposures to Ldn over 75 dB from surface transportation by the year 2000 can be achieved by constructing noise barriers.[15] This could be accomplished by building 10,000 miles of 10-foot high barriers and 3,000 miles of 15-foot high barriers. This would cost billions of dollars and cause inconvenience by limiting access to roads. A much more practical approach would be to use barriers in a limited number of areas where Ldn is over 75 dB to achieve a portion of this noise exposure reduction.

In practice it would be very difficult to eliminate the number of people exposed to Ldn over 65 dB. To reduce the number of people exposed to Ldn over 65 dB to even an insignificant level, i.e., about 10 percent of today's level, we would have to construct over 17,000 miles of 20-foot barriers.[16] This appears to be infeasible because of the extremely high cost. However, it may be possible to reduce exposure to Ldn over 65 dB in some selected areas by using barriers. The same applies to Ldn over 55 dB. Trade-offs between the barrier control and others are presented in Appendix E. The conclusion from these trade-offs is that less barriers would be required if sources were operated less noisily, and less height would be required if the main sources of noise were lower to the ground.

1. Medium/Heavy Trucks and Light Vehicles

In general, barriers will be most effective where high speed roads pass through densely populated urban areas. Barriers will be effective against noise from both trucks and light vehicles; however, trucks with tall exhaust stacks will generally require higher barriers for any desired noise attenuation level. Operator/rider exposure is not reduced by barriers, however, and under certain circumstances barriers might even aggravate exposure.

2. Buses

As long as the barriers are sufficiently close to the source, are of sufficient height, and have basic noise attenuating characteristics with respect to noise-path interference, it does not matter whether the noise source is a truck or a bus. Consequently, barriers are as effective a control against bus noise as they are against truck noise. Since bus noise does not materially affect the number of people exposed to Ldn over 65, any reduction in exposure achieved from barriers would not affect bus noise exposure. To eliminate exposure to Ldn over 55 dB, however, bus noise has to be addressed and barriers could serve as a control. Moreover, single event disturbances could be reduced.

As in the case of trucks, barriers by themselves would not reduce bus rider/operator exposure. It could even be made worse. This is, of course, an important consideration since buses carry large numbers of riders, unlike trucks.

3. Motorcycles

Motorcycle routes are not well defined and their distribution within the traffic flow is relatively scarce. A barrier solution for motorcycles only would make little sense because one would have to construct barriers along most roads, as well as in the wilderness (to address off-road bikes). Moreover, since the worst noise exposure accrues to the operator/rider of motorcycles, barriers would aggravate exposures rather than mitigate them.

4. Snowmobiles

The snowmobile noise case is like the motorcycle case. It is even worse because they operate seasonally and it would be most difficult to protect the public exposed to undesirable noise levels from snowmobiles. Moreover, the significant operator/rider exposure would not be reduced through barriers.

5. Summary

The above described effectiveness of barriers warrants inclusion of this control into the batch chosen for further analysis.

(9) Land-Use

Noise attenuation occurs naturally as the distance between the source and the receiver is enlarged. Theoretically, new surface transportation routes could be planned so that sufficient amounts of vacant land or land with specialized zoning surrounds the roads to avoid exposures to Ldn over 55 dB, even as the traffic flow increases and maximum loads are reached. Theoretically, the land around existing roadways can be treated in a like manner. In addition, selective zoning can thin the number of people exposed in heavily impacted areas, influence the length of exposure and the time of day exposures occur, or even remove people from noisy areas. (For specific estimates see Appendix A.)

1. Medium and Heavy Trucks

Even if all bystanders were removed beyond the range of injurious community noise levels through land use, drivers and riders of trucks would not escape high noise levels. Therefore, land use is only a partial answer to the total person noise exposure problem. In cases when other alternatives, discussed earlier, are not effective or are more expensive, this option might be used as a measure of last resort.

2. Light Vehicles

As in the case of medium and heavy trucks, riders and operators of light vehicles exposed to injurious noise levels (Leq(24) over 70 dB) cannot escape them through land use. As more light vehicle interior exposure data becomes available, the operator/rider exposures will be analyzed further. This data might become more relevant as more is learned about activity patterns of individuals and the noise associated with other than transportation vehicles.

Light vehicle traffic saturates communities to such an extent that land use alone cannot be relied upon to approach the Strategy goals. As in the case of trucks, this control might be used as a last resort or when no low cost alternatives are available. (See Appendices H and J for details.)

3. Motorcycles

As in the case of light vehicles, operator/rider noise exposure cannot be ameliorated merely through land use controls.

4. Buses

Since ridership on buses is large, it must be noted that as in the case of light vehicles and medium and heavy trucks, bus noise will not be affected by eliminating community noise exposure above Ldn 55 through land use alone.

5. Snowmobiles

The snowmobile case is similar to the motorcycle case except that snowmobiles generally operate in less populated areas and the community noise reduction benefits from land use would be smaller.

(10) Insulation

One can insulate dwellings effectively against noise from surface transportation sources. In fact, a by-product of general climatic insulation is additional shielding from exterior noise. Unfortunately, people lose the additional protection when they open their windows or leave the insulated dwellings.

It is estimated that ten million dwellings would have to be insulated to reduce interior noise levels associated with surface transportation noise to below Ldn 55 dB, affecting 24 million people. If we were to attain the Ldn 45 dB interior level, 40 million dwellings would be involved affecting 93 million people.

In addition to people not being protected outside the dwelling, rider/operator exposures would not be reduced unless the vehicles were also insulated, a highly impractical solution for motorcycles and snowmobiles. But this solution could be practical for other vehicles.

1. Medium and Heavy Trucks

The exact noise attenuation of truck driver insulation depends on variables like engine noise, tire noise, type of cab, open windows, etc. To eliminate potential hearing damage to drivers, truck cab noise would have to be reduced to less than 75 dB. There is little disagreement that this is possible at moderate cost for the majority of vehicles.

2. Light Vehicles

The tenor of light vehicle advertising reflects that there is some incentive to reduce interior light vehicle noise for the comfort of operators/riders. Presently it is estimated that about one million riders/operators are exposed to Leq(24) over 70 dB. To reduce this number to practically zero would entail insulation of about the same number of vehicles by the year 2000.

3. Buses

If we were to institute the present bus NPRM and insulate 75% of the existing buses to achieve interior levels of 78 dB, practically all Leq(24) 70 dB exposures to operators/riders would be eliminated by the year 2000. The LWPH would thus be reduced from four million to less than one million.

4. Motorcycles

Since the motorcycle driver is generally not surrounded by a protective cab and since many operators appear to enjoy noise, insulation of the driver/operator is not a likely method of control.

5. Snowmobiles

When these vehicles have operator enclosures, insulation will help. The number of vehicles with enclosures is so small that, in the aggregate, little benefit could be derived from insulation.

6. Summary

Given the many likely positive effects on noise exposure from noise insulation, this control will be retained in a batch of desirable controls for further analysis.

(11) Other Methods (Dwelling and Road Design)

Little empirical data is available dealing with noise exposure reductions resulting from applying controls such as modified dwelling designs, various types of road surfaces in combination with various types of tires and trucks, shielding devices used primarily for aesthetic purposes, recessed highway construction, noise oriented maintenance programs, etc. When evidence becomes available that such controls could make national noise abatement contributions, such information will be utilized immediately to update the surface transportation substrategy. Meanwhile, if States or localities find that these controls provide relief to their respective problems, they are urged to utilize them as they would any other control designed to improve the health and welfare of their citizens.

1. U.S. Environmental Protection Agency, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, March 1974.

2. Public Law 92-574, 92nd Congress, H.R. 11021, October 27, 1972, Section 2(b).

3. Ibid, Section 6(3)(1).

4. "Homeowners Volunteer to Pay for Reduced Highway Noise," Heavy Duty Trucking (Publishing Division, H.I.C. Corporation, Newport Beach, California., January 1978), p.71.

5. See U.S. Department of Transportation, Federal Highway Administration, Highway Noise Barrier Selection Design and Construction Experiences, (1975):

6. U.S. Department of Transportation, Noise Barrier Design Handbook (U.S. EPA/Federal Highway Administration), 1976.

7. U.S. Environmental Protection Agency, The Urban Noise Survey, August, 1977, p.39.

8. Jasbinder Singh and James C. Saxton, The Impact of Noise Abatement Standards Upon the Snowmobile Industry, International Research and Technology Corporation, prepared for U.S. Environmental Protection Agency, December 1973, p. 1.

9. U.S. Environmental Protection Agency, Control of Snowmobile Noise, Technology and Cost Information, Volume I, June 1974, p. 17.

10. Public Law 92-574, Section 6.

11. Kenneth J. Plotkin, "Occupational Noise Exposure of Truck Drivers," Wyle Laboratories memorandum to U.S. Environmental Protection Agency, (Unpublished) June 1978.

12. Commander Warren Heath, "Noise Team Enforcement Summary, 1972 to 1977," California State Police (Unpublished).

13. State of California Vehicle Code, 1975, p. 385.

14. Marcia A. Gilbert and Robert L. Hiatt, EPA Noise Labeling: General Audience Survey, Human Science Research, Inc., for U.S. Environmental Protection Agency, January 1978, pp. 13 and 18.

15. Kenneth J. Plotkin, National Exposure to Highway Noise and Effectiveness of Noise Abatement Strategies to the Year 2000-Appendix A, Wyle Laboratories, draft report for U.S. Environmental Protection Agency, October 1977.

16. Ibid, p. A-12.

# III. NATIONAL SURFACE TRANSPORTATION SUBSTRATEGY

## III. NATIONAL SURFACE TRANSPORTATION SUBSTRATEGY

### 1. INTRODUCTION

Many noise abatement controls such as new product regulations and in-use enforcement programs have been found in practice to be effective in lowering the number of people exposed to various noise levels. Computer simulations indicate that other controls would probably also be effective in lowering the number of people exposed to various noise levels. Since resources to address the noise problem are limited at any one time, controls should be assessed with respect to:

- Their effectiveness, taking into consideration the immediate and longer range goals to be achieved
- The magnitude of the cost
- The incidence of the abatement cost
- The number of years until measurable results would be realized, along with the permanency of the effect
- The authority imposing controls
- The cost effectiveness of combined controls.

#### (1) Effectiveness of Controls

The first step in determining whether or not a control should be considered is to determine whether or not it can contribute toward achieving the Ldn community exposure goals set forth in the National Strategy document, or if operator/rider hearing loss resulting from noise exposure can be eliminated.

#### (2) Magnitude of Costs

Costs should be considered along with expected benefits at all times. Controls that would cost orders of magnitude above levels of benefits will be considered undesirable in the initial sifting process. Costs are defined as expenses accruing to: (1) users of noisy vehicles; (2) producers of noisy vehicles; (3) Federal, State and local governments (enforcement and regulatory costs and tax revenues foregone less revenues collected from fines); (4) by-standers—those not involved in using, producing, or regulating the noisy vehicles.

(3) Incidence of Abatement Costs

The "incidence" of abatement costs is the final resting place of a cost. By contrast the "impact" is the initial place the cost is noticed. Generally the impact and incidence are different. For example, the impact of the cost of the recently promulgated air compressor noise regulation is on the manufacturer because the manufacturer incurs expenses to comply with the regulation. The incidence of this cost is shared by construction contractors and purchasers of homes built by contractors using the regulated, higher cost, air compressor.

While individuals suffering from noise might be willing to pay for abatement, this course of action will not be promoted because it is inequitable. It would offer no encouragement to producers and users of noisy vehicles to abate noise since the incidence of the abatement cost would not rest with them. However, a control that would increase the cost of a noisy vehicle over a quiet one would likely encourage users to switch to less costly and less noisy products. Such substitution would yield less noisy products in the future because producers would attempt to avoid sales losses. Consequently, such controls are preferred over controls that burden innocent bystanders.

(4) The Number of Years Until Measurable Results Are Realized

If we were to wait long enough, the surface transportation problem might solve itself. Crude oil resources could become so scarce that vehicles as we now know them could no longer be operated. Meanwhile, the damage due to excess noise exposure will have been inflicted upon the U.S. population. All other things being equal, the controls are ones that become effective immediately and last forever. Conversely, the longer it takes for a control to show any effects and the shorter the period the benefits will last, the less desirable the control. Any control that is not expected to result in measurable exposure reductions by the year 2000 will not be considered. Controls with projected benefits before the year 2000 and lasting beyond 2000 will be considered.

(5) Authority Imposing Controls

In light of the incidence of the cost, it is apparent that it would be best if producers of noisy vehicles would impose the noise controls on themselves (either independently by a monopoly or by mutual legal agreement if many firms are involved). In this manner, the incidence of the noise control costs would come to rest where it should, with the possible exception of general government revenue losses. Unless these controls translated into more profit, however, past industry behavior indicates that the likelihood for voluntary abatement is slim.

Well-informed consumers might, however, force industry to provide quiet products by buying less noisy ones. Reliance on this control might be effective when (1) the noisy product is a final consumer good, (2) the consumer is the one primarily subjected to the consequences of noise, and (3) the consumer is informed regarding the specific consequences of exposure to high noise levels and the availability of lower noise alternatives. Generally, however, the consumer is not the only one adversely affected by a noisy product he uses. It is unlikely that users of noisy vehicles, or the producers of such vehicles, would take it upon themselves to solve the community noise problems associated with surface transportation. On the contrary, the users of quiet and more costly vehicles, like delivery trucks, might be run out of business by users of noisy trucks that cost less when purchased and are less expensive to operate. This reinforces the contention that the private sector in general will not take steps to limit noise exposure growth unless encouraged to do so.

In the absence of adequate private action, the remaining options involve all levels of government. In a Federal system such as the U.S., State and local jurisdictions are given the option to provide for different life styles. Therefore, it is completely possible that some communities are willing to accept more noise for economic and noneconomic reasons than other communities. For example, a community relying heavily on tourists arriving by motor vehicles might be willing to accept higher property line noise levels than a retirement community where people have gone to escape city noise. The preservation of such spatial prerogatives is essential to the maintenance of a Federal system. In fact, the Tenth Amendment to the United States Constitution and the Noise Control Act provide this right to States, unless preempted by the Federal Government.

Therefore, States and the jurisdictions to which they delegate power are free to impose various controls to provide healthy and relatively quiet environments for their citizens. If States and localities do not provide an environment free of injurious noise levels, Federal preemptive authority may have to be invoked where necessary and legal, even though State and local controls would be preferred.

Noise control simulation results for various noise controls as well as other sensitivity studies (some completed and some underway) should give guidance to States and localities interested in providing a healthy and quiet environment. In many cases these political subdivisions can and should seek assistance from the Federal Government, and the Federal Government should have the capability to give technical guidance and provide information on noise.

It is EPA's view that no State or locality should permit levels of noise to exceed those deemed to adversely affect health and welfare. With respect to noise from surface transportation, community noise exposure of Ldn 75 dB and over should be eliminated, followed by exposures of Ldn over 65 dB and Ldn over 55 dB.

In summary, controls imposed by producers on themselves are preferred to controls imposed at consumer levels or by the public sector.

(6) Cost Effectiveness of Combined Controls

While cost information associated with the application of controls is generally not available, every effort was made to attain the information or to advance intuitive ordinal estimates. Then these costs were compared with the effectiveness of various combinations of controls. Effectiveness measures are numerous, including Ldn, Leq, and LWP. For cost effectiveness analyses, the level weighted population was used because it is felt that the greater severity of general adverse response to higher noise levels should be considered. Consequently, the removal of exposures to higher noise levels would warrant the application of more resources than the removal of exposures to lower noise levels, all other things being equal. The lower the cost per unit of effectiveness, the more desirable the controls. These conclusions will not, however, preclude the use of other than lowest cost alternatives for other than cost reasons, i.e., the incidence of the cost.

## 2. CHOOSING NATIONAL NOISE ABATEMENT STRATEGIES FOR SURFACE TRANSPORTATION NOISE CONTROL

The introduction to this substrategy indicated that noise exposure from surface transportation will grow steadily, from the present undesirable level to the year 2000. We found that something can be done about this problem by the private sector— producers of noisy equipment, users of noisy vehicles, and bystanders (third parties)—and the public sector—Federal, State, and local governments. Of the major generic controls analyzed in the preceding section, it was found that none had qualities so undesirable that they could be categorically dismissed. Moreover, many of the undesirable characteristics of the generically described controls could be eliminated if they were used in combination rather than alone. A case in point is the barrier control. If the source of truck noise were lowered by modifying exhausts from vertical stacks to horizontal under-frame types, lower barriers would be effective at lower cost per unit of noise benefit.

(1) Reducing Noise Exposure Using Source Controls

From the data gaps discussed in previous sections and the diversity of local conditions and tastes, it appears clear that we cannot empirically determine a most cost-effective combination of controls in a strictly mathematical sense for every place in the country (Figure III-1). Considering the effectiveness of controls, the time (with respect to the immediacy of benefits as well as the longevity of effects), the costs (including the incidence), the expectation that the private sector will not solve the problem by itself, and the authority associated with the control, the proceeding controls are endorsed. (See Table III-1 for a step-by-step analysis.)

1. New Product Regulations

New product regulations as promulgated on medium and heavy trucks and as proposed for motorcycles and buses is endorsed. In addition, it is proposed that a stronger "second round" medium and heavy truck regulation lowering the permissible noise level to around 75 dB be given high priority. Standards should also be set for the height of the noise source and for tire noise. Legislation should also be proposed to remove preemption so that States and localities could choose even lower levels. While it would be possible to gain additional noise exposure reductions by a lower standard for medium trucks than for heavy trucks, the projected exposure reduction would not be justified by the costs (in terms of exposure benefits foregone had the human and non-human resources been applied to alternative controls). This is also true with respect to light vehicles.

Figure III-1
SUBSTRATEGY STRUCTURE

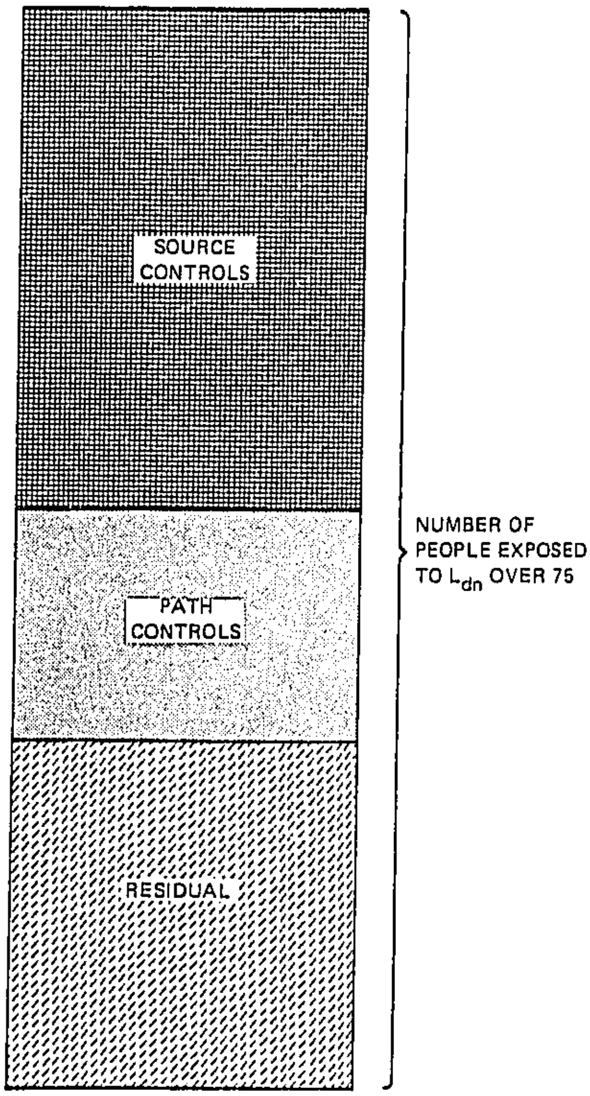


Table III-1

CONTROLS THAT FAVORABLY AFFECT EXPOSURE TO $L_{dn}$ GREATER THAN 75, 65, and 55 dB BY THE YEAR 2000

| Vehicles | Effective Controls | Magnitude of Cost | [illegible] | Years Until Noticeable Results Are Realized | [illegible] | [illegible] |
|---|---|---|---|---|---|---|
| | SOURCE CONTROLS<br>New Product Regs | | | | | |
| Medium/Heavy Trucks | As promulgated; Second round EPA; Height of source emission; Technology programs | Medium | Correct | Inbetween | Inbetween to Incorrect | Desirable |
| Buses | As proposed by EPA | Medium | Correct | Inbetween | Inbetween | Desirable |
| Motorcycles | As proposed by EPA | Low | Correct | Inbetween | Inbetween | Desirable |
| | RETROFITTING | | | | | |
| Medium/Heavy Trucks | For those built before January 1, 1979 | Medium | Correct | Few | Inbetween to Incorrect | Desirable |
| Buses | For those in "noise sensitive" areas | Low | Inbetween | Few | Correct to Inbetween | Desirable |
| Motorcycles | To meet levels proposed by EPA | Medium | Correct | Few | Inbetween | Desirable |
| | NOISE EMISSION INFORMATION | | | | | |
| Buses | Label interior levels | Medium | Inbetween | Inbetween to Many | Inbetween | Desirable |
| Motorcycles | Label; also label noise attenuating parts; inform purchaser of hazards of high noise exposure | Medium | Correct | Inbetween to Many | Inbetween | Desirable |
| Light Vehicles | Label interior and exterior levels | Medium | Correct | Inbetween | Inbetween | Desirable |
| Snowmobiles | Label; inform purchaser of hazards of high noise exposure | Low | Inbetween | Few | Inbetween | Desirable |
| | IN-USE CONTROLS | | | | | |
| All vehicles | Local programs for: Defective exhausts | Low | Correct | Few | Correct | Highly desirable |
| | Speed reduction Operation Routes Curfews Inspections (with noise codes) Traffic flow, etc. (self-financing through fines and fees) | Medium | Correct | Few | Correct | Highly desirable |
| | PATH CONTROLS<br>Barriers | | | | | |
| Primarily Medium/ Heavy Trucks, marginally Light Vehicles | Along newly constructed highways where maximum projected loads cause problems | Medium | Correct to Inbetween | Inbetween to Many | Correct to Incorrect | Desirable |
| Primarily Medium/ Heavy Trucks, marginally Light Vehicles | Along existing roadways where no other alternatives are available | High | Correct to Inbetween | Inbetween to Many | Correct to Incorrect | Desirable |
| | RECEIVER CONTROLS<br>Land Use | | | | | |
| All vehicles | Recessed highway construction Zoning, etc. | High | Correct to Inbetween | Inbetween to Many | Correct to Inbetween | Marginally desirable |
| All vehicles | Dwelling modifications | High | Correct to Inbetween | Inbetween to Many | Correct to Inbetween | Marginally desirable |
| | FINANCIAL INCENTIVES AND DISINCENTIVES | | | | | |
| All vehicles | Public education leading to evasive actions | Low | Incorrect | Inbetween | Correct | Desirable |
| Light Vehicles/Motorcycles/Buses/ Snowmobiles | Certifications costs for noise information programs paid for by manufacturers of noisy vehicles | Low | Correct | Few to Inbetween | Correct to Incorrect | Highly desirable |
| All vehicles | Labeling costs funded from earmarked taxes and fees with producers of noisier equipment paying more than producers of quiet equipment | Low | Correct | Few to Inbetween | Correct to Incorrect | Highly desirable |
| All vehicles | Local programs financed by fines on violators | Low | Correct to Inbetween | Few to Inbetween | Correct | Highly desirable |
| All vehicles | Noise component included in revenue sharing formula | Low | Correct to Inbetween | Few to Inbetween | Correct | Highly desirable |
| All vehicles | Maximum noise levels specified for federal construction grant programs and procurements | Medium | Correct to Inbetween | Few to Inbetween | Inbetween | Desirable |
| All vehicles | Excise taxes levied on noisy vehicles | Medium | Correct | Few to Inbetween | Correct to Incorrect | Highly desirable |

2. Retrofitting

Retrofitting is proposed for medium and heavy trucks which were built before January 1, 1978, but which do not comply with the present Interstate Motor Carrier regulation or with stricter regulations that might be forthcoming. As trucks become less noisy and the effectiveness of in-use and other controls on light vehicles diminishes and quiet light vehicle innovations surface, a retrofit control for light vehicles might be implemented. By that time historical data should be available to determine the need for such action; however, the opportunity costs do not warrant such a program on a massive scale at this time. Retrofitting implies that the vehicle will end up less noisy than before its original sale. Therefore, replacement of defective exhausts and of noisy tires are not covered under retrofitting. They are discussed in proceeding sections.

Retrofitting of buses is suggested for those operating in "noise sensitive areas," such as pedestrian malls, highly populated areas, and/or around facilities that require low noise levels like hospitals, schools, and outdoor theaters. For some jurisdictions this means that all buses would have to be retrofitted; for others only those buses serving "noise sensitive areas" should be covered by a retrofit program.

Motorcycles not presently covered by a regulation should be required to be retrofitted and minimally maintained to meet levels currently proposed by EPA. The cost per unit of benefits is small. (See Appendix H.) In fact, per dollar of expenditure it would be difficult to obtain higher noise exposure reduction benefits.

A formal retrofit program for snowmobiles is not proposed at this time due to the overwhelming opportunity costs.

3. Noise Emission Information

Noise emission information, including labeling, is not proposed for medium and heavy trucks at this time because the resources that would have to be spent for labeling would yield very little in terms of marginal benefits. Noise information would generally guide purchasers and manufacturers to shift to quiet trucks only when economic motivations were present. Presently, purchasers and producers of such pieces of major capital equipment can obtain information readily from other sources anyway, such as EPA's test data for newly manufactured trucks. The magnitude of expenditure for this type of equipment is such that the effort would be made only if economic incentives were to come into being.

However, noise information for light vehicles is highly recommended, with certification costs paid by manufacturers of noisier vehicles. Interior and exterior noise information could accompany presently supplied air pollution information and/or mileage information. This control has a high expected noise-exposure-reduction benefit per unit of cost because producers and buyers are expected to shift to quieter vehicles. In addition, local programs to enforce noise codes based on permissible dB degradation would be assisted at a relatively low per unit cost due to the economies of scale attained through volumes of labels. Moreover, localities would retain a high degree of flexibility without Federal preemption. Thus communities desiring a quieter environment could strive toward such a goal with the help of labeling, rather than more expensive controls like land use.

Buses should be labeled interiorly to give riders an idea of the maximum noise level they could expect in various seats. As a result, many passengers are expected to choose quieter seats. This option is estimated to yield noise exposure reduction at a low cost per unit of benefit.

For motorcycles and noise attenuating parts, labeling is recommended (along with a new product regulation), primarily to assist in-use enforcement and to eliminate the interstate transfer of excessively noisy parts. When motorcycles are sold it should also be required that the potential purchaser be informed of the potential health and welfare hazards of high noise exposure and noise ordinances in communities he is likely to operate in. The person so informed should acknowledge receipt of such information.

It is proposed that this program be funded from earmarked taxes and fees collected from motorcycle manufacturers; producers of noisier equipment should be required to contribute more than manufacturers of quiet equipment.

Snowmobiles should likewise be labeled, and consumers should be required to acknowledge receipt of information related to the potential health and welfare effects of noise and State and local noise ordinances. Labeling and certification expenses should, as in the case of motorcycles, be born primarily by manufacturers of noisier vehicles.

4. <u>In-Use Controls</u>

A wide range of in-use programs can be effectively employed against the road noise problem. One of the most effective programs is one directed toward defective exhausts. It is recommended that all jurisdictions institute programs to deal with this problem, because the benefits are high while programs can to a large extent be financed by the violators thus imposing little or no burden on bystanders.

Inasfar as noise is associated with speed, especially tire noise, enforced speed reduction can bring relief at negligible cost to bystanders. Violators should be fined and some of the proceeds used to finance the enforcement operation. Moreover, when the noise is primarily single event in nature, controlling the operation of vehicles, like preventing jack-rabbit starts, would also yield a reduction at minimal cost to bystanders.

Other major in-use options for populated areas are: (1) routing of traffic away from highly impacted areas, (2) imposing of curfews on the operation of certain vehicles at certain hours of the day, (3) inspection of vehicles (along with appropriate noise codes), and (4) improving the smoothness of traffic flow. All of these options yield significant benefits and are lower cost alternatives (especially to bystanders) than banning of traffic completely, relocating people to quiet areas, modifying dwellings structurally, or various other land use schemes.

## 5. Innovations

The large-scale deployment of technology is known as innovation. Quieting innovation, along with the technology development that makes innovation possible, is highly endorsed. Innovation is needed because: (1) current technology is inadequate to meet exposure goals outlined in the Strategy, (2) some of the other alternatives are likely to be more expensive, and (3) some of the other alternatives are less desirable from the standpoint of the incidence of the cost resting with bystanders instead of the users and producers of noisy equipment. The prime candidate for additional technology are trucks, because they contribute a large part to the high community noise exposure and large noise reductions are limited by current technology. Specific areas suggested that would yield payoffs are tires and engines as well as trucks.

## 6. Other Source Controls

Other controls suggested for adoption are financial incentives and disincentives. It is recommended that community noise problems be solved at least in part, by: (1) financial disincentives to those who use and produce noisy equipment, (2) financial incentives to those who abate noise, and (3) transfer payments designed to relieve noise-related financial burdens to innocent bystanders (funding for noise insulation).

Nationally, a quality of life component including noise should be made part of the revenue sharing formula, and all major Federal grants and procurement actions should have maximum noise levels specified when applicable.

7. Summary of Source Controls

Even though economically feasible source controls can assist in reducing noise exposure to various Ldn levels, they are not expected to reduce noise to desirable, or even necessary, levels. In the absence of noise reduction innovations the only remaining options are path controls and receiver controls. Our preliminary analysis shows that many path controls are more costly per unit of benefits than the implementation of available source control technology on a wide scale. Receiver controls, on the other hand, are generally deemed undesirable and are not the most preferred controls. Consequently, all technology potential should be utilized as long as the costs are not beyond reach.

(2) Reducing Noise Exposure Using Path Controls

The fleet noise levels for road vehicles would have to be severely reduced to meet the national strategy goals (see Appendix K for estimates). It appears highly improbable that technological innovations with respect to vehicle noise can reduce fleet noise levels by the year 2000 to eliminate the exposure in the Ldn over 55 dB, over 65 dB, and over 75 dB categories (Figure 8). Therefore, path controls must be considered.

The primary path control is the noise barrier, including the use of recessed highway construction. When no better alternatives are available, noise barriers should be erected along newly constructed highways which (1) are likely to pose a noise problem at maximum projected loads, and (2) lend themselves to barriers. (For details see Appendix L.) Along existing roadways it is also proposed that barriers be constructed (1) when they are less expensive per unit of benefit than other controls, (2) when the costs are not unreasonably high, and (3) when no other alternatives are available. In order to minimize the cost of barriers to bystanders, it is recommended that they be financed by earmarked taxes collected from vehicle noise contributors. The Federal highway and State and local trust funds could be employed, although this type of tax is not perfect because tax payments are to a large extent based on fuel consumption, not noise. Some of the vehicles with larger engines consuming more fuel are actually the quieter vehicles, but drivers pay more taxes per mile travelled than drivers of smaller, conceivably noisier, vehicles. It is, therefore, proposed that Federal highway trust fund money should be supplemented with excise taxes to be levied progressively with respect to noise. On the State and local level, as mentioned earlier, fines and fees could be levied on noisy vehicles. The latter would be an expecially attractive source of funds for constructing barriers along State and local roads.

While implicit costs, like neighborhood divisions, increase the total cost of barriers, the cost per unit of benefits is favorable in many situations. Benefits are enhanced because (1) the benefits from barriers are immediate; (2) they can be addressed to localized problems; (3) they can be used in combination with other controls to minimize the costs; (4) they could have other benefits, like halting snow drifts; (5) construction could conform with the general neighborhood architecture; and (6) they generally last a long time with minimal maintenance.

### (3) Reducing Noise Exposure Using Receiver Controls

Even if all of the aforementioned controls were applied as suggested, the national Strategy goals would not be met by the year 2000 because of the time it takes for many of the controls to show results and because of technological and resource limitations. To minimize the health and welfare risk to the population, low cost programs leading to receiver evasive actions promoted by education and public information programs should be instituted. Whenever possible these programs should be financed from earmarked funds collected from major contributors of noise.

#### 1. Land Use

In conjunction with barriers or by itself, land use is a suggested option for reducing potential noise exposure problems. It should be used as a control of last resort, or when more cost-effective than alternative controls. The goal is that under maximum projected traffic loads noise exposure will not exceed Ldn 55 dB along highways. Along existing roadways, when other alternatives are more costly or are not feasible, especially in densely populated areas, it is proposed that selective zoning be used to thin out the number of people exposed to excessive noise levels. In addition attempts should be made to reduce the number of hours of excessive noise, especially at night. Those individuals losing the free use of their property or those people forbidden to encroach upon a noisy area must, of course, be compensated through established eminent domain procedures. Since the majority of roadways are already constructed and problem noise areas are, to a large extent, inhabited, the costs per unit of benefits are expected to be significant but not necessarily prohibitive. This means that land use should be considered for the most part as a control of last resort for established communities.

2. Other Receiver Control Methods

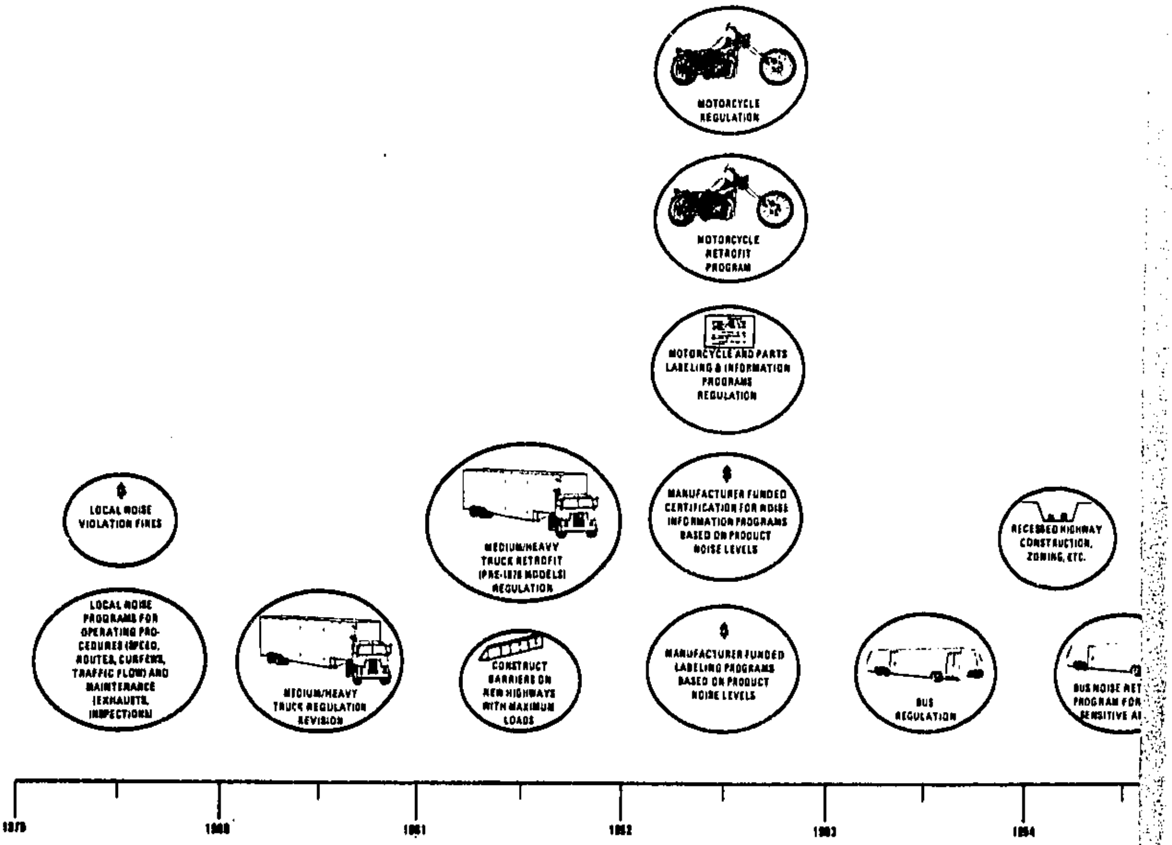
Inside dwellings, noise relief can be attained through closing windows, staggering openings, double glassing (along with other window modifications), and insulating. Even though this solution is very expensive, in isolated instances it might be cheaper per unit of benefit than alternative path or source controls. Dwelling modifications cannot, however, be counted on to solve the national noise problem, because alternative methods would generally be less expensive. Where past planning neglected to take surface transportation noise into consideration, residences should be insulated at the expense of the governmental unit that financed the construction of roads from which excess noise radiates; perhaps funds could be supplemented from taxes on noisier vehicles.

(4) Time-Phasing Controls

Financial constraints may make it impossible to excercise all controls at one time. Consequently, when such constraints are severe it is suggested that in-use controls (along with fines imposed by localities) be imposed immediately, because significant benefits can be attained with little time delay and with little cost to bystanders (Figure III-2). This control should be followed, before 1985, by a second round truck regulation, technology, research, a retrofit program for noisy trucks and the construction of barriers in noise "hot spots," along with noise reduction innovations. The most severe exposure problems can be addressed in this manner.

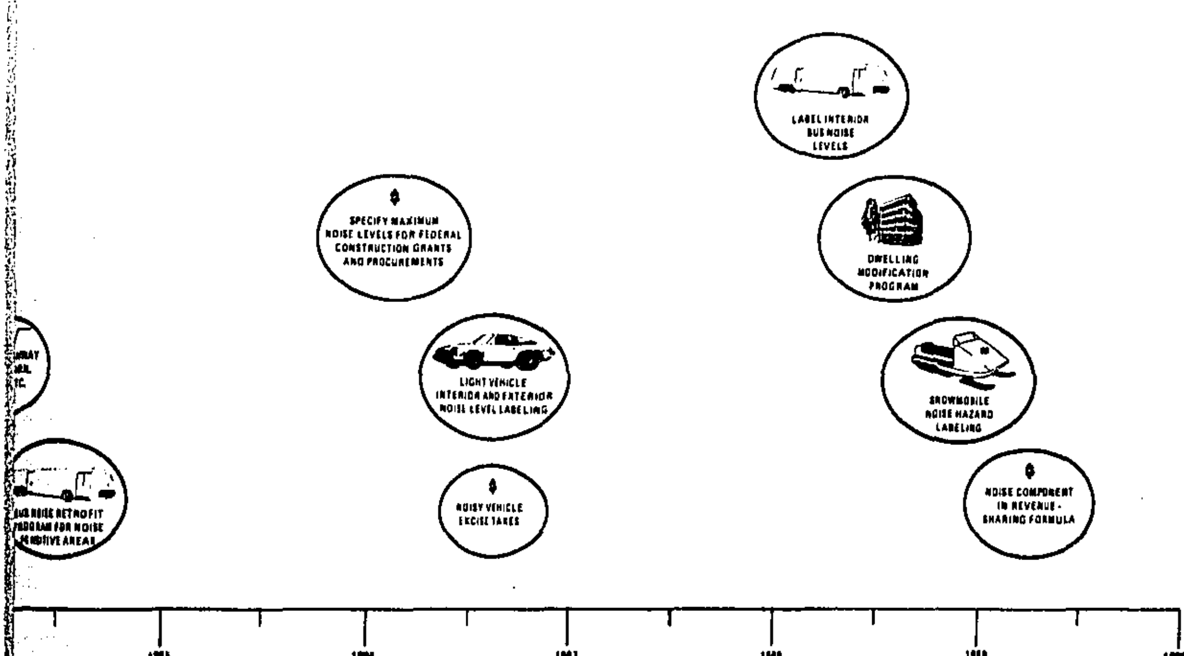
The motorcycle noise problem should be addressed next with promulgation of the new product regulation proposed by EPA, supported by the retrofitting and financial incentives proposed in this substrategy.

TIME PHASI



MOTORCYCLE REGULATION
MOTORCYCLE RETROFIT PROGRAM
MOTORCYCLE AND PARTS LABELING & INFORMATION PROGRAMS REGULATION
$
MANUFACTURER FUNDED CERTIFICATION FOR NOISE INFORMATION PROGRAMS BASED ON PRODUCT NOISE LEVELS
$
LOCAL NOISE VIOLATION FINES
MEDIUM/HEAVY TRUCK RETROFIT (PRE-1978 MODELS) REGULATION
RECESSED HIGHWAY CONSTRUCTION, ZONING, ETC.
LOCAL NOISE PROGRAMS FOR OPERATING PROCEDURES (SPEED, ROUTES, CURFEWS, TRAFFIC FLOW) AND MAINTENANCE (EXHAUSTS, INSPECTIONS)
MEDIUM/HEAVY TRUCK REGULATION REVISION
CONSTRUCT BARRIERS ON NEW HIGHWAYS WITH MAXIMUM LOADS
$
MANUFACTURER FUNDED LABELING PROGRAMS BASED ON PRODUCT NOISE LEVELS
BUS REGULATION
BUS NOISE RET PROGRAM FOR SENSITIVE A
1979
1980
1981
1982
1983
1984

FIGURE III-2
PHASING OF PROPOSED CONTROLS



In the time between 1978 and 1985 it is suggested that a public education campaign promoting noise avoidance proceed at full speed. The bus regulation, as proposed, should be promulgated and buses in noise sensitive areas should be retrofitted. In addition, quietness should be engineered into newly constructed highways. This timing is suggested to alleviate bus-related noise complaints. Also, it is important that noise be considered in the design stage of highways. This should be done immediately.

The second wave of noise controls is proposed to be instituted with full emphasis not later than 1985. The following controls should be included in this second wave. (1) Maximum noise levels should be prescribed for projects utilizing Federal grant and procurement funds. (2) Interior and exterior noise labels should be attached to light vehicles and disseminated along with mileage information in various printed media. The announcement that this is forthcoming should be made now. (3) Excise taxes should be imposed on noisier vehicles. (4) Buses should be labeled interiorally. (5) Dwellings should be modified to control noise exposure with financing primarily derived from taxes collected from major noise contributors, but including the use of highway trust funds. (6) Snowmobiles should be labeled, and purchasers should be informed about the ill effects of noise. (7) Community and State noise programs should be incorporated into revenue sharing formulae. The primary reason for not starting these controls as early as the previous ones is because in many cases the announcement effect can be exploited; i.e., by announcing a future action now, consumers and producers will adjust their patterns without a controlling agency's active involvement. Other reasons are the lack of an acceptable measurement procedure for light vehicles, the uncertainty about the probable noise exposure reduction benefits, and the speed of tax legislation.

(5) Noise Abatement and Control Participants

As alluded to earlier, the noise problem in the U.S. cannot be solved by relying merely on one control administered by one agency. It involves concern throughout the country. Possible participants range from EPA to HUD in the public sector and from consumers to producers in the private sector. A partial list of participants is found in Table III-2.

## Table III-2
## MAJOR PARTICIPANTS IN THE U.S. NOISE ABATEMENT PROGRAM

| Vehicles | Controls | Major Participants: Industry | State | Local | Federal: EPA | Federal: Other |
|---|---|---|---|---|---|---|
| | SOURCE CONTROLS | | | | | |
| | New Product Regs | | | | | |
| Medium/Heavy Trucks | As promulgated; | | | | X | DOT |
| | Second round ASAP; | | | | X | DOT/DOC |
| | Height of source emission; | | | | X | DOT |
| | Tires (technology) | X | | | X | DOT/DOC |
| Motorcycles | As proposed by EPA | | X | X | X | DOT/DOA/DOC |
| Buses | As proposed by EPA | | X | X | X | DOT/HUD/DOC |
| | Retrofitting | | | | | |
| Medium/Heavy Trucks | For those built before Jan. 1, 1978 | | X | X | X | DOT |
| Buses | For those in "noise sensitive" areas | | X | X | X | DOT/HUD |
| Motorcycles | To meet levels proposed by EPA for new motorcycles | | X | X | X | DOT/DOA |
| | Noise Emission Information | | | | | |
| Buses | Label interior levels | X | X | X | X | DOT/GSA |
| Motorcycles | Label; also label noise attenuating parts; inform purchaser of hazards of high noise exposure | X | X | X | X | DOT/DOA |
| Light Vehicles | Label interior and exterior levels; print information | X | X | X | X | DOT/GSA |
| Snowmobiles | Label; inform purchaser of hazards of high noise exposure | X | X | X | X | DOA |
| | In-use Controls | | | | | |
| All vehicles | Local programs for: Defective exhausts; Speed reduction; Operation; Routes; Curfews; Inspections (with noise codes); Traffic flow (self-financing through fines and fees) | | X | X | X | DOT/DOD |
| | PATH CONTROLS | | | | | |
| | Barriers | | | | | |
| Medium/Heavy Trucks Light Vehicles/Buses | Along newly constructed highways where maximum projected loads a problem | | X | X | X | DOT |
| Medium/Heavy Trucks Light Vehicles/Buses | Along existing roadways where no other alternatives available | | X | X | | DOT |
| | RECEIVER CONTROLS | | | | | |
| | Land Use | | | | | |
| Medium/Heavy Trucks/ Light Vehicles | Recessed highway construction | | X | X | X | DOT |
| All vehicles | Zoning | | X | X | X | DOD/DOT/ DOA/HUD/DOT |
| All vehicles | Dwelling modifications | | X | X | X | HUD/DOC/DOE/ DOL/GSA/HEW |
| All vehicles | Public education | | X | X | X | HUD/DOA/DOT/ GSA/HEW/DOD |
| | FINANCIAL INCENTIVES AND DISINCENTIVES | | | | | |
| —All vehicles Except Medium Heavy Trucks | Certification costs for noise information programs paid for by manufacturers of noisy vehicles | X | X | X | X | DOT |
| All vehicles | Labeling costs funded from earmarked taxes and fees with producers of noisier equipment paying more than ·roducers of quiet equipment | X | X | X | X | Treasury |
| All vehicles | Local programs financed by fines of violators | | X | X | | |
| All vehicles | Noise component included in revenue sharing formula | | X | X | | Treasury |
| All vehicles | Maximum noise levels specified for federal construction grant programs and procurement | | | | X | DOT/GSA/DOD/ Others |
| All vehicles | Excise taxes levied on noisy vehicles | | X | X | | Treasury |

(6) Summary

Table III-3 summarizes the major suggestions advanced in conjunction with the analysis in this substrategy and Table 4 indicates several major participants in the fight against noise. Additionally, Appendix H lists several acceptable alternatives and Figure 7 lists the proposed time-phasing. These solutions only indicate the general direction of the national surface vehicle substrategy and are designed to assist all sectors of the U.S. economy in their noise abatement efforts. It must be reiterated that local conditions and preferences do not lend themselves to averaging. Consequently, the nationally acceptable controls should not be accepted by any community without considering their own conditions and needs. Local conditions may call for stricter controls than those suggested here.

Without addressing special local conditions we can formulate several major conclusions from the previous discussion:

1. Without government action the community noise exposures and operator noise exposures originating from road vehicles will grow significantly.

2. It will be difficult, if not impossible, to eliminate the exposure growth by applying any source controls presently under the purview of EPA. Certainly the exposure goals, as they relate to road vehicle contributions, consisting of (a) eliminating hearing loss resulting from noise exposure, and (b) reducing environmental noise exposure to no more than Ldn 75 dB, 65 dB, or 55 dB cannot be met with these source controls. One reason is that no current technology can be employed to solve the problem. Even as fleet noise levels are reduced, the fleet expansion and population expansion will offset, at least in part, the advances made in reducing noise exposures.

3. Source controls under the purview of non-EPA authorities must be used intensively to give significant noise exposure relief. These authorities include Federal agencies (like the DOT's National Highway Traffic Safety Administration) and especially State and local governments.

4. Even when non-EPA source controls are used to any reasonable level, a significant amount of noise exposure remains. A portion of this exposure can be eliminated with path controls such as barriers.

Table III-3
SUMMARY OF RECOMMENDED CONTROLS

<u>Financial Incentives and Disincentives</u>

1. Certification costs for noise information programs paid for by manufacturers of noisy vehicles
2. Labelling costs funded from earmarked taxes and fees with producers of noisier equipment paying more than producers of quiet equipment
3. Local programs financed by fines of violators
4. Noise component included in revenue sharing formula
5. Maximum noise levels specified for federal construction grant programs
6. Excise taxes levied on noisy vehicles

| | SOURCE CONTROLS | | | | PATH CONTROLS | RECEIVER CONTROLS |
|---|---|---|---|---|---|---|
| | New Product Regs | Retrofitting | Noise Emission Info | In-use Controls | | |
| MHT | As promulgated;<br>Second round ASAP;<br>Height of source emission;<br>Tires | For those built before Jan. 1, 1978 | | | <u>Barriers</u><br>Along newly constructed highways where maximum projected loads a problem<br><br>Along existing roadways where no other alternatives available<br><br><u>Land Use</u><br>Recessed highway construction where applicable<br><br>Dwelling modifications | |
| Bus | As proposed by EPA | For those in "noise sensitive" areas | Label interior levels | | | |
| MC | As proposed by EPA | To meet levels proposed by EPA for new motorcycles | Label; also label noise attenuating parts; Inform purchaser of hazards of high noise exposure | Local programs for:<br>Defective exhausts<br>Speed reduction<br>Operation<br>Routes<br>Curfews<br>Inspections (with noise codes)<br>Traffic flow | | Public education leading to evasive actions |
| LV | | | Label interior and exterior levels | | | |
| SM | | | Label; inform purchaser of hazards of high noise exposure | | | |

MHT = Medium/Heavy Trucks
Bus = Buses
MC = Motorcycles
LV = Light Vehicles
SM = Snowmobiles

5. Part of the remaining exposure may be eliminated by introducing noise oriented innovations by encouraging the transfer of available technology into current technology, or by developing future technology and bringing it into use. This can be encouraged by all sectors of the economy through external stimulation to industry, financial disincentives for complacency in noise abatement technology development, and financial incentives as positive reinforcements for technology progress.

6. Even if all the aforementioned controls were utilized to an optimum degree, residual exposures are likely to remain in the Ldn 75 dB, 65 dB, and 55 dB ranges. In part these population exposures can be avoided through receiver controls, one of which is to inform the public about the adverse effects of noise.

In summary, everyone must participate in a concerted effort to solve the noise problem—industry, the Federal Government, State and local governments, and the population as a whole. The noise problem cannot be solved unilaterally by any sector in the United States.

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