United States
Environmental Protection
Agency

Office of Noise Abatement
and Control (ANR-490)
Washington, D.C. 20460

EPA 550/9-80-212
July 1980

N-96-01

Noise

II-A-107

EPA

Regulatory Analysis for the Final Noise Emission Regulation for Buses

N-96-01
II-A-107
EPA 550/9-80-212

Noise Emission Standards for Surface Transportation Equipment

Regulatory Analysis for the Final Noise Emission Regulation for Buses

July 1980

U.S. Environmental Protection Agency
Office of Noise Abatement and Control
Washington, D.C. 20460

T A B L E   O F   C O N T E N T S

TABLE OF CONTENTS
(continued)

TABLE OF CONTENTS
(continued)

TABLE OF CONTENTS
(continued)

FIGURES (Continued)

TABLES

TABLES (continued)

TABLES (continued)

TABLES (continued)

TABLES (continued)

TABLES (continued)

TABLES (continued)

TABLES (continued)

TABLES (continued)

SECTION 1

INTRODUCTION

Background

This Regulatory Analysis presents the basic information relevant to the development of noise emission standards for newly manufactured buses. The topics of major concern are: the noise emissions of buses and the technology for controlling the noise; noise measurement methodology; the environmental noise impact caused by operation of buses in the community; the reduction in noise impact expected from the establishment of noise limits for newly manufactured buses; and the economic status of the industry and the potential costs and economic effects of a noise regulation.

As a result of studies conducted under the authorities and duties given to the Administrator of the Environmental Protection Agency under the Noise Control Act of 1972 (the Act), buses were identified as a major source of noise on May 28, 1975 (40 FR 23105). In order to ascertain the basic data required to promulgate a noise regulation conforming to the requirements laid down in the Act, a program of detailed studies was undertaken by the Agency. These studies dealt with the areas of concern outlined above, and entailed a search of the pertinent industry and government statistics and the available technical literature, measurements of the noise emissions of a substantial number of buses, both new and in service, and associated analyses. In order to develop the factual data and gather the opinions of concerned persons and organizations, germane to the regulatory provisions and process, contacts were made with all segments of the affected industry, governmental units at various levels (Federal, state and local) and the general public.

Based on the results of this information gathering process and under the requirements of Section 6 of the Act, the Agency published a proposed noise emission regulation for newly manufactured buses on September 12, 1977 (42 FR 45775). A ninety day public comment period was opened from September 12, 1977 until December 11, 1977 and hearings were held in Washington, D.C. on October 25, 1977 and in San Francisco, California on November 1, 1977. Numerous comments were received from many different segments of the public through written submittals and at public hearings, and through communications with industry associations, as well as by further testing and analysis. The Agency thoroughly reviewed this information and, based on the results of this review, made six major revisions to the regulation and a number of clarifying changes. The public comments and the Agency's responses are summarized in the "Docket Analysis for the Final Noise Emission Regulation for Buses", EPA Document Number 550/9-80-213, a companion publication to this Regulatory Analysis. The revisions to the regulation are detailed in the preamble to the final regulation, which is published contemporaneously with this Regulatory Analysis.

Public Participation

Throughout the development of this regulation an effort has been made to allow all groups, organizations, and individuals who have an interest in, or who may be directly affected by, bus noise emission standards, the opportunity to participate in the rulemaking process. This public participation effort has included meetings with bus operator groups; bus industry associations; bus body and chassis manufacturers; bus distributors and concerned state, county, and city officials. A list of the organizations and individuals contacted in the development of this regulation is included as Appendix A to the Docket Analysis.

As another step in the Agency's continuing public participation program, an extensive effort is underway to inform the public of the benefits and impacts of the noise emission standards for buses. This effort will include direct mailings of information packets to the major groups affected by the regulation and briefings to selected groups. Appendix B to the Docket Analysis lists the groups that are to be contacted in this informative public participation effort.

Statutory Basis for Action

Through the Noise Control Act of 1972 (86 Stat. 1234), Congress established a national policy "to promote an environment for all Americans free from noise that jeopardizes their health and welfare." In pursuit of this policy, Congress stated in Section 2 of the Act that "while primary responsibility for control of noise rests with state and local governments, Federal action is essential to deal with major noise sources in commerce, control of which requires national uniformity of treatment."

As part of this essential Federal action, Section 5(b)(1) of the Act requires that the Administrator of the U.S. Environmental Protection Agency, after consultation with the appropriate Federal agencies, publish a report or series of reports "identifying products (or classes of products) which in his judgment are major sources of noise." Section 6 (a)(1) of the Act requires the Administrator to publish proposed regulations for each product identified as a major source of noise and for which, in his judgment, noise standards are feasible. Four categories of products are listed as potential candidates for regulation; one of these is transportation equipment.

It was under the authority of Section 5(b)(1) that the Administrator published the report on May 28, 1975 (40 FR 23105) that identified buses as a major source of noise, and under the requirements of Section 6(a)(1) that the Administrator published the Notice of Proposed Rulemaking (42 FR 45775) to control the noise emissions of newly manufactured buses. It is also under this authority and requirement that the final regulation is published.

Preemption

Section 6(e)(1) of the Noise Control Act states that after the effective date of a Federal regulation "no State or political subdivision thereof may adopt or enforce... any law or regulation which sets a limit on noise emissions from such new product and which is not identical to such regulation of the Administrator." Section 6(e)(2), however, states that "nothing in this section precludes or denies the right of any State or political subdivision thereof to establish and enforce controls on environmental noise (or one or more sources thereof) through the licensing, regulation, or restriction of use, operation or movement of any product or combination of products." The central point to be developed here is the distinction between noise emission standards on products, which may be preempted by Federal regulations, and standards on the use, operation or movement of products, which are reserved to the States and localities by Section 6(e)(2).

Section 6(e)(2) forbids States and local municipalities from controlling noise from products through laws or regulations that prohibit the sale (or offering for sale) of new products for which different Federal noise emission standards already have been promulgated. States and localities may augment the enforcement duties of the EPA by enacting a regulation identical to the Federal regulation, since such action on the State or local level would assist in accomplishing the purpose of the Act. Further, State and local municipalities may regulate noise emissions for all new products that were manufactured before the effective date of the Federal regulation(s).

Section 6(e)(2) explicitly reserves to the States and their political subdivisions a much broader authority: the right to "establish and enforce controls on environmental noise (or one or more sources thereof) through the licensing, regulation or restriction of the use, operation, or movement of any product or combination of products." Environmental noise is defined in Section 3(11) of the Act as the "intensity, duration, and character of sounds from all sources". Limits may be proposed on the total character and intensity of sounds that may be emitted from all noise sources, "products and combinations of products."

In summary, the noise controls which are reserved to State and local authority by Section 6(e)(2) include, but are not limited to, the following:

(1) Controls on the manner of operation of products

(2) Controls on the time during which products may be operated

(3) Controls on the places at which products may be operated

(4) Controls on the number of products which may be operated together

(5) Controls on noise emissions from the property on which products are used

(6) Controls on the licensing of products

(7) Controls on environmental noise levels.

State and local governments may regulate community noise levels more effectively and equitably than the Federal government due to their perspective on, and knowledge of, State and local situations. The Federal government assumes the duties involved in regulating products distributed nationwide because it is required and equipped to do so. Congress divided the noise emission regulation authorities in this manner to allow each level of government to fulfill that function for which it is best suited. Through the coordination of these divided authorities, a comprehensive regulatory program can be effectively designed and enforced.

Labeling

The enforcement strategies outlined in Section 9 of this document are accompanied by the requirement for labeling products distributed in commerce. The label provides notice to a buyer that a product is sold in conformity with applicable regulations. The label also makes the buyer and user aware that the bus possesses noise attenuation devices and that tampering with such items is prohibited. However, this labeling should not be confused with thjat required under Section 8 of the Act.

Acoustical Assurance Period

The attainment of the estimated health and welfare benefits from noise regulation is dependent upon the regulated products continuing to comply with the Federal not-to-exceed noise emission standard for a set period of time or use.

The Agency has given considerable attention to the question of product noise degradation (increase in noise level with time). It is the Agency's belief that if a product is not built such that it is even minimally capable of meeting the standard while in use over a specified initial period, when properly used and maintained, the standard itself will be ineffective and the anticipated health and welfare benefits will not be achieved.

Consequently, the Agency has developed the concept of an "Acoustical Assurance Period" (AAP). The AAP is defined as that specified initial period of time or use during which a product must continue to be in compliance with the Federal standard, provided it is properly used and maintained according to the manufacturer's recommendations.

The Acoustical Assurance Period is independent of the product's operational (useful) life, which is the period of time between sale of the product to the first purchaser and last owner's disposal of the product. The Acoustical Assurance Period is product-specific and thus may be different for different products or classes of products. The AAP is based, in part, upon:

(1) the Agency's anticipated health and welfare benefits over time resulting from noise control of the specific product, (2) the product's known or estimated periods of use prior to its first major overhaul, (3) the average first owner turnover (resale) period (where appropriate), and (4) known or best engineering estimates of product-specific noise level degradation (increase in noise level) over time.

The AAP requires the product manufacturer to assure that the product is designed and built in a manner that will enable it to comply with the Federal noise emission regulation which exists at the time the product is introduced into commerce, and that it will continue to conform with the applicable regulation for a period of time or use not less than that specified by the AAP.

Summary of Regulatory Analysis

The subjects addressed in this document are intended to provide background information on various aspects associated with the development of the regulation. The material presented in the Regulatory and Docket Analysis and the listed references constitute the basis for decisions revelant to the regulation of bus noise emissions.

Section 2 - "Identification of Buses as a Major Source of Noise." This section addresses the reasons for the classification of buses as a major source of noise.

Section 3 - "The Bus Industry." This section presents general information about the U.S. bus industry. It covers industry growth statistics; descriptions of intercity, transit and school bus systems; bus classifications; product life cycle estimates and other useful descriptive material.

Section 4 - "Bus Noise Data Base." This section details the results of exterior and interior bus noise level measurements conducted by EPA on transit, intercity, and school buses. Bus noise data from existing studies and from industry submissions are also presented.

Section 5 - "Noise Abatement Technology." In order to establish regulations restricting bus noise emissions, it was necessary to determine what constitutes the "best available technology" for bus noise reduction. Section 5 reviews the various components of exterior bus noise: noise radiated from the engine surface, fan intake, exhaust system and chassis. In addition to the exterior noise generating components, the interior noise of buses is also discussed along with the associated technology needed to reduce bus interior noise levels.

Consideration is given to the total bus noise problem. The technology is examined to determine what modifications or redesign work might be performed on buses in order to quiet them to levels below those which presently exist.

Section 6 - "Potential Impact of Proposed Bus Noise Regulation Schedules on the Environment." This section describes what health and welfare benefits would accrue from the institution of various regulatory options for exterior and interior bus noise. The percentage of the population affected by noise and the extent of the effect is measured by the Level Weighted Population (LWP) method. The reduction of potential equivalent impacts of sleep disturbances, sleep awakenings, and speech interferences from the lowering of exterior bus noise are detailed. In addition, the reduction of Level Weighted Population of hearing loss risk and speech interference effects from a lowering of interior bus noise are presented.

Section 7 - "Economic Impact of Bus Noise Control." In this section, the economic impact of increased bus costs due to the basic engineering changes (outlined in Section 5) that are believed to be required to achieve various levels of interior ad exterior bus noise is presented. The potential economic impacts on the three main types (intercity, transit, and school) of bus manufacturers and bus operators are evaluated.

Section 8 - "Measurement Methodology." This section reviews and examines the various test procedures that have been used to determine noise levels for buses. The EPA designated procedures for the measurement of exterior and interior bus noise emissions are presented.

Section 9 - "Enforcement." Enforcement of new product noise emission standards applicable to buses is discussed in terms of manufacturer self-certification through production verification testing of vehicle configurations, assembly line testing using selective enforcement auditing procedures or continuous testing of production vehicles, and in-use compliance provisions.

Section 10 - "Existing Noise Regulations Applicable to Buses." This section presents existing bus noise regulations, both foreign and domestic, and the history of such regulations.

Appendix A - "Foreign Technology Buses." This appendix presents a description of urban transit buses produced by European bus manufacturers.

Appendix B - "Thermostatically Controlled Fans." This appendix discusses the various types of thermostatically controlled fans and the rationale for requiring the fans to be engaged during compliance testing.

Appendix C - "Fractional Impact Procedure." This appendix summarizes the procedure used in assessing the health and welfare impact and benefits to be derived from regulating noise emissions.

Appendix D - "National Roadway Traffic Noise Exposure Model." This appendix presents in detail the workings of the health and welfare model known as the National Roadway Traffic Noise Exposure Model.

Appendix E - "Data on Interior Noise Levels." This appendix presents data on interior bus noise levels.

Appendix F - "Additional Supporting Information for Health and Welfare Analysis." This appendix provides various tables in support of the health and welfare analysis presented in Section 6.

Appendix G - "Bus Noise Abatement Costs." Presented in this appendix are the estimated costs increases and decreases required to manufacture quiet buses for the various technology levels discussed in Section 5.

Appendix H - "Estimates of Demand Elasticities for Urban Bus Transit and Intercity Bus Transportation." This appendix reviews some pertinent economic literature and reports estimates made of the fare elasticity of demand for both transit and intercity riders.

Appendix I - "Uniform Annualized Costs of Bus Noise Abatement." This appendix presents the annualized costs of the various bus noise abatement regulatory schedules.

Appendix J - "Model Noise Ordinance." This appendix provides information for State and local governments to aid them in preparing local noise ordinances for bus noise abatement.

SECTION 2

RATIONALE FOR REGULATION OF BUSES

On May 28, 1975 buses were identified as a major source of noise and as such was a candidate for regulation. This section presents the rationale that was used to identify buses as a major source of noise.

In determining whether a product (or class of products) is a major noise source for regulation under Section 6 of the Act, the Administrator considers primarily the following factors:

1. The intensity, character and/or duration of the noise emitted by the product (or class of products) and the number of people impacted by the noise;

2. Whether the product, alone or in combination with other products, causes noise exposure in defined areas under various conditions, which exceed the levels requisite to protect the public health and welfare with an adequate margin of safety;

3. Whether the spectral content or temporal characteristics, or both, of the noise make it irritating or intrusive, even though the noise level may not otherwise be excessive;

4. Whether the noise emitted by the product causes intermittent single event exposure leading to annoyance or activity interference.

The Agency has given first priority to those products that contribute most to overall community noise exposure. Community noise exposure is defined as that noise exposure, experienced by the community as a whole, which is the result of the operation of a product or group of products: not only that exposure experienced by the user(s) of the product(s).

The day-night sound level, L_{dn}, has been specifically developed as a measure of community noise. Since it is a cumulative energy measure, it can be used to identify areas where noise sources operate continuously or where sources operate intermittently but are present enough of the time to emit a substantial amount of sound energy in a 24-hour period.

EPA has identified an outdoor L_{dn} of 55 dB[1] as the day-night sound level requisite to protect the public from long-term adverse health and welfare effects in residential areas, and a 24-hour equivalent sound level, L_{eq} (24), of 70 dB as the threshold of hearing impairment.

An abbreviated summary of the identified levels requisite to protect the public health and welfare is given in Table 2-1.

TABLE 2-1

NOISE LEVELS PROTECTIVE OF HEALTH AND WELFARE

Human Response	Leq	Ldn
Hearing Loss (8 hours)	75	--
Hearing Loss (24 hours)	70	--
Outdoor Interference and Annoyance	--	55
Indoor Interference and Annoyance	--	45

Source: Reference 1

The fractional impact of a noise environment on an individual as used by EPA is proportional to the amount (in decibels) that the noise level exceeds the appropriate level identified in the "Levels Document" (Ref. 1) as shown in Table 2-1. The fractional impact is zero when the noise level is at or below the identified level. The fractional impact rises to 1.0 at 20 decibels above the identified level and can exceed unity in situations in which the noise level exceeds 20 decibels above the identified level. The range from zero to 20 decibels above the criterion level represents the range between those noise levels that are totally acceptable and those noise levels that are totally unacceptable to communities in terms of annoyance responses.

1 All noise levels presented in this entire Regulatory Analysis are expressed in terms of A-weighted decibels.

The total Level Weighted Population (LWP)[2] is then determined by summing the individual fractional impacts for all people affected by the environment. Thus, two people exposed to 10 decibels above the identified level (fractional impact = 0.5) would be equivalent to one person exposed to 20 decibels above the identified level (fractional impact = 1.0).

Studies have been made of the number of people exposed to various levels of community noise. Table 2-2 summarizes the 1974 estimated number of people in residential areas subjected to noise from urban traffic, freeway traffic, and aircraft operations at or above outdoor L_{dn} values ranging from 60 to 80 dB.

TABLE 2-2

ESTIMATED CUMULATIVE NUMBER OF PEOPLE IN MILLIONS IN THE UNITED STATES RESIDING IN URBAN AREAS WHICH ARE EXPOSED TO VARIOUS LEVELS OF OUTDOOR DAY-NIGHT SOUND LEVEL

Outdoor L_{dn} Exceeds	Urban Traffic	Freeway Traffic	Aircraft Operations	Total
60	59.0	3.1	16.0	78.1
65	24.3	2.5	7.5	34.3
70	6.9	1.9	3.4	12.2
75	1.3	0.9	1.5	3.7
80	0.1	0.3	0.2	0.6

Source: Reference 1.

The table shows that many millions of United States residents are subjected to day-night sound levels in excess of 60 dB; the bulk of the noise exposure being due to traffic noise. In order to reduce this noise exposure

2 LWP term is used interchangeably with Equivalent Noise Impact (ENI) and Equivalent Population (Peq).

significantly, it will be necessary to apply noise control measures to many of the major sources of noise in the environment.

Other Considerations

The preparation of noise emission regulations necessitates other considerations. Included among these other factors are available noise reduction technology, voluntary industry noise standards, the interrelationship of regulations, lead time necessary for the development of a regulation, economic impact, and the relative availability of data. All these factors have been considered in the development of the regulatory noise levels for buses.

REFERENCES

SECTION 2

1. U.S. EPA, "Information in Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety." March, 1974. 550/9-74-004.

SECTION 3

THE BUS INDUSTRY

GENERAL INDUSTRY BACKGROUND

Early buses, many of which utilized steam power, were designed and constructed in Europe and America at various times during the 1800's. Although some of these primitive buses were effective in passenger transportation, none of them were used for more than short periods of time. Reasons for their lack of success included poor roads, competition from railroads and stagecoaches, and the unreliable operating characteristics of the units themselves.

Bus transportation, as it is now perceived, began to take form in the early 1900's following the development of the internal combustion engine. Bus service was started in New York City and on the Pacific Coast in 1905. In many cases the vehicles used were ordinary passenger touring cars.

Development and improvement of bus design and construction were begun early and have continued to the present time. Touring car chassis were elongated to provide somewhat larger passenger carrying capacity and eventually passenger carrying bodies were mounted on truck chassis to provide the basis for the modern bus. During the middle 1930's, transit and intercity bus manufacturers began combining the chassis and body, utilizing principles of airplane construction. At the same time, it became common to mount the engine at the rear of the bus or under the floor instead of the traditional underhood mounting at the front. These developments resulted in greater strength and longer wear of buses, as well as greater comfort and safety for passengers, better driving vision, greater passenger capacity, and improved riding qualities.

School bus manufacturers continue to produce most of their models by mounting passenger carrying bodies on to truck chassis with forward mounted underhood engines. Transit and intercity buses are generally integrally constructed with under-floor rear mounted engines.

There is no reason to expect any change in these trends in the near future. The only major production changes which have been made in recent years were in the transit industry, where the 1959 standard "New Look" buses have been replaced by new Advanced Design Bus and articulated buses.

The Advanced Design Bus (ADB), built by both GMC and Flxible, was developed with the hope of reducing maintenance cost. Flxible eliminated the need for a frame by using new integral construction techniques. Due to the greater accessibility of mechanical components, routine service was conducted more quickly. The other manufacturer, General Motors, is employing a stainless steel module approach to construct the bus shell. Snap or fiberglass panels are designed to reduce maintenance problems caused when body damage occurs to the riveted skin of existing transit buses. Both designs require fewer parts and most of the changes have been designed to improve handling, rider comfort and appearance. The GMC and Flxible models are spinoffs of their prototypes built for the Transbus program. The Urban Mass Transportation Administration, through the Transbus program, is urging further modification, the most important of which would include lowering the bus floor; however, the future of this program is still indefinite.

The articulated bus is widely used around the world but it has been, until recently, virtually unknown in North America. The buses are 50 percent longer than standard buses, but they have accordian pleats in the middle that make them more manueverable than the regular models. These buses are being used on routes with heavy ridership. Their purpose is to increase the efficiency and productivity of the transit system.

The Motor Vehicle Manufacturers Association estimates the current size of the bus industry as follows:

1978 bus registrations - 500,362

1978 bus sales - 35,342

The general structure of the bus industry is schematically outlined in Figure 3-1. The figure illustrates:

1. Bus manufacturing operations obtain raw materials and components used in the manufacturing process from raw materials suppliers and component manufacturers.

2. Channels of distribution differ for integral (transit and intercity) buses and school buses. Integral bus manufacturers deal directly with end-users, while the distribution channel for most school buses is through body and/or chassis distributors.

3. Finished products are sold to school boards, intercity bus companies, transit authorities, sightseeing companies, or airports for passenger transportation.

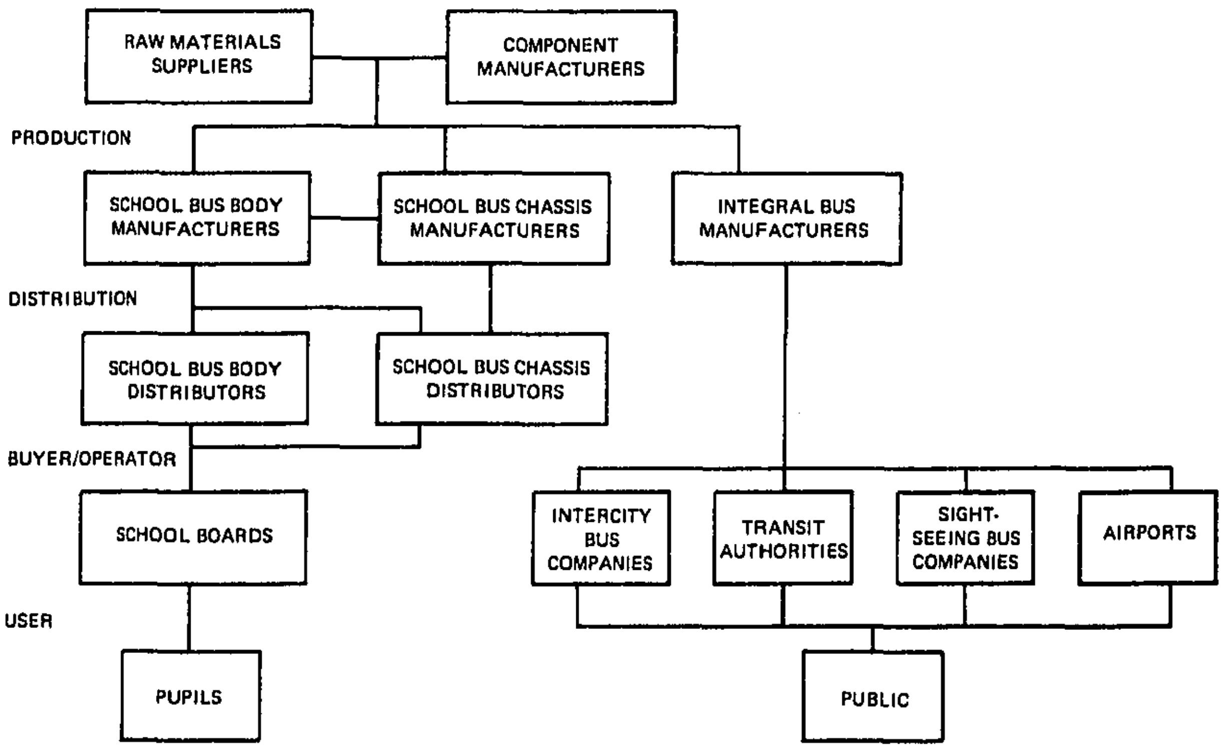
It should be stressed that Figure 3-1 is an overview of the structure of the industry and not all buyer/operators of buses are represented. Most significant of those excluded are government departments and agencies. Also, some integrally constructed buses are used as school buses.

THE BUS MARKET

The bus market is comprised of bus users and operators who provide multiple passenger transportation to the public. The market includes the following:

FIGURE 3-1

STRUCTURE OF THE BUS INDUSTRY



SOURCE: INDUSTRY INTERVIEWS

- Commercial Intercity Class 1, 2 and 3 Carriers
- Local or regional transit systems
- School Boards or Administrations
- Churches, Private Schools and Related Organizations
- Federal, state and local government agencies and departments
- All others
- Airports
- Hotels
- Demand response agencies or organizations
- Social services.

A brief overview of the most significant end-users is presented below. In 1978, three market segments - intercity bus carriers, transit authorities and school boards - accounted for approximately 83% of the buses in use.

(a) Commercial Intercity Class 1, 2, 3 Carriers[1]

The intercity bus operation in the United States is performed by approximately 1,050 operating companies utilizing some 20,100 motor coaches (Table 3-1). They provide regularly scheduled service over 270,000 miles of highway and employ an estimated 48,900 people. Intercity bus operations service over 15,000 cities and towns and are the only public intercity transportation service available to some 14,000 of them. In 1976, an estimated 340 million trips were taken by passengers. In 1977, the intercity buses operated over 1.1 billion miles.

---

1. Class designations are formed using annual revenue dollars:
Class 1 Carriers have revenues of $3,000,000 or more.
Class 2 Carriers have revenues between $500,000 and $3,000,000.
Class 3 Carriers have revenues less than $500,000.

TABLE 3-1

INTERCITY BUS INDUSTRY OPERATING PROFILE

	1970	1971	1972	1973	1974	1975	1976	1977	1978 (p)	1979(est)
Number of Operating Companies (Class 1, 2, 3 Carriers)	1,000	1,000	1,000	1,000	950	950	1,000	1,050	1,100	-
Number of Buses	22,000	21,900	21,400	20,800	21,000	20,500	20,100	20,100	20,205	21,100
Number of Employees	49,500	50,200	49,100	48,400	49,400	46,700	46,000	48,900	43,600	-
Miles Operated (Millions)	1,209	1,202	1,182	1,178	1,195	1,120	1,118	1,120	1,082	-
Revenue Passengers (Millions)	401	395	393	381	386	351	340	332	-	-
Operating Revenues ($ Millions)	901.4	953.2	974.4	1,022.7	1,151.9	1,171.6	1,231.9	-	-	1,500 +
Operating Expenses ($ Millions)	812.2	851.8	882.1	937.9	1,070.0	1,103.2	1,179.9	-	-	-
Net Operating Revenues, Before Income Taxes ($ Millions)	89.2	101.4	92.3	84.8	81.9	68.4	52.0	-	-	-

SOURCES: National Association of Motor Bus Owners, One-Half Century of Service to America, 1976
American Bus Association, Bus Facts, 1978.
Motor Vehicle Manufacturers Association. - 1979 "Facts and Figures"
P = Preliminary

Operating revenue of intercity bus lines was $1,231.9 million in 1976, up 36.7% from the 1970 level. During this same period, the number of miles operated and the number of revenue passengers declined 7.4% and 15.2% respectively. In 1976, net operating revenues before income taxes declined 41.9% from the 1970 figure.

(b) Transit Systems

In 1978, 965 transit systems utilized 52,866 buses and employed approximately 162,500 individuals. In 1976, they transported 4,168 million passengers. (See Table 3-2). Operating revenue attributed to motor bus operations reached $1,671 million in 1978.

Inspection of the total industry figures indicates that in spite of continued increases in revenue, transit systems have shown operating losses through the last eight years. These revenues have increased 33.5% while losses are 7.7 times larger than they were in 1970. These losses were $2,214.8 million in 1977 and $288.2 million in 1970.

(c) School Boards or Administrations

Pupil transportation is provided by public school operations for both public and private school children. These operations of the transportation systems are either assumed by local boards or contracted to independent operators. School bus operations are funded primarily with public monies, although certain private schools receive no funding. Depending on the local tax base and the area covered by the school districts, these funds are allocated on a per capita pupil basis or on total miles driven by the school bus fleet.

In the 1977/78 school year, 21,660,839 public and non-public school children were transported on a regular basis at an operating cost of $2,852.5 million. Table 3-3 shows the average cost of a pupil transported at public expense during the 1977/78 school year to be $131.69. This average figure reflects a continuing upward trend in the cost of pupil transportation since the 1959/60 school year when the average cost per pupil was $39.78.

TABLE 3-2

TRANSIT BUS INDUSTRY OPERATING PROFILE

	1970	1971	1972	1973	1974	1975	1976	1977	1978
Number of Systems Utilizing Buses	1,075	1,059	1,040	N.A	941	941	950	1,004	965
Number of Buses	49,700	49,150	49,075	48,286	48,700	50,811	52,382	51,968	52,866
Number of Employees[1]	138,040	139,120	138,420	140,700	153,100	159,800	162,950	162,510	*162,500
Passenger Vehicle Miles Operated (Millions)	1,409.3	1,375.5	1,308.0	1,370.4	1,431.0	1,528.0	1,581	1,623.3	-
Revenue Passengers (Millions)	4,058.3	3,734.8	3,560.8	3,652.8	3,977.6	4,080.9	4,168	4,247	-
Operating Revenues ($ Millions)	1,236.3	1,280.2	1,230.1	1,262.9	1,377.3	1,437.7	1,486	1,584.4	1,671
All Transit Systems [1]									
Operating Revenue ($ Millions)	1,707.4	1,740.7	1,728.5	1,797.6	1,939.7	2,002.4	2,161.1	2,280.0	-
Operating Expenses ($ Millions)	1,891.7	2,040.5	2,128.2	2,419.8	3,102.4	3,534.9	4,020.9	4,304.8	*3,342
Net Operating Revenues (Loss) ($ Millions)	(184.3)	(299.8)	(399.7)	(622.2)	(1,162.7)	(1,532.5)	(1,859.8)	(2,024.8)	-
All Taxes ($ Millions)	103.9	111.6	113.4	116.3	137.0	171.0	181.5	190.0	-
Net Operating Revenue (Loss) After Taxes ($ Millions)	(288.2)	(411.4)	(513.1)	(738.5)	(1,299.7)	(1,703.5)	(2,041.3)	(2,214.8)	-

* Approximate Figures

1. All Transit-Includes 6 Rail and 13 Multimode Systems

SOURCES: American Public Transit Association, 1977/1978 Transit Fact Book, Phone Conversations With American Public Transit Association.

TABLE 3-3

NUMBER AND PERCENT OF PUBLIC SCHOOL PUPILS TRANSPORTED AT PUBLIC EXPENSE, AND CURRENT EXPENDITURES FOR TRANSPORTATION: UNITED STATES, 1959-60 TO 1977-78

School Year	Total Enrollment	Pupils transported at public expense		Expenditure of public funds	
		Number	Percent of total Enrollment	Total, excluding capital outlay (in thousands)	Average Cost per pupil transported
1959-60	32,477,440	12,225,142	37.6	$ 486,338	$39.78
1961-62	34,682,340	13,222,667	38.1	576,361	43.59
1963-64	37,405,058	14,475,778	38.7	673,845	46.55
1965-66	39,154,497	15,536,567	39.7	787,348	50.68
1967-68	40,827,965	17,130,873	42.0	981,006	57.27
1969-70	41,934,376	18,198,577	43.4	1,218,557	66.96
1971-72	42,254,272	19,474,355	46.1	1,507,830	77.43
1973-74	41,438,054	21,347,039	51.5	1,858,141	87.04
1975-76	41,373,473	22,757,316	55.2	2,285,840	100.44
1976-77	40,620,000	23,156,000	57.0	2,666,447	115.15
1977-78	40,034,908	21,660,839	54.1	2,852,593	131.69

Note: All Enrollment and Pupil Figures are Average Daily Attendance.

Source: U.S. Department of Health, Education and Welfare, National Center for Education Statistics, Statistics of State School Systems.

PRODUCT CLASSIFICATION AND CHARACTERISTICS

The most common bus classification is by end use which generally determines the manufacturing process and the finished product. Four general classifications exist:

- Intercity
- Intracity or Transit
- School
- Special Purpose.

(a) Intercity Buses

Intercity buses are integrally constructed vehicles combining body and chassis into a single unit. Size of these vehicles is determined by practical limitations and state restrictions (Table 3-4).

As shown in Table 3-5 there are five principal producers of intercity buses who, combined, offer some sixteen models. The most popular models have passenger capacities of 41 or 49 passengers with a complete vehicle weight of between 20,000 lbs. and 29,000 lbs. However, large intercity carriers will generally order buses with restroom facilities which reduce passenger capacity by six seats. Depending on the size of the vehicle, two or three axles are utilized. Intercity buses usually have one door for passenger boarding and exit. Product features generally include reclining seats, individual reading lamps, air conditioning, and adequate storage space under the floor of the passenger compartment.

The typical intercity bus is utilized by a company engaged primarily in providing passenger transportation over regular intercity routes with regular time schedules. Approximately 90 percent of the total bus miles in the country are generated in regular route service. Charter and special

TABLE 3-4

SPACE LIMITS ON BUS SIZE

	Alabama	Alaska	Arizona	Arkansas	California	Colorado	Connecticut	Delaware	District of Columbia	Florida	Georgia	Hawaii	Idaho	Illinois	Indiana	Iowa	Kansas
Height (Ft)	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	12-1/2	13-1/2	13-1/2	13-1/2	14	13-1/2	13-1/2	13-1/2	13-1/2
Width (In)	96	96	96	96	96	96	102	96	96	96	96	96	96	96	96	96	96
Length (Ft)	40	40	40	40	40	40	55	42	40	40	55	40	40	42	40	40	42-1/2

	Kentucky	Louisiana	Maine	Maryland	Massachu-setts	Michigan	Minnesota	Mississippi	Missouri	Montana	Nebraska	Nevada	New Hampshire	New Jersey	New Mexico	New York	North Carolina
Height (Ft)	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	14	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2
Width (In)	96	96	102	96	96	96	96	96	96	96	96	96	96	96	96	96	96
Length (Ft)	40	40	56-1/2	55	40	40	40	40	40	40	40	40	40	NS	40	35	40

	orth Dakota	Ohio	Oklahoma	Oregon	Pennsyl-vania	Rhode Island	South Carolina	South Dakota	Tennessee	Texas	Utah	Vermont	Virginia	Washington	West Virginia	Wisconsin	Wyoming
Height (Ft)	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	14	13-1/2	13-1/2	13-1/2	13-1/2	13-1/2	14
Width (In)	102	96	102	96	96	102	96	96	96	96	96	96	96	96	96	96	102
Length (Ft)	40	40	45	35	40	40	40	40	40	45	45	55	40	40	40	40	50

Source: Commercial Car Journal, April, 1975.

TABLE 3-5

INTERCITY BUS SPECIFICATIONS

Make and Model	Passenger Rating	Type	Standard Wheelbase (In.)	No. of Axles	Length (Ft.)	Width (In.)	Complete Vehicle Weight Dry (lbs.)	Engine Make & Model
Crown								
RD568-11	49	IC	251	3	40	96	21000	Det D 8V-71N
A426-11	37-41	IC	232	2	36	96	21000	Det D 6-71N
A426T-11	37-41	IC	232	2	36	96	21000	Det D 6-71N
2A426-11	49-53	IC	258	3	40	96	-	Det D 6-71N
2A426T-11	49-53	IC	258	3	40	96	-	Det D 6-71N
A855T-11	37-45	IC	232	2	36	96	-	CUM NHHT-290
2A855T-11	49	IC	258	3	40	96	-	CUM NHHT-290
GMC								
H8H649	49	IC	318-1/2	3*	40	96	23027	Det D 8V-71N
Motor Coach Industries								
MC-50 (Challenger)	41	IC	261	2	35	96	20500	Det D 8V-71N
MC-9 (Crusader II)	49	IC	285	3**	40	96	26760	Det D 8V-71C
Prevost								
Champion TS 47	47,49,51	IC	280	3**	40	96	N.A.	Det D 8V-71N
Champion TS 102	47,49,51	IC	280	3**	40	102	-	Det D 8V-71N
Prestige TS 47	47,49,52	IC,SS	260	3**	40	96	N.A.	Det D 8V-71N
Prestige TS 10	47,49,51	IC,SS	280	3**	40	102	-	Det D 8V-71N
Le Mirage TS 47	47,49,51	IC,SS	280	3**	40	102	27600	Det D 8V-71N
Silver Eagle								
0-5	49	IC	285-1/2	3**	40	96	26500	Det D 8V-71N

* Optional third axle is air operated retractable single wheel.
** Third axle is a single non-drive bogie.
Cum-Cummings
Det D - Detroit Diesel
Silver Eagle is manufactured and distributed by Eagle International, Inc.
Prevost models Prestige TS 47 and Prestige TS 102 are also marketed as sightseeing buses.

Source: Manufacturer product literature; Commercial Car Journal, October, 1979.

service travel also play an important part in the industry's operation. In addition, sight-seeing bus operations and airports utilize a significant number of intercity buses.

(b) Intracity or Transit Buses

Intracity or transit buses are similar to intercity buses in that both are integrally constructed vehicles. Intracity bus vehicle size and weight are determined by practical limitation and state restrictions. In 1978, as shown in Table 3-6, three major domestic manufacturers produced some seventeen models of transit buses. AM General, while discontinuing production of standard transit buses, is now manufacturing the new articulated bus. In addition, Highway Products Inc. has withdrawn from transit bus production entirely.

The most popular transit buses seat 35 to 53 passengers and approximate a complete vehicle weight of between 20,000 lbs. and 25,000 lbs. Transit buses generally have two axles and utilize two doors for passenger boarding and exit. Product features include seats designed for both durability and comfort, and equal space capacity for standing and seated passengers.

GMC and Flxible have, however, discontinued production of the standard "New Look" buses to market the new Advanced Design Bus (ADB). GMC's model, the RTS-2, is a 47-seat, 40-foot long vehicle with a weight 4,000 pounds heavier than the old standard model. Flxible's model, the 870, has an overall length of 40 feet and seats 48 passengers. Flxible officials claim the design of the 870 will increase fuel economy and reduce the number of spare parts. The previous Flxible transit coach consisted of about 31,000 parts while the 870 has 9,000 parts. Both models were developed to improve handling, rider comfort and appearance while reducing maintenance costs.

TABLE 3-6

TRANSIT BUS SPECIFICATIONS

Make and Model	Passenger Rating	Type	Standard Wheelbase (In.)	No. of Axles	Length (Ft.)	Width (In.)	Complete Vehicle Weight Dry (Lbs.)	Engine Make & Model
Flxible								
870 35096-6	40	T	239	2	35	96	22777	Det D 6V-71N
870 35096-8	40	T	239	2	35	96	23177	Det D 8V-71N
870 35102-6	40	T	239	2	35	102	22927	Det D 6V-71N
870 35102-6	40	T	239	2	35	102	23327	Det D 8V-71N
870 40096-6	48	T	299	2	40	96	23685	Det D 6V-71N
870 40096-8	48	T	299	2	40	96	24085	Det D 8V-71N
870 40102-6	48	T	299	2	40	102	23875	Det.D 6V-71N
870 40102-8	48	T	299	2	40	102	24275	Det.D 8V-71N
GMC								
T7H 603	39	T	238-3/4	2	35	96	23509	Det D. 6V-71N
T7W 603	39	T	238-3/4	2	35	96	23130	Det D 6V-71N
T7W 203	39	T	238-3/4	2	35	102	23251	Det D 6V-71N
T7H 203	39	T	238-3/4	2	35	102	23680	Det D 8V-71N
T8W 603	47	T	298-3/4	2	40	96	24395	Det D 6V-71N
T8W 203	47	T	298-3/4	2	40	102	24583	Det D 6V-71N
T8H 603	47	T	298-3/4	2	40	96	24781	Det D 8V-71N
T8H 203	47	T	298-3/4	2	40	102	25027	Det D 8V-71N
Transportation Manufacturers Corp.								
T-30 Citycruiser.	32	T	180	2	30	96	18900	Det D 6V-53N

Abbreviations

Chy - Chrysler

Det D - Detroit Diesel

Twin Coach is manufactured by Highway Products

Source: Manufacturer product literature; Commercial Car Journal, October, 1979.

The new articulated buses are a significant departure from standard bus design. This new design consists of a minimum of three axles and of two body sections; a forward section and a rear section which are permanently connected by an articulated joint. This joint allows the vehicle to bend in the horizontal and vertical direction and allows longitudinal rotation of the rear section relative to the forward section. Flexible, reinforced rubber bellows maintain an environmental seal in the area of the joint. The passenger compartment is uniformly lighted, heated and air conditioned. These buses seat between 52 and 73 passengers with gross vehicle weight ranging from 34,000 to 36,000 pounds. The articulated buses sold in the U.S. are an international manufacturing venture. The main domestic distributor is AM General. AM General receives bus body shells that are 55% complete from MAN (Maschinfabrik Augsburg Nuremberg), a West German firm, and outfits them with final interiors, electrical systems and air conditioning. Crown Coach Corp., another domestic firm, is the U.S. distributor of the Hungarian built Ikarus 286. Crown Coach also receives partially built buses which it transforms into finished vehicles.

The typical intracity bus is utilized by a transit company engaged primarily in providing passenger transportation over regular local routes with regular time schedules. Charter and special service travel play a relatively minor role in the total intracity operation.

(c) School Buses

The vast majority of school buses, over 98% in 1978, are manufactured in a two-stage process. The chassis, which is primarily the same as a medium-duty truck chassis, is produced by a manufacturer and then shipped as an incomplete vehicle to another manufacturer who assembles the body on it. The chassis manufacturing process utilizes the assembly line concept, while the body manufacturing and assembly process utilizes the station or bay system concept.

Various configurations of two-stage school buses are available. The most popular type, approximately 90% of school bus production in 1978, is the conventional school bus, which has the engine located forward of the driver and passengers. The other two types of two-stage school buses are the forward control type which resembles a transit coach in appearance and parcel delivery type which utilizes a smaller chassis than does the conventional. Gas or diesel engines are available for the above types of school bus with the exception of the parcel delivery type school buses which are powered by gasoline engines.

The remaining small number of school buses are integrally constructed vehicles. The floor, sides, ends and roof are joined into a one-piece construction to form the bus shell. These units are powered by diesel engines located either at the rear or the mid-point of the bus. Only two firms, Crown Coach and Gillig Brothers, presently offer integrally constructed school buses.

The size and weight of all school buses are limited by state and local restrictions. In the case of the two-stage vehicles, the chassis GVWR (Gross Vehicle Weight Rating) is also a determining factor. Table 3-7 shows representative chassis specifications by manufacturer for the conventional school bus. The most popular school bus models currently being produced utilize chassis with seating capacities of between 30 and 72 passengers and a GVWR of between 17,000 and 29,000 lbs.

Six firms build school bus bodies which are assembled on the chassis. Bodies are built according to customer specifications; consequently manufacturing flexibility is essential. Table 3-8 presents the various types of bodies manufactured by the six companies.

TABLE 3-7

SCHOOL BUS CHASSIS SPECIFICATIONS

Make and Series	Axles	Engines	GVW (lb.)	Capacity (No. of Pupils)	Cowl to End of Frame (In.)	Overall Length (In.)	Wheelbase (In.)
Chevrolet							
B6P042	4X2	G	20500-24000	42-66	267-3/4	322-1/4-403-1/4	189-254
Ford							
B-600	4X2	G	17400-24500	36-60	210-3/4-322-1/4	274-1/2-386	156-242-1/2
B-700	4X2	G	23160-27250	60-72	332-1/4-369-1/4	386-433	242-1/2-280-1/2
B-7000*	4X2	D	26500-27250	66-72	349-1/4-369-1/4	413-433	260-1/2-280-1/2
GMC							
B6P042	4X2	G	19700-25300	42-66	267-3/4-348-3/4	322-1/4-403-1/4	189-254
International							
1723	4X2	G	16000-29000	48-66	217-387	271-1/2-441-1/2	152-276
1823	4X2	G	20200-29000	60-66	217-387	271-1/2-441-1/2	152-276
1853	4X2	D	17000-29000	60-66	217-387	271-1/2-441-1/2	152-276
Henrickson							
RE-305	4X2	G	24,000-33,800	48-72	-	345-417.75	165-229
RE-305	4X2	D	33,800	48-72	-	420-474.75	242-286

*To be reintroduced March or April 1980.

SOURCE: Manufacturer product literature; Commercial Car Journal, October, 1979.

TABLE 3-8

SCHOOL BUS BODIES BY MANUFACTURER AND TYPE

Manufacturer	Conventional	Forward Control	Parcel Delivery
Blue Bird	X	X	X
Carpenter Body	X	X	X
Superior Coach	X		X
Thomas	X	X[1]	X
Ward	X	X[2]	X
Wayne	X		X

[1]Chassis is built by Thomas

[2]Only produced for export

SOURCE: EPA interviews with above manufacturers and with the Truck Body and Equipment Association

School bus bodies are designed for occupant safety and for durability. Typically, there is one door for passenger boarding and exit, with an emergency door at the rear.

(d) Special Purpose Buses

Manufacturers will often custom-build a vehicle for an end-user's specific needs, such as airports, hotels, demand response agencies, amusement parks, or prisons. These buses can be either two-stage or integrally constructed. From the manufacturer's perspective, such vehicles are generally treated in the same manner as their standard units in terms of production and sale statistics. In addition, firms not in the bus industry, such as recreational vehicle manufacturers, may occasionally convert one of their products to fulfill an end-user's specific needs. Consequently, for the remainder of this overview of the industry, with the exception of the section devoted to end-use, these special purpose vehicles will not be treated separately.

SIZE AND GROWTH OF THE INDUSTRY

The demand for bus units is a derived demand based upon user/operator requirements. This section will develop the current size of the market for buses and identify the growth trends within each principal segment.

(a) Geographic Concentration

In 1977 there were 491,674 buses registered in the United States (Table 3-9). Over fifty percent of these registrations were concentrated in eleven states.

(b) Buses in Service by End Use and Product Classification

End-users generally utilize the type of bus that is manufactured and designed for a specific application. In other words, intercity carriers utilize intercity buses; transit systems utilize transit buses; and school districts, private schools and churches utilize school buses. However,

TABLE 3-9

U.S. MOTOR BUS REGISTRATIONS BY STATES - 1977

State	Private and Commercial: Commercial Buses (1)	Private and Commercial: School and Other (2)	Publicly Owned: Federal	Publicly Owned: School (3)	Total School Buses	Total Buses
Alabama	1,304	789	14	6,084	6,873	8,191
Alaska	728	425	26	235	660	1,414
Arizona	624	210	266	2,192	2,402	3,292
Arkansas	411	1,423	18	5,033	6,456	6,885
California	11,130	2,946	138	8,200	11,146	22,414
Colorado	578	982	31	3,985	4,967	5,576
Connecticut	1,881	5,617	4	584	6,201	8,086
Delaware	291	1,056	--	135	1,191	1,482
Florida	2,342	1,102	63	19,150	20,252	22,657
Georgia	1,149	2,577	30	8,580	11,157	12,336
Hawaii	1,844	552	8	164	716	2,568
Idaho	324	382	135	1,963	2,345	2,804
Illinois	6,111	13,717	27	4,292	18,009	24,147
Indiana	3,711	4,188	27	7,636	11,824	15,562
Iowa	1,143	828	9	6,604	7,432	8,584
Kansas	349	943	5	2,321	3,264	3,618
Kentucky	594	669	61	6,507	7,176	7,831
Louisiana	1,092	12,957	11	3,766	16,723	17,826
Maine	186	547	5	1,603	2,150	2,341
Maryland	2,137	5,624	56	3,224	8,848	11,041
Massachusetts	4,082	6,988	2	464	7,452	11,536
Michigan	2,682	3,422	15	8,627	12,049	14,746
Minnesota	1,667	4,596	10	9,087	13,683	15,360
Mississippi	1,092	2,154	52	5,248	7,402	8,546
Missouri	903	2,777	60	5,697	8,474	9,437
Montana	422	780	49	826	1,606	2,077
Nebraska	437	665	4	2,194	2,859	3,300
Nevada	194	113	48	829	942	1,184
New Hampshire	264	851	3	218	1,069	1,336
New Jersey	4,469	4,768	24	3,313	8,081	12,574
New Mexico	556	2,434	336	338	2,772	3,660
New York	11,877	5,449	37	12,868	18,317	30,231
North Carolina	1,794	6,760	18	15,653	22,413	24,225
North Dakota	85	413	32	1,259	1,672	1,789
Ohio	5,592	2,892	28	14,200	17,092	22,712
Oklahoma	322	1,465	76	7,100	8,565	8,963
Oregon	971	1,645	42	4,650	6,295	7,308
Pennsylvania	8,470	12,563	36	5,596	18,159	26,665
Rhode Island	276	690	2	267	957	1,235
South Carolina	836	2,290	9	7,279	9,569	10,414
South Dakota	250	422	41	1,972	2,394	2,685
Tennessee	1,534	1,408	40	5,792	7,200	8,774

"See footnotes at end of table, p. 3-21."

TABLE 3-9

U.S. MOTOR BUS REGISTRATIONS BY STATES - 1977 (Cont'd)

State	Private and Commercial: Commercial Buses (1)	Private and Commercial: School and Other (2)	Publicly Owned: Federal	Publicly Owned: School (3)	Total School Buses	Total Buses
Texas	2,613	13,325	146	17,051	30,376	33,136
Utah	370	75	42	661	736	1,148
Vermont	80	383	--	678	1,061	1,141
Virginia	1,960	34	61	8,990	9,024	11,045
Washington	511	2,687	108	7,366	10,053	10,672
West Virginia	868	7	10	1,616	1,623	2,501
Wisconsin	1,475	4,787	12	3,414	8,201	9,688
Wyoming	1,092	144	2	1,075	1,219	2,318
Dist. of Columbia	2,191	35	142	251	286	2,619
Total	97,864	144,556	2,417	246,837	391,393	491,674

(1) Includes municipal owned transit buses.
(2) In some instances church, industrial and other private buses are included here; and in other instances privately owned school buses could not be segregated from commercial buses, and are included with the latter.
(3) This column consists primarily of publicly owned school buses but includes a few privately owned school institutional and industrial buses registered free or at a reduced rate.

SOURCE: U.S. Federal Highway Administration.

exceptions do exist and an end user may utilize a type of bus which is not necessarily designed for the specific application. According to manufacturers, trade associations, and end users, such situations are rare. Thus, for purposes of analysis, Table 3-10, which is the basis for the following discussion, treats end-use of the three types of bus according to the traditional applications.

1. Total Buses. Bus registrations have increase 42% during the period 1968 to 1978. The relative size of each segment in 1978 was as follows:

	1978
Intercity	4%
Transit	10.6%
School	79.2%
Federal Government	.5%
Others	5.7%

2. Intercity Buses. Intercity buses are utilized primarily by Intercity Class 1, 2 or 3 Carriers, sightseeing bus companies, and firms providing transportation to and from airport locations. The American Bus Association estimates that in 1979, 21,100 intercity buses were operated by intercity carriers. Robert A. Kaye, Director of the Bureau of Motor Carrier Safety, Federal Highway Administration, has estimated that approximately 23,000 buses were operated by sightseeing and airport bus lines in 1979.

The number of intercity buses utilized by Class 1, 2, 3 Carriers has remained rather stable since 1968. However, a downward trend has developed since 1970 when the population reached 22,000. In 1975, the population was estimated to be 20,500, while estimates for 1978 are 20,100. A factor influencing this downward trend has been a 15.2% decline in revenue passengers (refer to Table 3-1).

3. Transit Buses Transit buses accounted for 10.6% of the total bus population in 1978. The number of operating transit buses has increased

TABLE 3-10

BUSES IN SERVICE BY END USE AND PRODUCT CLASSIFICATION

Year	INTERCITY & TRANSIT BUSES			SCHOOL BUSES (2)				
	Intercity Class 1,2,3 Carriers	Transit Systems	Others(1)	Transportation Public Expense	Transportation Private Expense	Total	Federal Government(3)	Total Buses
1979	21,100 (est)	-	-	-	-	-	-	-
1978	20,100	52,866	28,592	-	-	396,387	2,417	500,362
1977	20,100	51,968	25,796	-	-	391,393	2,417	491,674
1976	20,100	52,332	24,359	-	-	379,178	2,320	478,339
1975	20,500	50,811	22,522	-	-	365,982	2,329	462,144
1974	20,600	43,700	20,772	267,704	86,930	354,634	2,200	446,906
1973	20,800	48,286	20,390	262,579	71,313	333,892	2,159	425,527
1972	21,400	49,075	18,247	260,772	55,649	316,421	1,811	406,954
1971	21,900	49,150	17,566	245,608	61,677	307,285	1,682	397,583
1970	22,000	49,700	17,123	244,337	44,413	288,750	1,448	397,021
1969	21,600	49,600	17,792	238,103	35,871	273,973	1,317	364,282
1968	21,000	50,000	17,182	219,147	43,000	262,204	1.413	351,799

Notes: (a) The numbers given above are EPA estimates based on estimates by several reliable sources of the buses in use. Certain inaccuracies must be acknowledged and are listed below:

(1) End users of intercity and transit buses utilize a very small number of school buses in their operations. Such vehicles cannot be easily identified and consequently are included in the Intercity & Transit columns.

(b) The numbers given above are estimates based on state registration data. Buses owned by the Department of Defense are not included. In 1969, DOD buses were estimated to be 11,289.

1. Intercity buses used in sightseeing and airport operations accounted for an estimated 23,000 units in 1979.
2 Includes Class II school buses which are estimated to account for approximately 10% of the total.
3. Includes all types of buses. Only vehicles of the civilian branches of the Federal Government are given.

Source: U.S. Department of Transportation/Federal Highway Administration, Highway Statistics, 1968-1976, Table MV-10; Department of Health, Education, and Welfare, Office of Education, Statistics of State School Systems, 1967-68 to 1977-78; National Association State Directors of Pupil Transportation Services, Growth of School Transportation in the U.S., 1975; National Association of Motor Bus Owners, One-Half Century of Service to America, 1976; American Public Transit Association, Transit Fact Book, 1978; Motor Vehicle Manufacturers Association, Motor Truck Facts, 1970; Federal Highway Administration/Bureau of Motor Carrier Safety, Safe Transport, Intercity Bus Industry in the U.S., 1975; Motor Vehicle Manufacturers Association, Facts and Figures, 1979.

6.4% from 49,700 in 1970 to 52,866 in 1978. There has been a corresponding 2.7% growth in number of revenue passengers from a 1970 level of 4,058 million to 4,168 million in 1976. Operating revenues have increased from $1,236.3 million in 1970 for $1,584.4 million in 1977, a 28.2% increase. However, net operating losses after taxes climbed steeply from $288.2 million in 1970 to $2,214.8 million in 1977, an increase in losses of 668%.

4. School Buses. School buses accounted for a substantial majority, 79.2% of total buses in 1978. Most school buses are utilized in transportation of students, the handicapped, etc., at public expense. The vehicles used in this function are owned either by a school district (or other public entity) or by a private company which operates under contractual arrangement with a school district. The remaining school buses are privately owned and operated in a variety of situations without public funding. Common examples of users include churches, private schools, and related groups or organizations.

The number of school buses in use has increased dramatically since 1968 when 262,204 vehicles were registered. In 1978, total registrations of school buses had reached 396,387 units, a growth of some 51% since 1968.

These school bus figures include Class II school buses which are generally converted light trucks, vans or station wagons. These vehicles generally have a GVWR of less than 10,000 lbs. In 1977-78 there were 36,199 Class II school buses in use.

5. Federal Government. Buses used by civilian branches of the Federal Government represent only 0.5% of the total bus population. All three types of buses are utilized by this end-use segment. A significant growth rate of almost 71%,(2,417 units in 1978 as compared to 1,413 units in 1968), has characterized this market segment.

6. Others. As discussed earlier in the intercity bus section, the majority of vehicles in this end-use category are buses used in sight-seeing

and airport applications. The remaining buses in this category have many and varied applications. For example, amusement parks, hotels, rental car companies, etc., use buses to provide transportation in conjunction with some other activity. This general end use category has grown almost 66% to 28,592 vehicles in 1978 from 17,182 in 1968. From industry interviews with several manufacturers, it appears that some part of the total 20,772 buses in this segment are smaller than 16,000 lbs. GVWR and seat less than 16 passengers.

(c) New Product Shipments

In 1978 manufacturers of buses shipped 35,342 units. Table 3-11 presents a history of bus shipments from 1965 to 1977.

1. Intercity Buses. In 1977, the number of buses shipped to Class I intercity carriers was 709, as compared with 619 in 1976. The American Bus Association estimates that the average annual market for American made intercity buses is about 1,300. Between 1,100 and 1,200 of these are sold in the United States.

2. Transit Buses. Shipments of transit buses experienced constant growth from 1970 to 1975, when they reached 5,261 units. They declined during the 1976 to 1978 period, partially because of the shift to Advanced Design buses. In 1977, total shipments of new transit buses were 2,437 units.

3. School Buses. Total shipments of school buses will maintain a relatively stable growth rate until 1999. Most new buses are presently being bought to replace old ones as enrollment declines; however, this trend towards lower enrollment will be counteracted by trends toward expanding services.

PRODUCT LIFE CYCLE

Beyond the end-use industry conditions outlined above, product life cycle dictates the replacement activity within bus fleets. It is very difficult

TABLE 3-11

SHIPMENTS BY YEAR AND BUS CLASSIFICATION BASED ON REGISTRATIONS

Year	Intercity	Transit	School
1977	709[1]	2,437	* 30,000
1976	619[1]	4,745	* 30,000
1975	773[2]	5,261	* 30,000
1974	1,350	4,818	29,561
1973	1,276	3,200	30,039
1972	1,353	2,904	30,635
1971	977	2,514	28,358
1970	1,064	1,442	27,468
1969	NA	2,230	28,064
1968	NA	2,228	29,015
1967	NA	2,500	28,214
1966	NA	3,100	26,419
1965	NA	3,000	24,276

*Approximate figures.

1 Only shipments to Class I carriers; Class I revised to exclude carriers with revenues less than $3,000,000.

2 Only shipments to Class I carriers.

Source: National Association of Motor Bus Owners; American Public Transit Association, Transit Fact Book, 1978, Interviews with General Motors and International Harvester.

to determine an average product life for the three major types of buses. Product life is contingent on factors such as maintenance routines and procedures, geographic location, miles traveled, and the economic conditions of the end-users. Given this situation, the following are estimated ranges for product life with the original owner:

Intercity - 12 to 15 years

Transit - 10 to 15 years

School - 8 to 12 years

Certain factors can affect these ranges. For example, when a bus is first put into operation it incurs its heaviest utilization. A typical intercity bus will travel 250,000 miles during the first two years of utilization. Transit buses, depending on the geographic location and the attendant route size, will travel between 30,000 and 60,000 miles per year. School buses travel an average of 38 miles per day, but individual mileage totals vary substantially around this mean figure.

NATURE OF THE INDUSTRY

This section will describe the nature of the bus industry in terms of channels of distribution, sales practices, pricing, and resale. It is organized according to the three major product segments of Intercity, Transit, and School Buses.

(a) Intercity Buses

The nature of the intercity bus segment is generally determined by the following:

1. Channels of Distribution. The flow of new intercity buses is incorporated in Figure 3-1. Note that the manufacturer deals directly with the end-user and that a dealer or distribution network does not exist.

All intercity bus prices are F.O.B (freight-on-board) factory, and delivery of the vehicle is the responsibility of the end-user. Two alternatives are primarily utilized: end-user personnel are sent to the factory to drive the units to their destination, or an independent bus delivery company will drive the completed unit from the factory to an end-user designated location.

2. Sales Practices. Manufacturers of intercity buses deal directly with intercity operators. Generally, bus requirements and specifications are determined by the end-user, with custom units made in accordance with a variety of special requirements. Each order is separately priced in competitive bids.

However, certain exceptions to the above exist. For example, the Greyhound Corporation, the largest Class I Intercity Carrier, purchases its vehicles from a subsidiary, Motor Coach Industries. Continental Trailways, another large end-user, has maintained a purchase agreement with Eagle International.

3. Pricing. The American Bus Association estimates the average price of buses delivered to Class I carriers as follows:

1975	$81,000
1976	$93,000
1977	$99,000

4. Resale/Used Buses. The impact of the resale of used buses on the nature of the intercity bus market is relatively insignificant. Original end-users of intercity buses generally utilize the vehicle throughout the useful life of the unit. After the useful life of the vehicle is expended, the original end-user will either sell the unit for salvage; strip the unit for useful parts and sell the remainder for salvage; or sell the unit to another end-user. Purchasers of used vehicles generally are smaller intercity carriers which usually do not purchase new vehicles.

(b) Transit Buses

The nature of the transit bus segment is generally determined by the following:

1. Channels of Distribution. The flow of new transit buses into distribution as shown in Figure 3-1 is the same as the flow for new intercity buses.

2. Sales Practices. In summary, manufacturers deal directly with end-users and the coaches are custom made according to customer specifications. The significant difference is in the formality of the bid procedure in the transit market segment. UMTA, which provides up to 80 percent of the funding for local transit agencies to buy new buses, requires that all federally funded bus orders be placed on a competitive bid basis. Each coach is separately priced in competitive bids by industry. This formal bid procedure is dictated by government guidelines which are prerequisite to the awarding of grants and subsidies.

3. Pricing. Prices have climbed sharply with the introduction of Advanced Design Buses. In 1977 the average price for 40 foot transit buses was $77,142. The current average price of Advanced Design Buses is about $110,000. The 60 foot articulated buses cost roughly $191,000.

4. Resale/Used Buses. Transit buses are generally utilized by the original owner throughout their useful life. The original end-user will dispose of a unit by either selling it for salvage; by stripping the useful parts and selling the remainder for salvage; or by selling it to another transit authority or end-user.

Transit authorities may occasionally purchase used buses to fill an unexpected demand, to cover delays in new bus delivery, to obtain parts, or to avoid costs of new bus purchases.

(c) School Buses

The nature of the school bus segment is generally determined by the following:

1. Channels of Distribution. As depicted in Figure 3-1, distribution of conventional school buses differs greatly from that of intercity and transit buses. School bus distribution is a complex two-step distribution process. The difference principally is that either a chassis dealer or a body dealer can sell the complete bus to the end-user. Most orders will typically be handled by the school bus body manufacturer.

The distribution process begins when a bus body builder orders a chassis that meets the specifications in his contract. The chassis is then shipped to the bus body manufacturer's plant where the body is installed to end-user specifications. Typically, when a chassis is used the regional chassis manufacturer representative is notified and credit is given to the local chassis dealer.

In the case where a chassis dealer takes an order for complete buses, the process is similar. The principal difference is that the local body distributer is given commission on the sale of the body. In both cases warranty service is provided on a local dealer basis for the part of the product that each represents.

2. Sales Practices. Due to the type of distribution, the principal sales of school buses are through dealers. National selling responsibility for each part of the product is maintained by body and chassis manufacturers.

There is a slight difference between the selling efforts of chassis and body manufacturers. Chassis manufacturers market their product to both body builders and school boards while body manufacturers promote their companies' products and services directly to the school administrations.

The majority of school bus sales are made in public bids to predetermined specifications. As previously noted, these specifications, beyond meeting minimum safety standards, vary greatly from locality to locality. The company, whether a chassis or body manufacturer, with the winning bid will then manage the production of the complete vehicle.

3. Pricing. Due to the variety of school bus model types, a single price range would not accurately portray the proper perspective. Therefore, Table 3-12 presents school bus prices by vehicle type.

4. Resale/Used Buses. School buses find a rather large resale market. Typically, school authorities will sell used buses to brokers. These buses in turn will be sold to such groups as churches, boys' clubs, P.T.A.'s, Y.M.C.A.'s, and a wide variety of other groups.

BUS MANUFACTURERS PROFILE

The remainder of this discussion will profile individual bus manufacturers in terms of a general description, financial resources, employment, production facilities, and market share. It is organized into four sections, as determined by the basic bus classifications and market segments, as follows:

- Intercity Bus Manufacturers
- Transit Bus Manufacturers
- School Bus Chassis Manufacturers
- School Bus Body Manufacturers.

The basic information used in this section is developed from composite tables of manufacturers shown in Table 3-13 and 3-14. Market share data are represented in Table 3-15 through 3-18.

(a) Intercity Bus Manufacturers

The firms, subsidiaries, or divisions shown below account for the vast majority of intercity bus production:

TABLE 3-12

May, 1979 Prices for

COMPLETED SCHOOL BUS, BY TYPE OF BUS

Type of Bus	Range of Prices	Average Price
Gasoline Powered:		
Conventional	13,000 - 22,000	19,000
Forward Control	35,000 - 42,000	38,000
Parcel Delivery	12,000 - 16,500	14,500
Diesel Powered:		
Conventional	17,000 - 28,000	23,500
Forward Control	35,000 - 43,000	40,000
Integral Mid-engine	45,000 - 100,000	60,000
Integral Rear-engine	50,000 - 70,000	55,000

TABLE 3-13

BUS MANUFACTURERS FACILITY PROFILE, 1977

Manufacturer	Corporate Headquarters Location	Production facilities: Location	Production facilities: Products Manufactured
General Motors Corporation	Detroit, Michigan	Pontiac, Michigan	School bus chassis medium duty trucks
		Pontiac, Michigan	Transit buses
Ford Motor Company	Dearborn, Michigan	Louisville, Kentucky	School bus chassis
		Windsor, Ontario, Canada	School bus chassis
International Harvester Co.	Chicago, Illinois	Springfield, Ohio	School Bus chassis medium duty trucks
Greyhound Corporation	Phoenix, Arizona		
Subsidiaries: a. Transportation Manufacturing Corp.	Roswell, New Mexico	Pembima, North Dakota	Transit buses
b. Motor-Coach Industries		Pembima, North Dakota	Intercity buses
		Winnipeg, Manitoba, Canada	Intercity buses
		Fort Gary, Manitoba, Canada	Intercity buses

TABLE 3-13 (Continued)

BUS MANUFACTURERS FACILITY PROFILE, 1977

Manufacturer	Corporate Headquarters Location	Production facilities: Location	Production facilities: Products Manufactured
Grumman Allied Industries, Inc.	Bethpage, New York		
Subsidiary: Grumman FLXIBLE (originally Rohr Flxible)		Delaware, Ohio	Transit Buses
		Loudonville, Ohio	Bus components
		Millersburg, Ohio	Bus components
Indian Head Incorporated (Wayne Corp.)	New York, New York	Richmond, Indiana	School bus bodies Ambulances Hearses Professional cars
Sheller-Globe Corporation (Superior Div.)	Toledo, Ohio	Lima, Ohio	14,500 School bus bodies
Thomas Built buses	High Point, North Carolina	High Point, North Carolina	School bus bodies Specialty vehicles
Blue Bird Body Co., Inc.	Fort Valley, Georgia	Fort Valley, Georgia	School bus bodies Specialty vehicles
		Mount Pleasant, Iowa	School bus bodies Specialty vehicles

TABLE 3-13 (Continued)

BUS MANUFACTURERS FACILITY PROFILE, 1977

Manufacturer	Corporate Headquarters Location	Production facilities Location	Production facilities Products Manufactured
Crown Coach Corporation	Los Angeles, California	Los Angeles, California	Integral school buses Intercity buses Specialty vehicles
Carpenter Body Works, Inc.	Mitchell, Indiana	Mitchell, Indiana	School bus bodies Specialty vehicles
Ward School Bus Manufacturing, Inc. (Subsidiary of Ward Industries, Inc.)	Conway, Arkansas	Conway, Arkansas	School bus bodies
The Herrick Corporation	Hayward, California		
Subsidiary: Gillig Corp.	Hayward, California	Hayward, California	Integral buses
Overseas Inns	Luxembourg City, Luxembourg		
Subsidiary: Eagle International		Brownsville, Texas	Intercity buses
Prevost Car	Ste. Claire, Dorchester, Quebec, Canada	Ste. Claire, Dorchester, Quebec, Canada	Intercity buses Specialty vehicles

TABLE 3-14

BUS MANUFACTURERS FINANCIAL CHARACTERISTICS, 1978

Manufacturer	Financial Characteristics ($ Millions) Sales	Net Income	Assets	Principal Bus Products
General Motors Corporation Detroit, Michigan (GMC Truck & Coach Division)	$54,961.3	$3,337.5	$26,658.3	Transit buses; School bus chassis
Ford Motor Company Dearborn, Michigan	37,841.5	1,672.8	19,241.3	School bus chassis
International Harvester Chicago, Illinois	5,975.1	203.7	3,788.1	School bus chassis
Greyhound Corporation Phoenix, Arizona	3,841.5	82.5	1,586.5	-
Subsidiaries: a. Transportation Manufacturers Corporation	-	-	-	Transit buses
b. Motor Coach Industires	118.5	11.6	.057	Intercity buses
Indian Head Incorporated New York, New York (Wayne Corporation)	603.8	27.4	390.0	School bus bodies
Grumman Allied Industries, Inc. Bethpage, New York	1,552.7	32.4	569.5	-
Subsidiary: Grumman Fixible	102.0			Transit buses and components

TABLE 3-14 (Continued)

BUS MANUFACTURERS FINANCIAL CHARACTERISTICS, 1978

nufacturer	Financial Characteristics ($ Millions) Sales	Net Income	Assets	Principal Bus Products
Sheller-Globe Corporation Toledo, Ohio (Superior Division)	$ 600.3 (78.5)	$ 16.5	$ 297.9	School bus bodies
Thomas Built Busses High Point, North Carolina	-	-	-	School bus bodies Specialty vehicles
Blue Bird Body Company, Inc. Fort Valley, Georgia	-	-	-	School bus bodies Specialty vehicles
Carpenter Body Works, Inc. Mitchell, Indiana	20.0	-	-	School bus bodies Specialty vehicles
Ward School Bus Manufacturing, Inc. Incorporated, Conway, Arkansas (Subsidiary of Ward Industries, Inc.)	-	-	-	School bus bodies
Crown Coach Corporation Los Angeles, California	25.0	-	-	Integral buses
The Herrick Corporation Hayward, California	10-14	-	-	-
Subsidiary: Gillig Corporation	-	-	-	Integral buses

TABLE 3-14 (Continued)

BUS MANUFACTURERS FINANCIAL CHARACTERISTICS, 1978

Manufacturer	Financial Characteristics ($ Millions) Sales	Net Income	Assets	Principal Bus Products
Overseas Inns Luxembourg City, Luxembourg	-	-	-	-
Subsidiary: Eagle International	-	-	-	Intercity buses
Prevost Car Ste. Claire, Dorchester, Quebec, Canada	-	-	-	Intercity buses Specialty vehicles

TABLE 3-15

ESTIMATED MARKET SHARE
INTERCITY BUSES

Manufacturer	1970[1]	1974[1]	1978[2]
Motor Coach Industries	47.8%[3]	45.9%[3]	35.0%
Transportation Manufacturing Corporation	-	-	25.9%
General Motors	22.7%	32.1%	19.6%*
Eagle International	27.3%	17.5%	12.0%
Others[4]	2.2%	4.4%	6.5%

* As of June 1979, GMC ceased production of intercity buses.

1 United States Only.

2 North America.

3 MCI and TMC combined.

4 Includes units manufactured by Prevost and Crown Coach.

Source: Based upon interviews with the American Bus Association, Motor Coach Industries, General Motors Corporation; calculations by A. T. Kearney and EPA.

TABLE 3-16

TRANSIT BUS MARKET SHARES

ESTIMATED MARKET SHARES - TRANSIT BUSES: TOTAL TRANSIT BUS FLEET
June 30, 1977.

Manufacturer	Market Share
General Motors	62.4%
Flxible	24.7%
A M General	9.2%
All Others*	3.7%

*Includes imported buses.

Source: EPA estimates based on data from American Public Transit Association, Fleet Inventory.

ESTIMATED MARKET SHARES - TRANSIT BUSES
NEW EQUIPMENT DELIVERED, 1974-1976

Manufacturer	Market Share
General Motors	30.7%
Flxible	25.9%
A M General	32.7%
All Others*	10.7%

*Includes imported buses.

Source: EPA estimates based on data from American Public Transit Association, Fleet Inventory.

ESTIMATED MARKET SHARES - TRANSIT BUSES
NEW EQUIPMENT DELIVERED, 1978

Manufacturer	Market Share
General Motors	60%
Flxible	30%
All Others*	10%

*Includes imported buses.

Source: EPA estimates based on interviews with manufacturers.

TABLE 3-17

U.S. DOMESTIC FACTORY SALES AND MARKET SHARES
SCHOOL BUS CHASSIS

Manufacturer	1969 Units	1969 Market Shares	1971 Units	1971 Market Shares	1973 Units	1973 Market Shares	1975 Units	1975 Market Shares	1977 Units	1977 Market Shares
Chevrolet	9,105	29.6%	5,294	17.1%	3,793	11.2%	5,139	15.1%	3,335	11.0%
Dodge	1,511	4.9	1,676	5.4	677	2.0	-	-	440	1.5
Ford	6,670	21.7	5,503	17.8	9,815	29.0	7,903	23.2	7,364	24.4
GMC	4,764	15.5	5,114	16.6	2,455	7.3	2,703	7.9	2,482	8.2
IHC	8,117	26.4	12,399	41.1	15,510	45.9	16,654	49.0	15,262	50.5
All Others[1]	603	2.0	897	2.9	1,580	4.7	1,595	4.7	1,338	4.4
Total	30,770	100.0%*	30,883	100.0%*	33,820	100.0%*	33,996	100.0%*	30,221	100.0%

* Totals do not add up to 100% due to rounding.

[1] National Chassis Company; Perry, Georgia and Hendrickson Manufacturing Company; Lyons, Illinois account for a significant number of units.

Source: School Bus Fleet; Interviews with General Motors, International Harvester and Chrysler.

TABLE 3-18

ESTIMATED FACTORY SHIPMENTS AND MARKET SHARE: SCHOOL BUS BODIES, 1974

Manufacturer	Shipments	Market Share (units)
Blue Bird	6,592	22.3%
Sheller Globe (Superior)	6,592	22.3
Indian Head (Wayne)	5,055	17.1
Thomas	4,257	14.4
Carpenter	3,784	12.8
Ward	2,838	9.6
All Others[1]	443	1.5

[1] Crown Coach and Gillig account for the majority with integrally constructed buses. Also includes units manufactured by firms not in the bus industry such as recreational vehicle manufacturers.

Source: EPA compared estimated market share information provided by body manufacturers with Dunn & Bradstreet sales estimates.

- Crown Coach Corporation
- Eagle International Incorporated
- Motor Coach Industries, Limited
- Prevost Car.

1. Crown Coach Corporation. Established in 1904, this family controlled business has operated on a profitable basis and has increased net worth annually through retained earnings. In 1974, Crown had sales of approximately $14 million, total assets of $18,165.223, and a tangible net worth of $3,755,232. Sales reached $25 million in 1978. In addition to intercity buses, the firm also manufactures integrally constructed school buses and fire trucks. Crown is also a distributor of coaches and bodies for other manufacturers and operates a coach maintenance division. The firm's integrally constructed vehicles compete primarily in two market segments, intercity and school, and accounted for less than 1% of total sales in each market in 1978.

2. Eagle International, Incorporated. This company, a subsidiary of Overseas Inns, S.A., Luxembourg, was founded in 1973 to manufacture buses primarily for Continental Trailways, the second largest U.S. intercity carrier. Prior to 1973, another subsidiary of Overseas Inns manufactured such buses in Belgium. However, with the devaluation of the U.S. dollar, the Belgian units could no longer be competitively priced and Eagle was formed. Continental Trailways now buys Eagle buses which are built in Brownsville, Texas. In 1978, Eagle accounted for approximately 12% of total intercity bus sales.

3. Greyhound Corporation. This holding company has numerous subsidiaries whose business activities can be categorized into six general groups: transportation, leasing, consumer products and pharmaceuticals, food, services, and food services. Greyhound holds two bus manufacturing

companies, Transportation Manufacturing Corporation (TCM) and Motor Coach Industries (MCI). TMC builds transit and intercity buses at a facility in Rosewell, New Mexico. These intercity buses are used by Greyhound Lines. MCI produces the same intercity buses for use by other operators. These buses are produced at facilities in Pembima, North Dakota, and in Fort Gary and Winnipeg, Manitoba. In 1978, Greyhound Corporation generated sales of $4,358,848,000; derived a net income of $58,353,000; and retained total assets amounting to $1,265,767,000. Greyhound employed 50,850 persons.

4. Prevost Car. This Canadian-based manufacturer was formed in 1957. Intercity buses account for approximately 60% of total production, motor homes account for 25% and the remaining 15% of production is accounted for by specialty vehicles.

1974 sales were estimated to be $4.5 million with total assets of between $2.5 million and $3.5 million.

Prevost Car was estimated to have a 3% share of the sales of the total United States intercity bus market in 1978.

(b) Transit Bus Manufacturers

The following firms, subsidiaries or divisions account for the vast majority of transit bus production:

- The Flxible Company
- GMC Truck & Coach
- Transit Manufacturing Corporation

1. The Flxible Company. This subsidiary was acquired by Grumman Allied Industries, Inc. in 1978. In the same year, Flxible built the last of its "New Look" buses and began building their advanced design bus, the 870, at a new final assembly plant in Delaware, Ohio. The new bus is being produced according to a modular approach. The drive train, front suspension, driver's console and several other components are produced in the company's Loudonville, Ohio, and Millersburg, Ohio, plants and are then shipped to

the Delaware facility. Flxible claims to have increased their market share from 30% to 45% since production of the 870 started. Specific employment and financial information is not available.

Grumman builds many types of transportation vehicles for both civilian and military purposes. Its products include aircraft, ships, spacecraft, canoes and buses. In 1978, Grumman had a net income of $32,397,000 on sales of $1,552,695,000 and assets of $569,450,000. Grumman employed approximately 27,000 persons.

2. GMC Truck & Coach. In 1943, General Motors Corporation (GMC) acquired the assets of Yellow Truck & Coach Manufacturing Company. Business formerly conducted by that organization is today being carried on by the GMC Truck & Coach Division. In 1978, General Motors had net sales of $54,961.3 million; net income of $3,337.5 million; total assets of $26,658.3 million; and employed approximately 797,000 persons. Specific financial information for GMC Truck & Coach Division is not available.

General Motors functions primarily as an operating corporation, carrying on activities through its operating divisions. The firm also owns stock in many other companies. Generally, GM is engaged in manufacture, assembly, and distribution in the United States of various motor driven products, most of which relate to transportation equipment. Subsidiaries and associated companies conduct similar operations in Canada and other foreign countries.

Automotive products consist of passenger cars, trucks, buses, motor homes, and their related components, as well as parts and accessories. The greatest portion of such components, parts and accessories is used in the manufacture of GM automotive products. In addition, substantial amounts of these products are sold to outside manufacturers, and are also marketed through distributors, dealers, and jobbers.

In the United States there are 29 major operating divisions, while in Canada, GM manufacturing operations are carried on by a subsidiary. Products are distributed to other world markets through the Overseas Operations Division which has assembly and manufacturing operations in 21 countries.

GMC Truck & Coach operates two bus manufacturing facilities in Pontiac, Michigan; one of which is devoted entirely to the production of transit buses, while the other manufactures school bus chassis and medium duty trucks. An existing facility, also in Pontiac, has been refurbished to accommodate production of GMC's new transit bus, the RTS-2.

General Motor's "New Look" bus, designed in 1959, set the industry standard for fifteen years. This bus is now produced only in Canada. The new RTS Advanced Design Bus is now the only bus produced by General Motors in the United States.

In 1978, GMC's respective estimated market shares were as follows:

Transit	62.4%
School Bus Chassis	8.2% (1977)

3. Transit Manufacturers Corporation. This subsidiary of the Greyhound Corporation began production of the TC-30 Citycruiser in 1978 at a plant in Pembima, North Dakota. For a profile, see the information on Motor Coach Industries, Limited in the Intercity Bus Manufacturers portion of this section.

4. Highway Products Incorporated. This subsidiary of Midwest Management Corporation halted production of transit buses in 1975.

5. AM General Corporation. This subsidiary of American Motor Corporation has fulfilled its last contract for standard "New Look" buses. AM General will, however, continue to manufacturer the new articulated bus, of which 325 were sold in 1976.

(C) School Bus Chassis Manufacturers

The following firms or divisions account for the vast majority of school bus chassis production:

- Ford Motor Company
- GMC Truck & Coach
- International Harvester Company.

1. Ford Motor Company. Ford school bus chassis are produced at plants located in Louisville, Kentucky and Windsor, Ontario, Canada. Ford's 1977 share of the school bus chassis market amounted to 24.4%. Specific financial, employment, manufacturing and marketing data for Ford's school bus chassis production operation are not available.

The corporation is primarily an operating company with several subsidiaries. The manufacture, assembly and sale of cars, trucks and related parts and accessories accounted for approximately 91% of sales in 1974. In the United States, Ford ranks second in the industry in unit factory sales of cars and trucks. Outside the U.S., cars and trucks are manufactured by several subsidiaries throughout the free world. The remaining 9% of sales in 1974 was accounted for by operations dealing with tractors and farm implements, communications and electronic systems, automotive production component materials, the dealer organization, land developments, and public transit "people mover" systems. Total sales in 1978 amounted to $37,841.5 million which generated net income of $1,672.8 million. Assets total approximately $19.2 billion. In 1978, Ford employed 479,000 workers.

2. GMC Truck & Coach. This General Motors operating division markets its school bus chassis under the Chevrolet or GMC product line. For a profile, refer to the Transit Bus Manufacturers portion of this section.

3. <u>International Harvester</u>. International Harvester manufactures school bus chassis and medium duty trucks in their Springfield, Ohio plant. In 1977, the company accounted for 50.5% of the total school bus chassis market. Additional specific financial information is not available.

The corporation is primarily an operating company with numerous wholly-owned subsidiaries. International Harvester's principal products are trucks, agricultural/industrial equipment and construction equipment. The company is also a major producer of gasoline and diesel engines, primarily for use with its products. International Harvester owns 17 manufacturing plants in the United States, while its subsidiaries own 18 manufacturing plants throughout the free world. International Harvester has 93,160 employees. Sales in 1978 amounted to $5,975,061,000 with a net income of $203,737,000. Total assets amounted to $3,788,134,000.

4. <u>Others</u>. There are also several smaller chassis manufacturers, such as Hendrickson Manufacturing Company, National Chassis Company, and Oshkosh, who produce limited number of chassis for use in forward control and pusher type school buses.

(d) <u>School Bus Body Manufacturers</u>

The following firms, subsidiaries or divisions account for the vast majority of school bus body production:

- Blue Bird Body Company
- Carpenter Body Works
- Superior
- Thomas Built Buses
- Ward School Bus
- Wayne Corporation

1. <u>Blue Bird Body Company, Incorporated</u>. A privately owned company, Blue Bird was originally started in 1927. The company wholly-owns

five subsidiaries, all of which are associated with the school bus market. Three of the subsidiaries are located in the United States, with one in Canada and the other in Guatemala. The main plant is located in Fort Valley, Georgia.

Although Blue Bird is primarily a conventional school bus body manufacturer, it also produces forward control school bus bodies and motor homes. In addition, one U.S. subsidiary manufactures school bus accessories and parts. In 1974, Blue Bird had sales of approximately $30 million which resulted in an estimated 22.3% (unit) share of the school bus body market. Additional financial information is not available.

2. Carpenter Body Works, Inc. This privately owned company was founded in 1918. The most significant portion of Carpenter's operation is the manufacture and assembly of conventional school bus bodies; however, the company also builds forward control and parcel delivery school bus bodies mounted on special chassis according to customer specifications. The company operates a production facility, and is the largest employer in Mitchell, Indiana. 1978 sales were reported at $20 million. Carpenter held a 12.8% (unit) share of the total school bus body market in 1974.

3. Superior. An operating division of Sheller-Globe Corporation, Superior was acquired in 1969. In addition to conventional school bus bodies, Superior manufactures forward control and parcel delivery school bus bodies, ambulances, funeral hearses and military vans, most of which are mounted on chassis furnished by automotive manufacturers. One plant is located in Lima, Ohio while another is located in Kosciusko, Mississippi. The firm's estimated 1974 share of the school bus body market, in units produced, was 22.3%.

Sheller-Globe is a diversified company which produces automotive parts and accessories, general industrial products, office supplies, and precision instrumentation. In 1978, Sheller-Globe received $533.12 million in revenue and employed 14,000 workers.

4. Thomas Built Buses. This operating company has two subsidiaries, one in Canada and the other in Ecuador. Conventional school bus bodies represent the most significant portion of the operation. The firm is also engaged in the manufacture and assembly of forward control school bus bodies and other specialized vehicles. The firm operates a facility located in High Point, North Carolina. Thomas also operates a plant in Woodstock, Ontario, Canada. For the fiscal year ending March 31, 1975, Thomas reported sales of approximately $30 million and assets of $14.6 million. During the prior fiscal year, net income was reported as $1.6 million. The firm's 1974 estimated share of the market, in units produced, was 14.4%.

5. Ward School Bus Manufacturing, Inc. This family owned business is a subsidiary of Ward Industries, Incorporated which serves as a holding company for three other subsidiaries. Manufacture and assembly of school bus bodies is the primary operation of Ward School Bus Manufacturing. The subsidiary operates a 234,000 square foot plant located in Conway, Arkansas. Ward's estimated share of the 1974 school bus body market, in units produced, was 9.6%.

6. Wayne Corporation. A subsidiary of Indian Head, Inc., this corporation manufactures ambulances, hearses, postal delivery vehicles and other specialty vehicles. However, the most significant part of the operation is the manufacture and assembly of school bus bodies. The Wayne Corporation operates a plant in Richmond, Indiana. The 1974 estimated share of the market, in units produced, was 17.1%. Additional specific information pertaining to this subsidiary is not available.

The parent corporation, Indian Head, Inc., reported 1978 sales of $604 million. Indian Head is a diversified company engaged in the manufacture and processing of glass containers, metal and automotive products, specialty textiles, utilities and communications products, and micropublishing.

EXPORTS AND IMPORTS

With regard to all types of buses, the U.S. has experienced a favorable balance of trade situation. In 1977, the U.S. exported a total of 4,893 new and used buses with a value of almost $77.2 million. During the same year, the U.S. imported a total of 2,184 units valued at about $32.7 million.

(a) Exports

Table 3-19 shows U.S. bus exports in terms of units and value for both new and used buses. New buses figures are listed according to engine type. In 1977, the U.S. exported 4,893 units at $77,281,300. In 1968, 4,929 units valued at $27,513,075 were exported.

(b) Imports

Table 3-20 presents U.S. bus imports in terms of units and value by country of origin. U.S. imports of 2,184 units in 1977 represents a significant increase over the previous ten years. With the exception of certain Canadian manufacturers identified in prior sections, such as Motor Coach Industries and Prevost Car, only two foreign bus manufacturers have been the source of significant imports to the United States. Mercedes Benz accounts for virtually all buses imported from West Germany and a subsidiary of Overseas Inns (parent company of Eagle International) accounts for all buses imported from Belgium. As discussed in the Bus Manufacturer Profile section, Continental Trailways, the second largest intercity carrier, had maintained bus purchase agreements with Overseas Inns (which has a subsidiary with a plant in Belgium). With the devaluation of the U.S. dollar, the manufacture of such units outside the United States became economically unsound and Eagle International was formed in 1973. Production of the Belgian units was gradually phased out in 1975 with Eagle International assuming production of all Continental Trailways buses in the United States.

TABLE 3-19

U.S. BUS EXPORTS

	New Buses				Used Buses	
	Gas Engines		Diesel Engines			
Year	Units	Value	Units	Value	Units	Value
1977	2,417	$30,083,419	1,523	$43,009,743	953	$4,188,148
1976	2,526	51,498,626	557	26,601,451	598	2,891,924
1975	4,621	86,101,082	432	21,909,768	620	4,349,393
1974	2,607	15,391,587	455	13,649,000	381	1,545,689
1973	2,068	11,188,240	287	5,830,917	324	1,175,850
1972	2,579	13,179,882	206	4,132,188	266	799,222
1971	3,384	14,435,144	414	4,664,188	355	1,271,542
1970	3,141	11,978,367	359	6,527,308	297	945,006
1969	2,686	11,001,298	190	3,888,541	307	704,549
1968	3,952	19,736,151	371	6,139,753	606	1,637,171

Source: U.S. Bureau of the Census, U.S. Exports, FT 410, Schedule B, Commodity by Country, 1968-1977.

TABLE 3-20

U.S. BUS IMPORTS

Year	Total Imports		Canada		United Kingdom		Belgium		West Germany		Others	
	Units	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units	Value
1977	2,184	$32,736,572	2,045	$30,702,553	42	$125,315	-	-	90	$1,674,983	4	$10,446
1976	1,118	42,775,336	927	37,435,730	46	960,152	35	$2,177,911	108	2,133,570	2	67,973
1975	881	20,113,458	545	7,484,196	40	116,274	149	8,921,151	141	3,546,608	6	45,229
1974	1,319	28,504,289	561	6,969,929	24	46,840	262	13,384,153	469	8,033,367	3	70,000
1973	1,230	25,375,908	794	6,316,020	53	66,460	307	17,735,226	72	1,183,276	4	74,926
1972	1,433	23,855,177	779	7,137,549	52	113,633	306	15,154,884	125	1,200,763	171[1]	248,348
1971	959	21,456,271	370	3,342,758	27	26,027	328	15,911,197	234	2,176,289	-	-
1970	752	17,228,225	374	3,581,444	27	64,075	278	13,089,103	72	491,043	1	2,560
1969	478	12,894,227	166	1,393,697	22	50,335	251	10,794,048	38	640,262	1	15,885
1968	433	12,562,821	109	925,521	20	49,764	266	10,745,567	37	839,299	1	2,670

[1] Includes 169 units valued at $181,934 from Japan.

Source: U.S. Bureau of the Census, Imports, FT 135, Schedule A, Commodity by Country.

RAW MATERIAL - COMPONENT - AFTERMARKET SUPPLIERS

As illustrated in Figure 3-1, bus manufacturers obtain raw materials and components from suppliers and manufacturers. The bus aftermarket is served by those same firms which are classified as component suppliers. These suppliers and manufacturers also supply the large auto and truck manufacturing industries.

An examination of sales figures developed by the Motor Vehicle Manufacturers Association presents the relative importance of the bus industry to suppliers when compared to the much larger auto and truck industries. In 1978, auto, truck and bus sales were estimated to be 7,654,889 units, of which buses accounted for an estimated 35,342 units or 0.46% of the total. Table 3-21 lists some suppliers which have been identified during interviews with bus manufacturers.

BASELINE INDUSTRY FORECAST

In order to measure the economic impact of the proposed bus noise emission levels selected for study, a baseline forecast of industry activity was established. Against this forecast, estimated post-regulation activity will be compared so as to measure the change.

(a) Transit Buses

Based upon the APTA Market Forecast and interviews with UMTA officials, the future market forecast for transit buses has been estimated to be a slowly growing market. Table 3-22 shows this expected market.

TABLE 3-21

SELECTED SUPPLIERS TO THE BUS MANUFACTURING INDUSTRY

Manufacturer	1975 Sales ($ Millions)	Manufactured Component
Bendix	$2,481	Engine Accessories
Borg-Wagner	1,768	Radiator
Caterpillar	4,082	Engine
Cummins	833	Engine
Dana	1,070	Transmission
Donaldson	120	Air Cleaner, Muffler
Eaton	1,760	Axle
Garlock (Stemco)	151	Muffler
Midland-Ross	415	Engine Accessories, Frame
Modine	128	Radiator
Questor (A Parts)	384	Muffler
Rockwell International	4,409	Axle, Brake
Wagner Electric	236	Engine Accessories, Brake
Wallace-Murray (Schwitzer)	330	Radiator Fan
Westinghouse	5,799	Engine Accessories
Young Manufacturing	36	Radiator

Source: Interviews with bus manufacturers; Dunn & Bradstreet.

TABLE 3-22

BASELINE FORECAST: TRANSIT BUSES

Year	Production (units)
1979	4600
1980	4700
1981	4800
1982	4850
1983	4900
1984	5000
1985	5050
1986	5150
1987	5200
1988	5300
1989	5400
1990	5450
1991	5500
1992	5600
1993	5675
1994	5700
1995	5800

Source: EPA estimates based on telephone conversation with Mr. Wilbur Hare, Transit Assistance, UMTA and forecast ranges developed by the American Public Transit Association as described in United States Transit Industry Market Forecast.

(b) Intercity Buses. The intercity bus industry has experienced a recent increase in production. A survey of manufacturers indicated that a steady increase in production can be expected throughout the rest of the century. The estimated market is shown in Table 3-23.

(c) School Buses. Industry and DOT officials indicate that slow growth can be expected in the school bus industry. This market is dependent upon many types of federal and local regulations and programs. A continued shift toward diesel and parcel delivery models can be expected. The estimated demand for all types of school buses is shown in Table 3-24.

TABLE 3-23

BASELINE FORECAST: INTERCITY BUSES

Year	Production (units)
1980	1770
1981	1850
1982	1975
1983	2000
1984	2080
1985	2085
1986	2100
1987	2180
1988	2200
1989	2240

Source: EPA estimates based on Commercial Car Journal, "Industry Trends and Statistics", June 1978; Automobile Manufacturers Association, Motor Truck Facts, 1971; Department of Transportation, Interagency Study of Post-1980 Goals for Commercial Motor Vehicles - Executive Summary, July 1976; Telephone conversations with: Mr. Harold Morgan, American Bus Association and Mr. Bill Chaddick, Hausman Bus distributor.

TABLE 3-24

BASELINE FORECAST: SCHOOL BUSES

Year	Production (units)
1979	30,000
1980	30,300
1981	30,500
1982	30,700
1983	31,000
1984	31,300
1985	31,500
1986	31,700
1987	32,000
1988	32,300
1989	32,500
1990	32,700
1991	33,000
1992	33,300
1993	33,500
1994	33,700
1995	34,000
1996	34,300
1997	34,500
1998	34,700
1999	35,000

Source: EPA estimates based on telephone conversations with: Mr. David Soule, Pupil Transportation Director, Department of Transportation; Mr. Jerry Dior, International Harvestor; Mr. James Buxton, Truck Body and Equipment Association, Inc.; and Mr. Scott Sickler, Ford Motor Company.

REFERENCES

SECTION 3

A. "A Study to Determine the Economic Impact of Noise Emission Standards in the Bus Manufacturing Industry," Draft Final Report submitted by A. T. Kearney, Inc., under EPA Contract No. 68-01-3512, prepared for the Office of Noise Abatement and Control, September, 1976.

SECTION 4

BASELINE BUS NOISE EMISSIONS

Noise emissions from urban transit buses, intercity buses and school buses were measured by EPA in a series of tests. This section describes the results of these tests plus additional noise emission data obtained from existing studies and from industry. Noise levels were measured as A-weighted sound levels at 50 feet using SAE J366b or the EPA test methodology in most cases.

1. Urban Transit Buses

Exterior and interior noise level measurements for urban transit buses are presented in this section. The data include noise level measurements conducted by EPA as well as data supplied by industry.

Exterior Noise Levels

Noise level measurements taken for EPA of 24 in-use "New-Look" type urban transit buses along with mean levels and standard deviations are presented in Table 4-1 for various measurement procedures.

The variation in noise levels between in-use buses of identical construction is thought to be due to the following reasons:

The maximum noise occurs at transmission shift, which does not always occur at the same engine rpm or test location for each test for older buses.

The rear engine compartment doors for the older buses tend to be ill-fitting and failed to lock on many of the buses tested causing some variation between test runs.

The difference in noise levels between the curbside and streetside of the buses occurred because the fan and radiator are located on the streetside of the bus causing higher levels on that side.

TABLE 4-1

Summary of Exterior and Interior Noise Levels
for In-Service "New Look" Transit Buses

MAKE AND MODEL NO.	TRANSMISSION	EXTERIOR NOISE LEVELS (50 FT.) (SAE J366b) STREET SIDE	EXTERIOR NOISE LEVELS (50 FT.) (SAE J366b) CURB SIDE	EXTERIOR NOISE LEVELS (50 FT.) PULL-AWAY STREET SIDE	EXTERIOR NOISE LEVELS (50 FT.) PULL-AWAY CURB SIDE	EXTERIOR NOISE LEVELS (50 FT.) STATIONARY IMI STREET SIDE	EXTERIOR NOISE LEVELS (50 FT.) STATIONARY IMI CURB SIDE	INTERIOR NOISE REAR
GM-6504	Automatic	83 (83)	81 (80.7)	87 (86.5)	79.5 (79.5)	--	--	83 (82.5)
GM-6302	Automatic	82 (81.7)	79.5 (78.7)	82 (82)	79.5 (79.5)	--	--	87.2 (86.6)
GM-6323	Automatic	84 (83.7)	80 (79.7)	85 (85)	77 (77)	--	--	89.5 (88.8)
GM-6610	Automatic	82 (82)	80 (80)	82.5 (82)	76.25 (76.2)	--	--	86.75 (86.4)
GM-6400	Automatic	82 (81.8)	79.7 (79.1)	82 (82)	75.25 (75.2)	--	--	83.5 (83.2)
GM-6401	Automatic	84.25 (84.2)	83.1 (82.4)	85.5 (85.3)	80.5 (80.3)	-- (86.7)	-- (--)	84 (83.7)
GM-6321	Automatic	86.1 (85.7)	81.5 (81.5)	86 (85.8)	82.25 (82)	-- (86)	-- (--)	82 (81.3)
GM-6408	Automatic	79 (78.7)	79.25 (78.8)	81 (80.7)	76.25 (76.75)	-- (--)	-- (--)	83 (82.3)
GM-6616	Automatic	82 (82)	78.25 (78.25)	84.25 (84.17)	79 (79)	86.7 (86.7)	-- (--)	90 (88.4)
GM-6503	Automatic	-- (--)	78.75 (78.5)	81.75 (81.5)	78 (77.7)	86 (86)	-- (--)	87 (85.8)
GM-6703	Automatic	83.5 (83.3)	83.25 (81.8)	89.25 (89.25)	78 (77.5)	87 (87)	74 (74)	85.75 (84.8)
GM-6601	Automatic	82.5 (82.2)	77 (77)	81.5 (81.2)	77 (76.8)	87 (87)	78 (78)	83 (82.8)
FLX-6808	Automatic	81 (80.8)	80 (80)	82.5 (82.3)	78.5 (78.5)	89 (89)	74 (74)	86 (85.8)
FLX 6812	Automatic	80.75 (80.7)	79.5 (79.7)	80.25 (81.25)	76.75 (76.5)	87 (87)	79 (79)	85 (85)
FLX-6826	Automatic	80 (80)	78.75 (78.5)	81.75 (81.7)	76.5 (76.3)	86 (86)	74 (74)	86.75 (85.8)
FLX-6800	Automatic	82.25 (82.17)	81.5 (81.3)	82 (81.7)	81 (81)	91 (91)	75 (75)	85 (84.8)
AM-7110	Automatic	79.75 (79.7)	80.75 (80.7)	83.75 (83.5)	78.25 (78.2)	89 (89)	80 (80)	81 (80.6)
AM-7120	Automatic	80 (80)	80.75 (80.7)	82.5 (82.5)	79.25 (79)	89 (89)	76 (76)	82.75 (82.2)
AM-7130	Automatic	80 (80)	81 (81)	83.5 (83.3)	77.75 (77.5)	88 (88)	74 (74)	80.25 (80)
AM-7135	Automatic	80 (80)	81 (80.8)	82 (82)	77.75 (77.7)	88 (88)	79 (79)	81.25 (79.3)
AM-7540	Automatic	81.75 (81.2)	77.75 (77.5)	80.5 (80.3)	79 (78.7)	83 (83)	75 (75)	80.25 (79.6)
AM-7545	Automatic	77.75 (77.5)	79 (78.3)	79.25 (79.2)	75.5 (75)	83 (83)	80 (80)	83.5 (80.5)
6M-50/51	Standard	78.75 (78.7)	78.75 (78.5)	81 (81)	77 (76.8)	88 (88)	76 (76)	82.75 (79.4)
FLX-6509	Automatic	81 (80.7)	81 (80.8)	82.5 (82.5)	79.5 (79)	88 (88)	76 (76)	85 (81.9)
MEAN		81.5 (81.3)	80.0 (79.8)	82.9 (82.8)	78.1 (78)	87.2 (87.1)	76.4 (76.4)	84.3 (83.4)
STD.		1.96 (1.93)	1.53 (1.44)	2.31 (2.25)	1.75 (1.74)	2.09 (1.98)	2.31 (2.31)	2.67 (2.82)

NOTE: Numbers in parentheses are computed from all data, while numbers not in parentheses are computed from the two highest noise levels.

Histograms of in-service transit bus exterior noise levels under maximum acceleration, pull-away, and stationary conditions under maximum acceleration test conditions are shown in Figure 4-1.

Exterior noise levels of two GMC "New-Look" transit buses tested in Seattle, Washington under different operating conditions are given in Tables 4-2 and 4-3. (Ref. 1.) The buses are designated as #440D and #704. Attention should be given to a comparison of the noise levels on the streetside and curbside.

The Flxible Company has performed an extensive series of exterior noise measurements on their "New-Look" type transit buses as summarized in Table 4-4.

The data presented for new and in-use transit buses indicates that the median design level of new transit buses should be 2 to 2.5 dB below a "not-to-exceed" standard.

General Motors Corporation has recently initiated a "Quiet Bus Program." (Ref. 2) For a GMC "New-Look" bus before it was "quieted," Model No. T8H5307A GMC reports a mean noise level of 80.5 dB using a modified SAE J366b test procedure with the fan off, and 83.7 dB with the fan on. This model is a 40 ft, 53 passenger urban transit bus powered by an 8V-71 diesel engine. GMC also reports that for 15 identical transit coaches of this model (T8H 5307A) using a modified SAE J366b maximum acceleration procedure (like the EPA Test Procedure) a mean noise level of 81.2 dB with the fan off (standard deviation of 0.43) was measured while a mean level of 83.9 dB was measured with the fan on (standard deviation 0.75). (Ref. 3)

In four trials, while using a special dual muffler configuration, GMC was able to lower the noise level of the "quieted coach" to just over 75 dB under acceleration on the left side of the test coach and less than 71 dB on

FIGURE 4-1(1)

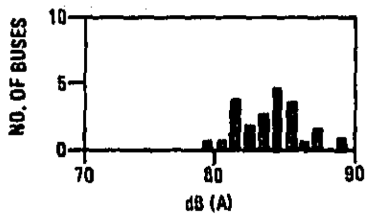
Histograms of In-Service "New-Look" Transit Bus Exterior Noise Levels

SAE J366b (Acceleration) Pull-Away, and Stationary Runup Test Levels.

Wide Open Throttle Acceleration
(SAE J366b)

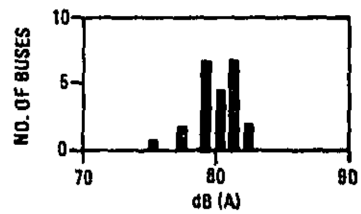
DRIVERSIDE

MEAN 83.79 dB
STD. DEV. 2.4



CURBSIDE

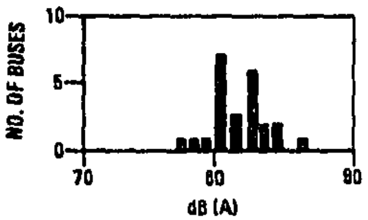
MEAN 79.92 dB
STD. DEV. 1.57



PULL-AWAY TEST LEVELS (50 FT.)

DRIVERSIDE, FRONT DOOR

MEAN 81.37 dB
STD. DEV. 1.84



CURBSIDE, FRONT DOOR

MEAN 78.77 dB
STD. DEV. 2.00

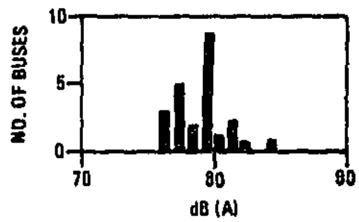
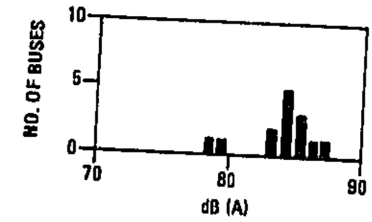


FIGURE 4-1(2)

Stationary Runup

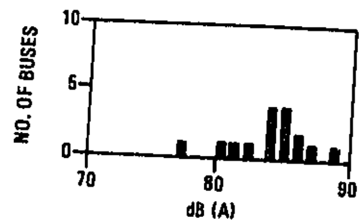
DRIVERSIDE, FRONT DOOR

MEAN 83.82 dB
STD. DEV. 2.45



DRIVERSIDE, REAR DOOR

MEAN 84 dB
STD. DEV. 2.87



CURBSIDE, FRONT DOOR

MEAN 79 dB
STD. DEV. 3.0

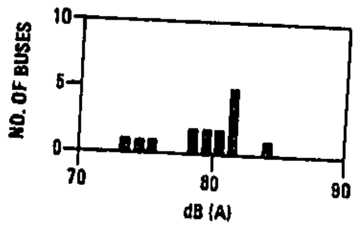


TABLE 4-2

Exterior Noise Levels at 50 ft, Bus #440D (GMC "New Look")

Test Description	Interior Accessories	Sound Level, dB Curbside	Sound Level, dB Streetside
Acceleration, J366b Test	OFF	77.5	84.0
Acceleration, J366b Test	ON	77	81.5
Deceleration from 30 mph (no brakes)	OFF	67	66
Deceleration from 30 mph (no brakes)	ON	70	71
Coast-by 30 mph	OFF	70	71
Coast-by 30 mph (hydraulic fan off)	ON	71	71
Coast-by 30 mph (hydraulic fan off)	OFF	68	70
Coast-by 55 mph	OFF	77	80
Cruise 30 mph	ON	72	76

Source: Reference 1

TABLE 4-3

Exterior Noise Levels, Bus #705

(GMC "New Look")

Test Description		Sound Level, dB Curbside	Streetside
Curb Idle	- 5 ft	77	-
0-5 mph, Wide Open Throttle, Rear Corner	- 5 ft	88	-
0-5 mph, Wide Open Throttle, Rear Door	- 5 ft	90	-
10 mph Drive By	- 50 ft	66	73
30 mph Drive By	- 50 ft	72	78
55 mph Drive By	- 50 ft	78	87
25 mph Acceleration	- 50 ft	75	81
50 mph Acceleration	- 50 ft	78	86
30 mph Deceleration	- 50 ft	71	77
55 mph Deceleration	- 50 ft	77	84
55 mph Coast By	- 50 ft	77	84

Source: Reference 1

TABLE 4-4

Flxible "New-Look" Type Transit Buses Exterior Sound Levels
at 50 feet Wide Open Throttle Acceleration

Coach Length (feet)	Engine	Number of Buses Tested	Models	Sound Level, dB			
				Curbside		Streetside	
				Mean	Standard Deviation	Mean	Standard Deviation
40	6V-71	7	53096-6-1 53102-6-1	80.46	0.55	82.25	0.69
40	8V-71	9	53096-8-1 53102-8-1	80.92	0.87	82.05	0.73
35	6V-71	3	45096-6-1	82.16	1.26	83.17	0.76
35	8V-71	1	45102-8-1	80.50		82.00	

Source: Flxible Company

TABLE 4-5

GMC Quiet Bus Program ("New Look" Type)

Exterior Sound Levels @ 50 ft (Wide Open Throttle Acceleration)

Run	Left Side (dB)	Right Side (dB)
1	75.3	71.5
2	74.9	70.0
3	75.8	71.4
4	75.1	70.6

Source: Reference 2

the right. GMC indicates this developmental coach would meet a regulated level of 78 dB. Exact results are shown in Table 4-5. The test used is a modified SAE J366b test with the starting point adjusted so that the transmission shift, and therefore maximum noise, is achieved in the test zone. All cooling fans were running during the test.

General Motors and Flxible have virtually ceased production of "New Look" transit buses in the U.S. A Canadian company, Flyer, still sells "New Look" buses, but the supply of them is limited. Flyer buses are very similar to the AM General "New Look" buses and can be expected to emit similar noise levels.

Both General Motors and Flxible have introduced a new line of Advanced Design Buses (ADB's). The Urban Mass Transportation Administration (UMTA) specifications for ADB's require these buses to meet an 83 dB not-to-exceed exterior standards. These vehicles have been less extensively tested, however, since their drive train is essentially the same as the "New Look" drive trains, their noise levels can be expected to be similar to those of "New Look" buses.

Using the EPA test procedure, General Motors has found the exterior noise levels for their RTS II ADB's to range from 82 dB to 85 dB. The average level is 83 dB, but 40% of the buses exceed that level. Grumman Flxible tests of two of their 870 ADB's demonstrated exterior noise levels of 81.25 dB and 84.5 dB, under the EPA test procedure.

AM General does not produce ADB's but instead assembles articulated buses which are imported from the M.A.N. company in West Germany. These buses employ in-line 6 cylinder turbocharged engines which are mounted under the floor in front of the mid-axle. The drive train is quite different from that of the "New Look" and ADB, however, the noise levels are similar. AM General says that the buses have average noise levels of about 83 dB, which is sufficient to meet UMTA requirements. (Ref. 23)

Other than the "New Looks" ADB's and M.A.N. articulated buses, there are few other types of transit buses in service in the U.S. There are some double deck buses made by British Leyland and Neoplan in use, however, the market for these is not strong. Similarily, articulated buses made by Ikarus, Volvo, and Hamburger Hochbahn have been demonstrated in the U.S., however, they have not captured a significant share of the market. These buses tend to emit noise levels similar to those of standard North American buses except for the Hamburger Hochbahn bus, which is somewhat quieter.

Interior Noise Levels

The Flxible Company reported that the mean interior noise level measured 24 inches from the rear window of their "New-Look" type transit bus under maximum acceleration conditions was 83.5 dB with a standard deviation of 0.75. They also reported that interior noise levels of some coaches can be 87 dB at the shift point. (Ref. 4)

Figure 4-2 shows a histogram of interior noise levels of in-service transit buses measured at the rear of the bus during stationary run-up tests.

Interior noise level measurements of two GMC transit buses, presented in Tables 4-6 and 4-7, indicate that carpeting will slightly lower the noise level in the interior. Inside the non-carpeted buses, Table 4-7, no difference

FIGURE 4-2

Histogram of In-Service Transit Bus Interior Noise Levels

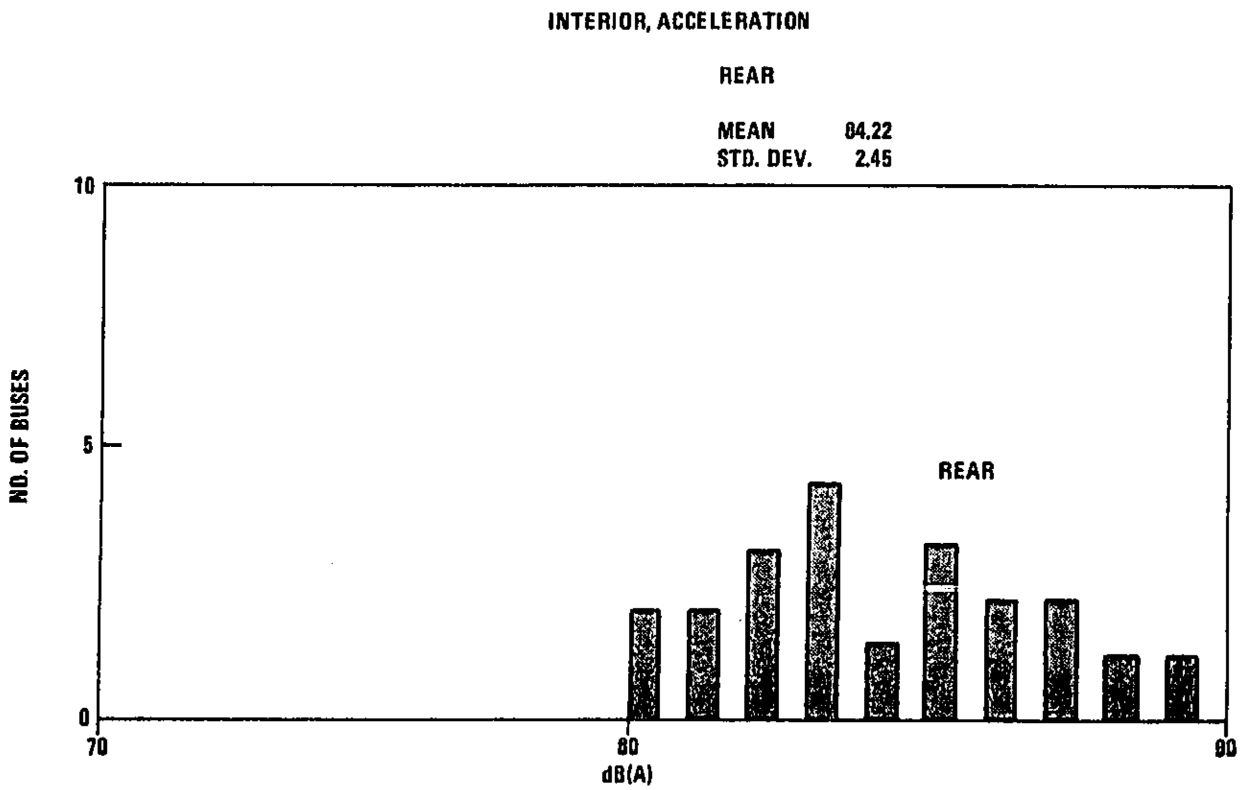


TABLE 4-6

Interior Noise Levels (Empty Bus), Bus #440D

(GMC "New Look")

Test Description	Sound Level, dB			
	Without Carpet		With Carpet	
	Standing	Seated	Standing	Seated
10 mph - Front	68	67	68	67
Middle	70	71	70	70
Rear	74	74	-	75
30 mph - Front	73	72	72	71
Middle	75	76	73	72
Rear	80	81	78	78
55 mph - Driver's Ear	-	77	-	77
Front	79	79	77	75
Middle	79	79	77	77
Rear	84	83	84	83
0-55 Acceleration - Front	-	79	77	76
Middle	81	81	79	79
Rear	82	84	84	84
55-0 Deceleration - Front	78	76	75	74
Middle	78	77	77	77
Rear	80	81	81	83
Standing Idle - Accessories Off, Middle	-	63	-	61
Standing Idle - Accessories On, Middle	-	69	-	68
10 mph - Accessories Off, Middle	-	67	-	63
30 mph - Accessories Off, Middle	-	72	-	69
55 mph - Accessories Off, Middle	-	78	-	76

Source: Reference 1

TABLE 4-7

Interior Noise Levels (Empty Bus), Bus #705
(GMC "New Look")

Test Description	Sound Level, dB	
	Standing	Seated
10 mph - Front	74	73
Middle	75	75
Rear	79	78
30 mph - Front	75	74
Middle	77	77
Rear	85	84
55 mph - Front	77	78
Middle	79	80
Rear	85	85
0-55 Acceleration - Front	78	78
Middle	82	81
Rear	89	86
55-0 Deceleration - Front	77	76
Middle	77	79
Rear	86	85

Source: Reference 1

in noise level appears evident from a change in the height of the microphone for noise levels taken at any one measurement location. This indicates that a sitting or standing passenger in the same general area of the bus receives the same noise exposure.

GMC also reported a reduction of interior noise levels for its "Quiet Bus." The technical approach for quieting the bus is summarized as follows:

Noise Source	Quieting Method
Engine	Enclose and acoustically insulate engine
Cooling system	Install remote cooling system
Exhaust	Install large volume double-wall insulated muffler
Air conditioning	Enclose and insulate air conditioner compressor compartment

Measurements were made at ear level in various coach seat positions during wide open throttle acceleration and maximum sound levels were recorded. Observed data are shown in Table 4-8.

TABLE 4-8

GMC Quiet Bus Program ("New Look"-Type) Interior Sound Levels (Wide Open Throttle Acceleration)

Interior Microphone Location	Standard Coach (dB)	Quieted Coach (dB)
Rear	81	76
Center	79	72
Driver	73	70

Source: Reference 2

Component Noise Levels

For diesel powered urban transit buses of current configurations, the important noise sources are the engine exhaust, engine case radiation, cooling fan, air intake system, chassis, and tires. Data on relative contributions of these sources (minus tire noise) were obtained for a GMC "New Look" transit bus during tests conducted by EPA. (Ref. 1) Additional data were obtained from tests conducted on "New Look" type buses for the U.S. Department of Transportation (DOT) by two major transit bus manufacturers. (Refs. 5,6) The data are summarized in Table 4-9. All buses were 40 feet long and had Detroit Diesel 8V-71 engines except for the Flxible bus which was a 35-foot bus with a 6V-71 engine. The GMC and Flxible buses demonstrated the potential of feasible retrofit techniques to lower bus noise. The manufacturers' contracts with DOT required them to make these retrofit parts available to transit bus users. (It should be noted that the GMC data in Table 4-9 were not obtained during their "Quiet Bus Program" but rather under the retrofit study for DOT.) (Ref. 5) An independent estimate of transit bus component noise levels conducted by Wyle Laboratories (Ref. 7) is also included in Table 4-9.

The main contributor to interior noise for transit buses is the engine. Engine noise is transmitted through the panels by vibration and by flanking paths. The latter two sound transmission paths are very difficult to control and are thought to be the limiting factor to interior noise reduction. Air conditioning ventilation noise is also a contributing source to interior noise levels.

TABLE 4-9

"New Look"-Type Transit Bus, Component Exterior

Noise Levels, dB at 50 Feet

	EPA Tests	GMC Standard Bus	GMC Quieted Bus	Flxible Standard Bus	Flxible Quieted Bus	Wyle Estimate
Engine Mechanical	75	73	71	79	75	79-80
Exhaust	80	76	74	79	65	80
Cooling Fan	81	84	73	77	73	78-85
Intake	70					60-75
All Other Sources	70	76	76	65	65	68-73
Overall Sound Level	84.5	85.5	80	83.5	78	84-87.5

Source: References 1, 5, 6, 7

2. Intercity Buses

Exterior and interior noise level data were gathered on intercity buses for the three major U.S. intercity bus manufacturers (Eagle International, General Motors Corporation and Motor Coach Industries).

Exterior Noise Levels

Exterior noise level data, measured by EPA, of 12 newly manufactured intercity buses under various test procedures may be found in Table 4-10 (Ref. 21). The buses tested emitted average exterior noise levels at 50 feet ranging between 82 and 87 dB under wide open throttle acceleration conditions (SAE J366b) with a mean level of 85.5 dB. In addition, SAE J366b deceleration tests were run on two intercity coaches with engine brakes fully engaged. The buses emitted average maximum noise levels of 89.4 dB under the SAE J366b deceleration procedure as compared to average maximum noise levels of 87 dB under the SAE J366b acceleration procedure. The standard deviations exhibited in the data indicate that 2-2.5 dB difference between an engineering design level and a "not-to-exceed" regulatory level appears adequate for intercity buses.

Data measured by using the SAE J366b procedure for a GMC manual transmission production intercity coach Model P8M4905A (Ref. 8) are shown in Table 4-11.

TABLE 4-11

GMC Intercity Bus Exterior Noise Levels at 50 ft

Wide-Open Throttle Acceleration Test

Cooling Fan On		Cooling Fan Off	
Streetside	Curbside	Streetside	Curbside
84.2 dB	81.4 dB	80.6 dB	79.1 dB

Source: Reference 8

TABLE 4-10

Summary of Exterior Noise Levels at 50 ft. For Intercity Buses

BUS SERIAL NO.	MODEL	TRANSMISSION	A-WEIGHTED SOUND LEVELS, dB(A) AT 50 FEET: (SAE J366b) MAXIMUM ACCELERATION		PULL-AWAY		STATIONARY IMI		STATIONARY MAXIMUM GOVERNED SPEED	
			STREET SIDE	CURB SIDE	STREET SIDE	CURB SIDE	STREET SIDE	CURB SIDE	STREET SIDE	CURB SIDE
S 12327	MC-8	Standard	86 (85.1)	82.5 (80.6)			86.5 (85.25)	85 (81.50)	79.5 (77.5)	79.5 (77.0)
S 12337	MC-8	Standard	86 (85.3)	83.25 (81.3)			87.5 (85.5)	82.75 (79.80)	80 (78.25)	78 (76)
S 12361	MC-8	Automatic	86.5 (85.7)	83.25 (82.4)	86 (85.63)		88 (85.75)	77.25 (77.25)	80.5 (78.75)	75 (74)
S 12239	MC-8	Automatic	86 (85.5)	84.25 (82.9)	84.75 (84.5)	82.75 (82.63)	86.25 (84.6)	83.75 (80.6)	81 (78.5)	78 (75)
S 12359	MC-8	Automatic	84.5 (84.25)	81 (79.75)	84 (83.88)	81 (80.75)	86.75 (85.4)	81 (78.50)	81.5 (79.25)	78 (75.75)
S 12322	MC-5B	Standard	87.25 (85.2)	81 (79.6)	90.25* (89.33)	83* (82.17)	86 (85.5)	81 (79.25)	79 (78.75)	77 (76)
S 12323	MC-5B	Standard	87 (85.6)	81 (79.5)	89* (88.25)	82.25* (81.0)	85.5 (85.25)	80.25 (78.9)	80 (78.75)	77 (75.5)
19699	05	Standard	85 (84.5)	85.5 (84.5)	--	--	84.8 (82.9)	85.8 (82.3)	82.3 (81.1)	84.5 (81.3)
19704	05	Standard	85.5 (84.3)	86.5 (84.8)	--	--	84 (82.1)	85.8 (85.1)	82.5 (80.6)	84.5 (83.6)
9678	05	Standard	85.3 (84)	85.3 (84)	--	--	84 (82.4)	84.5 (82.1)	83 (80.5)	82.5 (80.3)
9677	05	Standard	84 (83.8)	85.8 (83.8)	--	--	84.8 (82.4)	84.5 (80.4)	83 (82.9)	82.5 (80.6)
--	17	Automatic	82.5 (81.4)	81 (79.9)	--	--	80 (79.4)	79.3 (77.6)	75.8 (75.4)	78.5 (77.3)
Mean	All	All	85.5 (84.6)	83.4 (81.9)	84.9 (84.9)	81.9 (81.7)	85.3 (83.9)	82.6 (80.3)	80.7 (79.2)	79.6 (77.7)
Std. Dev.	All	All	1.33 (1.18)	2.09 (2.05)	1.01 (.89)	1.24 (1.33)	2.11 (2.0)	2.78 (2.23)	2.06 (1.91)	3.14 (3.0)
Mean	MC-8	All	85.8 (85.1)	82.9 (81.4)	84.9 (84.7)	81.9 (81.7)	87 (85.3)	82 (79.6)	80.5 (78.3)	77.7 (75.6)
Std. Dev.	MC-8	All	.76 (.48)	1.21 (1.30)	1.01 (.89)	1.24 (1.33)	.73 (.42)	3.01 (1.70)	.79 (.65)	1.64 (1.12)
Mean	MC-5B	Standard	87.1 (85.4)	81 (79.5)	89.6* (88.8)	82.6* (81.6)	85.8 (85.4)	80.6 (79.1)	95.5 (78.8)	77 (75.8)
Std. Dev.	MC-5B	Standard	.18 (.29)	0 (.06)	.88* (.76)	.53* (.83)	.35 (.18)	.53 (.36)	.71 (0)	0 (.35)
Mean	05	Standard	85 (84.2)	85.8 (84.3)	--	--	84 (82.5)	85.2 (82.5)	82.7 (81.3)	83.5 (81.5)
Std. Dev.	05	Standard	.67 (.31)	.53 (.46)	--	--	.46 (.33)	.75 (1.95)	.36 (1.11)	1.15 (1.49)
Mean	17	Automatic	82.5 (81.4)	81 (79.9)	--	--	80 (79.4)	79.3 (77.6)	75.8 (75.4)	78.5 (77.3)
Std. Dev.	17	Automatic	0 (.78)	0 (.74)	--	--	0 (.58)	.35 (1.41)	.35 (.32)	0 (1.16)

*Deceleration tests with engine brake.

NOTE: Numbers in parentheses are computed from all data, while numbers not in parentheses are computed from the two highest noise levels.

In addition, during a demonstration at the GMC noise test track in Pontiac, Michigan, on December 16, 1975, wide open throttle acceleration (SAE J366b) noise levels at 50 feet of 83.4 and 84.1 dB were measured on the streetside of a GMC intercity coach while 82.8 and 83.2 dB were measured on the curbside.(Ref. 1) The test was performed with the transmission in second shift.

Motor Coach Industries (MCI) reports a curbside noise level of 82.5 dB and a streetside noise level of 85 dB using the SAE J366b procedure. At 70 mph cruise conditions, the same bus was said to produce 80.5 dB on the curbside and 82.5 dB on the streetside. (Refs. 9,20)

Wyle Research (Ref. 7) estimated wide open throttle acceleration noise levels for intercity coaches at 84 to 86 dB, which is about the same as their estimate of 85.5 dB for urban transit buses with 8V-71 engines.

Under high speed cruise conditions, tire noise levels at 50 feet may reach 75 dB at 55 mph for rib-type tires used for intercity coaches. (Ref. 6) This estimate is based on measurements conducted by DOT and the National Bureau of Standards at Wallops Island, Virginia, on a loaded International Harvester Truck (Model No. 1890) of 25,640 pounds GVWR.

Interior Noise Levels

Table 4-12 presents interior noise level data for 12 intercity coaches recorded during various testing procedures. It is interesting to note that in certain cases up to a 10 dB difference in noise level is present from the front of the vehicle to the rear of the vehicle.

Besides the data reported in Table 4-12 Eagle International reports levels of 72 to 73 dB at the rear seat at 50 mph, (Refs. 10,21) after noise treatment had been added around the engine compartment.

MCI reports levels of 70 to 71 dB at an unspecified seat location in their MC-5 35-foot coach. (Refs. 9,20) MCI also conducted measurements under

TABLE 4-12

Interior Noise Levels for Intercity Buses

BUS SERIAL NO.	MODEL	TRANSMISSION	MEASUREMENT LOCATION	A-WEIGHTED SOUND LEVEL, dB(A) AT 50 FT.			
				(SAE J366b) MAXIMUM ACCELERATION	PULL-AWAY	STATIONARY IMI	STATIONARY MAXIMUM GOVERNED SPEED
S 12327	MC-8	Standard	Front	74.5		74.25	
			Mid	73.25		73	
			Rear	79.25		77.3	74.3
S 12337	MC-8	Standard	Front	73.75		73.5	
			Mid	72		72	
			Rear	78.25		77	75.7
S 12239	MC-8	Automatic	Front	73	73	72.5	
			Mid	72	72	71.7	
			Rear	77.5	77.5	76.6	74.6
S 12239	MC-8	Automatic	Front	73.5	73.75	73.2	
			Mid	74	74.25	72.5	
			Rear	80.25	79	77.5	74
S 12359	MC-8	Automatic	Front	73	73	73	
			Mid	71	71	70.75 •	
			Rear	77	75.5	74.7	73
S 12322	MC-5B	Standard	Front	74.6	77.25	75.5	
			Mid	78	76.5	78.75	
			Rear	79.75	79.25	78.5	76.75
S 12323	MC-5B	Standard	Front	77.25	75.25	74.5	
			Mid	76.75	74.5	77.75	
			Rear	81	79.5	80.15	79
19699	05	Standard	Front	71.25	--	71.5	70
			Mid	76.5		75.75	--
			Rear	81.75		82	81
19704	05	Standard	Front	69.5	--	72.25	69
			Mid	74.75		72.75	70
			Rear	81		82	81
9678	05	Standard	Front	67.75	--	70	66
			Mid	73		77.25	74.8
			Rear	82		--	80
9677	05	Standard	Front	70.75	--	72	69.5
			Mid	77		76	72.5
			Rear	82		82.5	80
--	17	Automatic	Front	74	--	75.8	72
			Mid	79.25		80.5	77
			Rear	84		84	83
Mean	All	All	Rear	80.3	77.3	79.1	77.7
Std. Dev.	All	All	Rear	2.06	1.76	2.91	3.36
Mean	MC-8	All	Rear	78.5	77.3	76.6	74.3
Std. Dev.	MC-8	All	Rear	1.37	1.76	1.13	.98
Mean	MC-5B	Standard	Rear	80.4	79.4	79.3	77.9
Std. Dev.	MC-5B	Standard	Rear	.88	.18	1.17	1.59
Mean	05	Standard	Rear	81.7	--	82.2	80.5
Std. Dev.	05	Standard	Rear	.47		.29	.58
Mean	17	Automatic	Rear	84	--	84	83
Std. Dev.	17	Automatic	Rear	0		0	0

stationary and cruise conditions at various locations in the coach with and without approximately 90 square feet of sound insulation (Baryfoil #10.25) between the engine compartment and passenger compartment. This insulation was found to have no consistent effect on interior sound levels, which are summarized in Table 4-13.

TABLE 4-13

Interior Sound Levels in

Rear of MCI MC8 Coach, dB

	Normal Idle	High Idle	Maximum rpm	60 mph Cruise
Standard Coach	64	65	69	73
Insulated Coach	63	65	72	72

Source: Reference 9,20

Bray (Ref. 11) reports average sound levels for intercity coaches of 74 to 78 dB at the front seat and 70 to 84 dB at the rear seat.

Levels under normal street acceleration conditions at the rear seat of a new GMC intercity bus ranged from 80 to 84 dB, compared to 77 dB at cruise (30 mph) and 72 dB at idle. (Ref. 1)

For intercity buses, interior noise levels at pass-bys of 55 mph are more representative of actual driving conditions than the interior noise levels measured under maximum acceleration. However, maximum noise levels are most likely to occur under maximum acceleration conditions.

Current Component Noise Levels

Data on component levels of intercity buses are presently not available but are believed to be closely aligned with Urban Transit Bus component noise levels. This is believed to be true since many of the same noise generating sources (engine, transmission, cooling system) are similar on identical to

Urban Transit Buses. Almost all transit and intercity buses use Detroit Diesel 6V71 or 8V71 engines with Allison transmissions. The reader is referred to the Urban Transit Bus discussion on component noise levels for intercity bus component levels.

3. Gasoline-Powered Conventional School Buses

Exterior Noise Levels

Measurements taken for EPA of in-service and newly-manufactured, gasoline powered, conventional school buses indicate a wide range of noise levels between 73 dB and 84 dB under wide open throttle acceleration. The SAE J366b acceleration procedure and the EPA measurement methodology were used (see Section 8). The data indicate that the noise level depends on engine size and Gross Vehicle Weight Rating (GVWR). Table 4-14 presents a summary of noise tests that were conducted on in-service school buses in December 1975 at Fort Belvoir, Virginia, and in March 1979 at RFK Stadium in Washington, D.C. (Refs. 1,12)

Newly manufactured school bus noise data presented in Table 4-15 includes data from:

. New 1976 conventional gasoline engine buses
. New 1978 Sheller-Globe conventional gasoline engine buses
. New 1978 Blue Bird gasoline and diesel engine buses.

Table 4-16 shows a comparison of the exterior noise levels of conventional gasoline engine school buses. Table 4-17 presents the reported school bus exterior noise levels measured using the EPA test methodology. Chrysler Corporation also provided some noise data based on a Dodge gasoline truck chassis that has identical components to their conventional school bus chassis. These data are summarized in Table 4-18.

TABLE 4-14(1)

Exterior Noise Levels at 50 ft., In-Service Gasoline Engine Conventional School Buses
Tests Conducted at Ft. Belvoir, Va., December 1975

SCHOOL BUS TYPE				ACCELERATION (dBA) (J366b)				PULLAWAY (dBA)				STATIONARY (dBA)				COAST BY (dBA)				INTERIOR (dBA) (J366b)			
GVWR	DATE OF MANUFACTURE	TRANSMISSION	ENGINE SIZE (in³)	CURBSIDE		STREETSIDE		CURBSIDE		STREETSIDE		CURBSIDE		STREETSIDE		CURBSIDE		STREETSIDE		FRONT		REAR	
				X	S	X	S	X	S	X	S	X	S	X	S	X	S	X	S	X	S	X	S
23,000	1972	Standard	345	80.1	0.95	79.3	1.13	N.A.	N.A.	N.A.	N.A.	84.9	1.85	84.8	1.35	N.A.	N.A.	N.A.	N.A.	85.9	1.61	N.A.	N.A.
23,000	1973	Standard	361	81.0	0.00	80.5	2.70	76.5	I.D.	78.5	I.D.	85.7	0.94	85.0	1.91	65.0	I.D.	69.0	I.D.	84.75	0.75	77.75	I.D.
23,000	1973	Automatic	361	82.0	0.84	83.6	1.36	77.5	0.87	78.6	0.42	85 0	2.26	85.4	2.96	N.A.	N.A.	N.A.	N.A.	83.9	1.22	77.4	1.18
23,000	1975	Automatic	361	83.5	1.50	83.1	0.54	77.8	1.03	77.1	0.55	86.8	1.48	86.3	0.83	N.A.	N.A.	N.A.	N.A.	81.25	1.48	N.A.	N.A.
23,000	1975	Automatic	330	82.0	I.D.	83.0	I.D.	79.0	I.D.	77.5	I.D.	86.5	I.D.	87.0	I.D.	N.A.	N.A.	N.A.	N.A.	82.0	I.D.	N.A.	N.A.
21,200	1975	Standard	330	77.25	0.25	77.25	0.25	N.A.	N.A.	N.A.	N.A.	80.0	1.0	82.0	2.0	N.A.	N.A.	N.A.	N.A.	83.9	0.35	80.75	0.35
21,200	1974	Standard	361	77.0	I.D.	77.5	I.D.	N.A.	N.A.	N.A.	N.A.	82.0	I.D.	81.5	I.D.	N.A.	N.A.	N.A.	N.A.	83.0	I.D.	N.A.	N.A.
19,700	1975	Standard	330	78.0	I.D.	77.0	I.D.	N.A.	N.A.	N.A.	N.A.	76.5	I.D.	75.5	I.D.	N.A.	N.A.	N.A.	N.A.	83.5	I.D.	N.A.	N.A.
17,900	1974	Standard	345	80.3	1.89	81.2	3.06	78.0	I.D.	79.5	I.D.	83.2	2.39	84.7	2.90	N.A.	N.A.	N.A.	N.A.	85.75	0.75	N.A.	N.A.
17,900	1975	Standard	330	76.0	I.D.	77.5	I.D.	N.A.	N.A.	N.A.	N.A.	82.0	I.D.	83.5	I.D.	N.A.	N.A.	N.A.	N.A.	84.0	I.D.	N.A	N.A.
17,400	1975	Standard	330	79.0	1.0	79.5	0.5	N.A.	N.A.	N.A.	N.A.	83.5	0.5	82.5	3.5	69.5	I.D.	74.0	I.D.	83.0	0.0	81.25	0.35
17,400	1975	Automatic	330	75.0	I.D.	74.0	I.D.	N.A.	N.A.	N.A.	N.A.	76.5	I.D.	76.0	I.D.	N.A.	N.A.	N.A.	N.A.	81.25	I.D.	78.75	I.D.
All Bus Types				79.3	2.65	79.5	2.94	77.8	0.90	78.2	0.95	82.7	3.5	82.9	3.71	67.25	I.D.	71.5	I.D.	83.5	1.53	79.2	1.74

N.A. indicates data was not available for that test.
I.D. indicates there was insufficient data to compute mean or standard deviation.

X indicates mean

S indicates standard deviation

TABLE 4-14(2)

Noise Levels at 50 ft,
In-Service Gasoline Engine Conventional School Buses

(1978 Wayne/Ford B-700/GVWR 23,160 lbs.
5-Speed Manual Transmission)
Wide Open Throttle Acceleration Test

Test No.	Vehicle Body No	Measured Maximum Governed Speed*	Maximum Exterior Levels** Front Reference Right	Front Reference Left	Rear Reference Right	Rear Reference Left
Fan On	41	3,700	75.5	76.0	75.0	75.0
Fan On	44	3,600	78.0	79.0	77.5	79.0
Fan On	52	3,800	77.0	78.5	77.0	79.0
Fan On	46	3,700	74.0	76.5	77.0	76.0
Fan On	49	3,800	78.0	78.5	77.0	77.5
Fan On	54	3,750	77.0	77.5	no reading	no reading
Fan On	51	3,750	75.75	75.75	75.25	76.25
Fan On	56	3,700	76.6	76.4	75.75	76.4
Fan On	40	3,750	76.5	76.5	76.0	76.8
Fan On	50	3,750	77.0	77.3	76.5	77.3
All measurements Fan On		Mean	76.54	77.2	76.33	77.03
		Standard Deviation	1.20	1.15	0.88	1.34
Fan Off	41	3,700	75.0	74.5	75.0	74.5
Fan Off	44	3,600	76.0	77.0	76.0	76.5
Fan Off	46	3,700	74.0	73.5	74.0	75.5
Fan Off	49	3,800	77.6	77.5	76.4	77.0
Fan Off	54	3,750	75.75	76.6	no reading	no reading
Fan Off	51	3,750	75.3	74.6	74.2	75.4
Fan Off	56	3,700	74.3	76.3	73.3	74.3
All measurements Fan Off		Mean	75.42	75.71	74.82	75.53
		Standard Deviation	1.20	1.50	1.21	1.07

* Measured with transmission in neutral

**Tests conducted on Arlington County, Virginia, School Buses in March 1979. Acceleration tests in second gear with fan engaged according to modified EPA test procedure.

Source: Reference 12

TABLE 4-15(1)

Noise Levels at 50 ft. for New (1976) Gasoline Engine Conventional School Buses--Wide-open Throttle Acceleration Test

GROSS VEHICLE WEIGHT RATING (POUNDS)	ACCELERATION TEST(1) (SAE J366b) EXTERIOR NOISE LEVELS* STREETSIDE		CURBSIDE		NO. OF BUSES TESTED/TOTAL NO. OF TESTS
	MEAN	STD. DEV.	MEAN	STD. DEV.	
23,600	81.4 (81.0)	0.78 (0.78)	80.2 (80.0)	1.19 (1.13)	3/18
22,000	82.8 (83.4)	2.55 (2.57)	80.0 (79.6)	1.68 (1.56)	7/46
20,500	81.7 (80.9)	0.69 (1.42)	79.7 (78.5)	2.53 (1.42)	2/16
19,700	81.6 (80.0)	0.64 (1.46)	81.1 (79.8)	0.89 (1.57)	2/12
19,200	81.6 (81.0)	1.06 (1.04)	81.4 (81.0)	1.30 (1.62)	2/14
15,700	82.6 (82.5)	0.64 (0.38)	82.8 (82.5)	0.58 (0.30)	1/6
All Buses	82.1 (81.9)	1.80 (1.99)	80.4 (79.8)	1.67 (1.70)	--

*Only one reading was taken.

(1) Top row of numbers are noise level values computed in accordance with SAE Standard J366b, i.e., taking the average of the two highest readings which were within 2 dB of each other, for each bus in the GVWR class. Numbers in parentheses were computed by averaging all readings for all buses in each GVWR class. "All Buses" values (last line) were similarly computed.

Source: Reference 13

TABLE 4-15(2)

Noise Levels at 50 ft for New (1978)
Sheller-Globe Gasoline Engine Conventional School Buses --
Wide Open Throttle Acceleration Test

Vehicle	Engine Displacement (in.^{3})	Transmission (Speeds/Type)	Engine Fan	Maximum Exterior Noise Level			
				Front Reference		Rear Reference	
				Right	Left	Right	Left
B7046	366	4/Automatic	On	80.4	82.6	79.6	81.0
B7045	366	4/Automatic	On	80.0	81.9	79.8	81.2
B4183	366	5/Manual	On	81.3	83.0	80.8	82.5
B4180	366	5/Manual	On	81.5	83.0	80.6	83.8
			Mean	80.8	82.63	80.2	82.13
			Standard Deviation	0.72	0.52	0.59	1.30
B7046	366	4/Automatic	Off	75.8	76.7	77.2	80.2
B7045	366	4/Automatic	Off	76.2	77.9	76.9	80.0
B4183	366	5/Manual	Off	75.5	80.1	76.6	80.6
B4180	366	5/Manual	Off	78.9	82.1	78.6	82.1
			Mean	76.6	79.2	77.33	80.73
			Standard Deviation	1.56	2.39	0.88	0.95

Source: Reference 14

TABLE 4-15(3)

Noise Levels at 50 ft New Standard Engine 1978 Model
Blue Bird School Buses --
Wide Open Throttle Acceleration Test

Vehicle	Engine	Tail Pipe Location	Wheelbase (inches)	Maximum Exterior Noise Level			
				Front Reference		Rear Reference	
				Right	Left	Right	Left
42376	INT1603A	Right	254	86	87	84.5	86
42230	Ford B600330	Right	222	77	78.5	76	78
F42497	Chevrolet	Left	218	80.5	83	79	85
42287	Ford B700361	Right	242	79.5	79.5	78	79
43836	GMC	Left	254	78.5	81	77	82
F40138	INT1703H	Right	187	82.5	81.5	80.0	81
F40258	Chevrolet	Left	254	79.5	81.5	78	82.5
43850	Chevrolet 350	Left	218	80	83	79.5	86
42257	GMC 6000	Left	254	81	82	78.5	80.5
			Mean	80.5	81.89	78.94	82.22
Gasoline Engined Buses N=9			Standard Deviation	2.57	2.42	2.42	2.94

Source: Blue Bird

TABLE 4-16

Comparison of Noise Levels at 50 ft of
Conventional Gasoline Engine School Buses
Wide Open Throttle Acceleration Test

Data Source	Number of Buses Measured	Reference	Maximum Exterior Noise Levels*			
			Right Side		Left Side	
			Mean	Standard Deviation	Mean	Standard Deviation
EPA Measurements of New 1976 Buses	17		80.4	1.67	82.1	1.80
Sheller-Globe New 1978 Buses	4	Front	80.8	0.72	82.6	0.52
		Rear	80.2	0.59	81.1	1.30
Blue Bird New 1978 Buses	8	Front	80.5	2.57	81.9	2.42
		Rear	78.9	2.42	82.2	2.94
In-Service Wayne/Ford (1978) Buses	10	Front	76.5	1.20	77.2	1.15
		Rear	76.3	0.88	77.0	1.34

*The reported levels are the means and standard deviations of the four recorded measurements for each of the vehicle references (front, rear, and right side, left side) reported separately.

TABLE 4-17

Reported Vehicle Noise Levels
(Per EPA Test Methodology)
Conventional Gasoline Engine School Buses

Type of Bus	Reported Vehicle Noise Level (dB)*	
	Mean	Standard Deviation
Sheller-Globe (New 1978) With Fan	82.8	0.79
Sheller-Globe (New 1978) Without Fan	80.7	0.95
Blue Bird (New 1978)	82.7	2.65
Wayne/Ford (In-service 1978) With Fan	77.4	1.10
Wayne/Ford (In-service 1978) Without Fan	76.2	0.94

* The reported levels are the means and standard deviations of the maxima of the four recorded measurements for each of the vehicle references (front, rear and right side, left side).

TABLE 4-18

Noise Data Supplied by Chrysler Corporation

Model	Equivalent Bus Chassis	Engine Displacement (in^3)	Exterior Sound Level (SAE J366b) dB
D600	S600	318	76.8 to 81.6
D600 & D700	S600 & S700	361	79.2 to 81.3
D700	S700	413	79.1 to 82.6

Source: Reference 1

While there is no clear trend as to which side of the older, conventional buses is noisier (Table 4-14), exterior measurements from the new school buses tested indicate that the streetside (left side) of the buses is generally noisier than the curbside (right side). It is believed that the difference in standard deviations between the streetside and the curbside measurements of the older buses indicates that the variation in noise levels is probably a function of the test conditions and the age of the bus rather than bus design itself. These data and past vehicle tests indicate that production buses, if tested under carefully controlled test conditions, will all produce noise levels within four to five decibels of each other. Therefore, an allowance of 2 to 2.5 dB appears appropriate between the mean design noise level and a regulated "not to exceed" levels.

Figure 4-3 shows histograms of measured exterior noise levels on each side of the gasoline powered in-service school buses along with interior noise levels at the driver and the maximum levels from all the buses. Figure 4-4 presents the same data for the new 1976 buses. Reported sound levels (per EPA methodology) are shown separately.

Octave band spectra for gasoline-powered conventional school bus noise are shown in Figure 4-5.

Interior Noise Levels

Interior noise level data measured during wide open throttle acceleration are shown for in-service and newly manufactured school buses in Table 4-19. Specific data include:

Interior noise levels of in-service school buses tested December 1975 at Ft. Belvoir, Virginia measured during wide open throttle acceleration

FIGURE 4-3

Histograms of In-Service Gasoline Engine
Conventional School Bus Noise Levels
(Wide Open Throttle Acceleration Test)

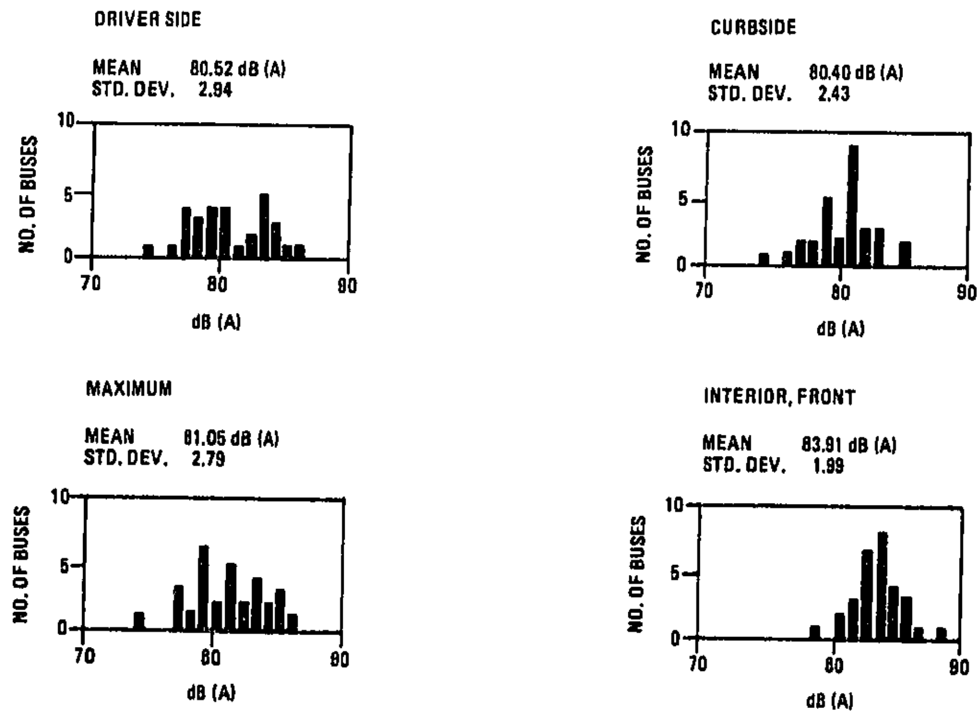


FIGURE 4-4

Histograms of Noise Levels fo .w (1976) Gasoline Engine Conventional School Buses Acceleration Tests (SAE J366b)

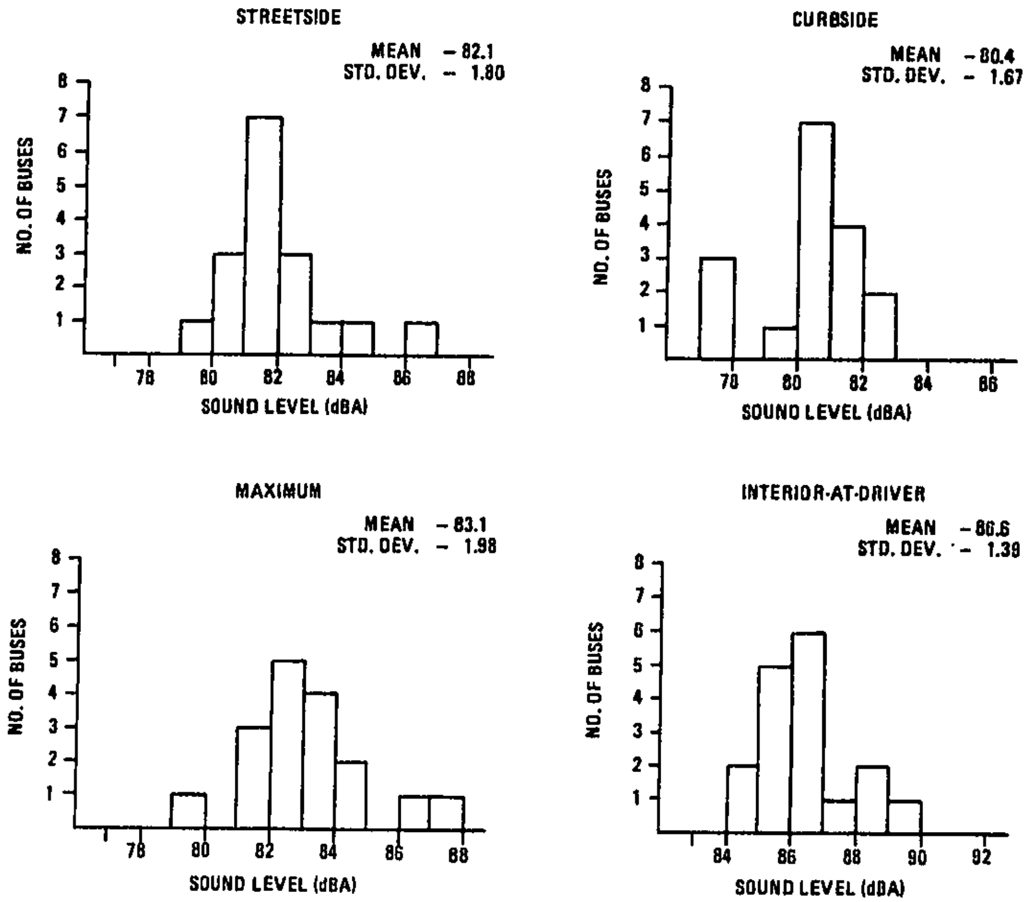


FIGURE 4-5

Typical Octave Band Spectrum of
Gasoline Engine Conventional
School Bus Noise

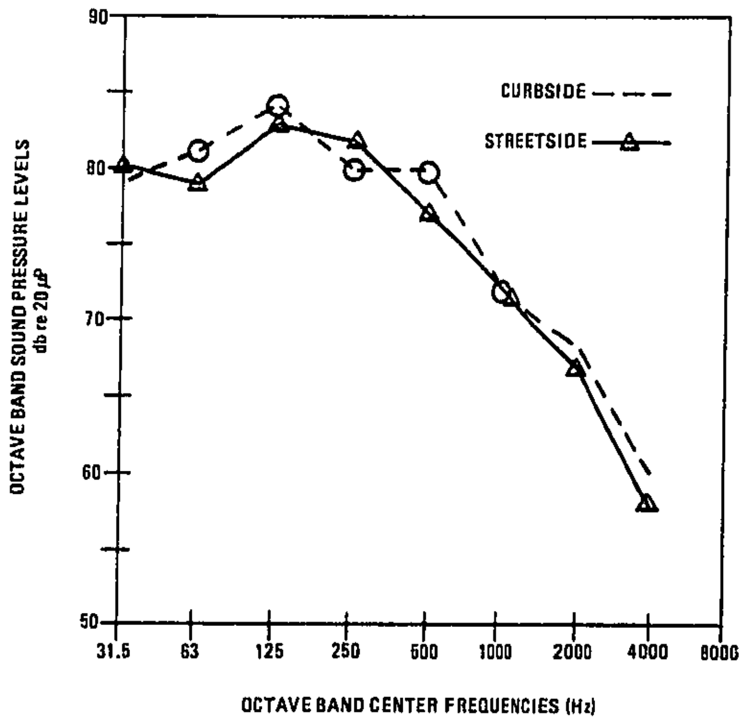


TABLE 4-19 (1)

Interior Noise Levels for In-Service Gasoline Engine Conventional School Buses -- Wide Open Throttle Acceleration Tests (Ft. Belvoir, Virginia, December 1975)

SCHOOL BUS TYPE				INTERIOR (dB)* (J366b)			
				FRONT		REAR	
GVWR	DATE OF MANUFACTURE	TRANSMISSION	ENGINE SIZE (in^3)	X	S	X	S
23,000	1972	Standard	345	85.9	1.61	N.A.	N.A.
23,000	1973	Standard	361	84.75	0.75	77.75	I.D.
23,000	1973	Automatic	361	83.9	1.22	77.4	1.18
23,000	1975	Automatic	361	81.25	1.48	N.A.	N.A.
23,000	1975	Automatic	330	82.0	I.D.	N.A.	N.A.
21,200	1975	Standard	330	83.9	0.35	80.75	0.35
21,200	1974	Standard	361	83.0	I.D.	N.A.	N.A.
19,700	1975	Standard	330	83.5	I.D.	N.A.	N.A.
17,900	1974	Standard	345	85.75	0.75	N.A.	N.A.
17,900	1975	Standard	330	84.0	I.D.	N.A.	N.A.
17,400	1975	Standard	330	83.0	0.0	81.25	0.35
17,400	1975	Automatic	330	81.25	I.D.	78.75	I.D.
All Bus Types				83.5	1.53	79.2	1.74

*All accessories on
X indicates mean
S indicates standard deviation
N.A. indicates data was not available for that test.
I.D. indicates there was insufficient data to compute mean or standard deviation.

TABLE 4-19 (2)

Interior Noise Levels for New (1976) Gasoline Engine
Conventional School Buses -- Engine at Idle Conditions
Stationary Tests (Complete Data for All Buses and All Test Runs)
(EPA Tests at Sandusky, Ohio, June 1976)

TEST VEHICLE NUMBER	GROSS VEHICLE WEIGHT RATING (POUNDS)	MANUFACTURER CHASSIS/BODY	TRANSMISSION TYPE	ENGINE SIZE ($IN.^3$)	STATIONARY TEST – INTERIOR NOISE LEVELS								
					ENGINE ONLY			ACCESSORIES ONLY			ENGINE & ACCESSORIES		
					FRONT	MIDDLE	REAR	FRONT	MIDDLE	REAR	FRONT	MIDDLE	REAR
1	23,660	IHC/Superior	Manual	392	56.9	54.1	55.1	78.4	72.2	71.0	81.2	74.7	73.8
3	23,660	IHC/Superior	Automatic	392	57.3	55.8	53.2	77.4	71.8	71.0	78.9	73.2	72.3
4	23,660	IHC/Superior	Automatic	392	54.7	51.5	53.5	76.8	70.1	69.8	78.2	72.4	71.8
8	22,000	Ford/Superior	Manual	330	55.0	54.0	53.5	77.2	72.7	74.5	78.6	74.3	75.1
9	22,000	Ford/Superior	Manual	330	--	--	--	77.2	72.8	73.7	79.7	75.0	75.6
11	22,000	Ford/Superior	Manual	361	57.5	56.0	56.5	76.4	71.0	71.3	77.3	72.5	72.7
12	22,000	GMC/Superior	Manual	350	--	--	--	77.3	70.7	70.3	77.7	73.0	71.8
13	22,000	GMC/Superior	Manual	350	58.7	56.0	54.0	76.8	72.8	74.2	80.9	76.8	78.2
14	22,000	GMC/Superior	Manual	350	54.3	53.3	51.8	77.2	72.2	74.4	78.2	73.5	74.3
15	22,000	GMC/Superior	Manual	350	60.5	56.6	55.0	77.4	71.1	70.0	80.9	74.6	73.9
16	20,500	Chev/Superior	Manual	350	--	--	--	75.8	71.6	70.6	76.2	72.2	70.6
17	20,500	Chev/Superior	Manual	350	58.7	52.5	51.0	73.7	70.9	72.7	75.8	73.2	75.8
2	19,700	IHC/Superior	Manual	345	--	--	--	76.5	72.2	71.8	79.8	75.4	74.6
6	19,700	IHC/Superior	Manual	345	--	--	--	74.2	68.9	66.4	75.8	72.5	69.3
7	19,200	Ford/Superior	Manual	361	57.5	53.5	52.8	78.5	74.1	75.7	81.0	76.7	78.2
10	19,200	Ford/Superior	Manual	389	--	--	--	73.8	72.2	75.5	75.0	73.2	76.0
5	15,700	IHC/Superior	Automatic	345	57.2	54.0	56.0	76.7	73.0	70.8	79.2	75.1	73.5
All Buses					$\bar{x}$ = 57.1 s = 1.88	$\bar{x}$ = 54.3 s = 1.62	$\bar{x}$ = 53.8 s = 1.69	$\bar{x}$ = 76.5 s = 1.42	$\bar{x}$ = 71.8 s = 1.24	$\bar{x}$ = 72.0 s = 2.44	$\bar{x}$ = 78.5 s = 1.99	$\bar{x}$ = 74.0 s = 1.45	$\bar{x}$ = 74.0 s = 2.44

TABLE 4-19 (3)

Summary of Interior Noise Levels for New (1976) Gasoline Engine Conventional School Buses--Wide Open Throttle Acceleration Test (EPA Tests at Sandusky, Ohio, June 1976)

GROSS VEHICLE WEIGHT RATING (POUNDS)	INTERIOR NOISE LEVELS** FRONT MEAN	FRONT STD. DEV.	MIDDLE MEAN	MIDDLE STD. DEV.	REAR MEAN	REAR STD. DEV.	NO. OF BUSES TESTED/TOTAL NO. OF TESTS
23,660	89.2 (87.2)	0.50 (1.58)	83.0 (81.3)	0.10 (1.68)	82.1 (80.1)	0.14 (1.97)	3/18
22,000	87.0 (85.9)	0.28 (0.68)	83.0 (81.4)	0.10 (0.92)	81.2 (79.9)	0.36 (1.13)	7/46
20,500	84.9 (84.8)	0.00 (0.26)	80.7 (79.8)	0.28 (1.11)	80.6 (78.9)	0.22 (2.01)	2/16
19,700	87.2 (86.9)	0.36 (0.37)	83.8 (83.3)	0.78 (0.78)	80.8 (80.9)	0.28 (0.20)	2/12
19,200	89.0 (88.0)	0.14 (1.23)	84.7 (84.2)	0.42 (0.75)	83.4 (32.2)	0.50 (0.34)	2/14
15,700	88.4* (88.4)*	0.22* (0.22)*	85.7* (85.7)*	0.14* (0.14)*	84.0* (84.0)*	0.22* (0.22)*	1/6
All Buses	86.6 (86.5)	1.39 (1.34)	82.2 (82.0)	1.94 (1.49)	80.8 (80.6)	1.85 (1.86)	---

*Only one reading was taken.
**All accessories on.

(1) Top row of numbers are noise level values computed in accordance with SAE Standard J366b, i.e., taking the average of the two highest readings which were within 2 dB of each other, for each bus in the GVWR class. Numbers in parentheses were computed by averaging all readings for all buses in each GVWR class. "All Buses" values (last line) were similarly computed.

Source: Reference 13

TABLE 4-19 (4)

Interior Noise Levels of Sheller-Globe (New 1978 Model)
Conventional Gasoline-Engine School Buses
Wide Open Throttle Acceleration Test

Vehicle	Engine Displacement ($in.^2$)	Transmission (Speed/Type)	Fan	Interior Noise Level (Without Air Conditioner) dBA
B7046	366	4/Automatic	On Off	83.5 78.3
B7045	366	4/Automatic	On Off	84.2 78.8
B4183	366	5/Manual	On Off	85.0 78.8
B4180	366	5/Manual	On Off	83.9 78.4
		Mean	On	84.15
		Standard Deviation	On	0.64
		Mean	Off	78.58
		Standard Deviation	Off	0.26

Source: Sheller-Globe

Source: Reference 13

TABLE 4-19 (5)

Interior Noise Levels of Blue Bird (New 1978 Model)
Conventional Gasoline-Engine and Diesel-Engine School Buses
Wide Open Throttle Acceleration Test

Vehicle	Engine	Tail Pipe Location	Wheelbase (inches)	Interior Level at Operator		Notes
				Heater Fan On	Heater Fan Off	
42376	INT1603A	Right	254	90	89	Hollow wall body construction
42230	B600330	Right	222	84	81	Hollow wall body construction
F42497	Chevrolet	Left	218	85	83	Hollow wall body construction
42287	B700361	Right	242	85	81	Hollow wall body construction
43836	GMC	Left	254	82	81	Insulated wall body construction
F40138	INT1703H	Right	187	83	83	Hollow wall body construction
F40258	Chevrolet	Left	254	84	82	Insulated wall body construction
43850	Chevrolet 350	Left	218	86.5	84.5	Hollow wall body construction
42257	GMC6000	Left	254	83.5	81	Insulated wall body construction
			Mean	83.17	81.33	Gasoline-engined buses with insulated wall body construction (N=3)
			Standard Deviation	1.04	0.58	
			Mean	85.58	83.58	Gasoline-engined buses with hollow wall body construction (N=6)
			Standard Deviation	2.46	2.97	

Source: Blue Bird

TABLE 4-19 (6)

Interior Noise Levels of In-Service (1978 Model)
Conventional Gasoline Engine School Buses --
Arlington County, Virginia School Buses
Test at RFK Stadium in Washington, D.C., March 1979
Wide Open Throttle Acceleration Test

Vehicle Body No.	Maximum Governed Speed	Maximum Interior Noise Level at Operator	Notes
41	3,700	80.5	Fan on - Second Gear
		82	Fan off - Second Gear
44	3,600	84.25	Fan on - Second Gear
		84.25	Fan off - Second Gear
52	3,800	83.5	Fan on - Second Gear
46	3,700	85	Fan on - Second Gear
		84	Fan off - Second Gear
49	3,800	84.5	Fan on - Second Gear
		85	Fan off - Second Gear
54	3,750	84.3	Fan on - Second Gear Cardboard Removed
		84.5	Fan off - Second Gear Cardboard in Radiator
51	3,750	82.2	Fan on - Second Gear
		83.5	Fan off - Second Gear
56	3,700	83.5	Fan on - Second Gear
		81.8	Fan off - Second Gear
40	3,750	83	Fan on - Second Gear
50	3,750	82.75	Fan on - Second Gear
Mean with Fan On (N=10)		83.35	
Standard Deviation with Fan On (N=10)		1.32	
Mean with Fan Off (N=7)		83.58	
Standard Deviation with Fan Off (N=7)		1.24	

Source: EPA

Stationary and acceleration interior noise levels of new (1976) gasoline engine conventional school buses tested by EPA at Sandusky, Ohio

- Interior noise levels of new (1978) Sheller-Globe conventional gasoline engine school buses provided by Sheller-Globe.
- Interior noise levels of new (1978) Blue Bird conventional gasoline and diesel engine school buses provided by Blue Bird
- Interior noise levels of in-service (1978) conventional gasoline engine school buses measured March 1979 at RFK Stadium in Washington, D.C.

Full results on interior noise levels are shown in Table 4-19 for both in-use and new conventional gasoline-powered school buses, respectively. Tests on both in-service and new (1976) conventional school buses indicate that the noise levels are significantly higher at the front of the bus than at the rear of the bus (refer to Table 4-19 (1), (2), (3)). During tests for new buses involving an idling engine only, interior fan accessories only (heating and cooling fans), and then an idling engine and interior fan accessories together, the average noise level difference between the front and rear interior of the buses tested was about 4 dB (see Table 4-19 (2)). Interior noise levels at the driver's seat for the in-use school buses tested under maximum acceleration conditions with all fan accessories on ranged from 81 to 86 dB while levels at the rear interior of the buses ranged from 78 to 81 dB. Tests on new (1976) buses with all accessories on under maximum acceleration conditions produced a range of interior noise levels from 85 to 89 dB for the front interior and 81 to 84 dB in the rear interior.

Interior noise levels on new 1978 Sheller-Globe school buses ranged from 83.5 to 85 dB with the heater fan on and from 78.3 to 78.8 with the heater fan off. Blue Bird new 1978 gasoline engine school bus interior noise levels at the operator position ranged from 82 to 90 dB with the heater fan on and 81 to 89 dB with the heater fan off. Maximum interior noise levels at the operator's position of 1978 in-service gasoline engine school buses ranged from 80.5 to 85 dB with the heater fan on and 81.8 to 85 dB with the heater fan off.

Component Noise Levels

Table 4-20 shows the estimated range of contributed noise levels of conventional gasoline-powered school bus major noise components. These estimates are based on component noise levels of medium-duty trucks using similar engines (Refs. 15,16) and estimates made during a previous study. (Ref. 7) None of the school bus body or chassis manufacturers contacted were able to supply actual measured data for component noise levels of gasoline-engine school buses or of equivalent trucks.

4. Diesel-Powered Conventional School Buses

Physical dimensions and weight rating for diesel-powered conventional school buses are similar to those for gasoline-powered conventional school buses.

A variety of medium-duty diesel engines are used in this type of bus including the CAT 3208, the Ford V636, and the IHC D-150, D-170, D-190, and the DT-466.

Exterior Noise Levels

Blue Bird provided data for two diesel engine conventional-powered school buses. These data are shown in Table 4-21.

Very little additional data are available in the form of direct measurement of noise from conventional diesel school buses.

TABLE 4-20

Range of Component Noise Levels for Current Gasoline Powered Conventional School Bus

Noise Source	Contributed Noise Level, dB at 50 feet (SAE J366b Procedure)
Engine, including air intake and transmission	69 to 73
Exhaust	75 to 78
Fan	71 to 82.4
Chassis at 30 mph (including accessories)	65 to 73
Total Bus Noise	77 to 84

Source: References 7, 15 and 16

TABLE 4-21

Blue Bird School Bus Data - Diesel

Powered Conventional School Buses - New 1978 Models - Wide Open Throttle Acceleration

Vehicle	Engine	Tail Pipe Location	Wheelbase	Maximum Exterior Noise Levels				Interior Levels	
				Front Reference		Rear Reference		Heater Fan	Heater Fan
				Right	Left	Right	Left	On	Off
F42500	INT1853	Right	236	82	83	82	83	85	84
42499		Right		81	81	80.5	81	85	83
			Mean	81.5	82	81.3	82.0	85	83.5

Source: Blue Bird

International Harvester (IH) indicated that exterior noise levels measured from all of their school buses were below 86 dB. School buses sold in California and Oregon must meet those states' exterior noise level standards of 82 dB and 80 dB respectively, according to the SAE J366b test procedure.

Diesel powered conventional school buses utilize medium diesel truck chassis, therefore, noise levels from such trucks can be considered representative of those buses.

Table 22 presents data on 1978 model medium-duty trucks obtained from Production Verification reports submitted to EPA and surveillance data developed by EPA Noise Enforcement Division.

Component Noise Levels

For diesel vehicles, important noise sources are the engine, the exhaust, and the cooling fan. The typical range of noise levels from each of these sources is between 75 dB and 85 dB. (Ref. 17) Another major noise source in diesel engines is the intake noise. Typical unsilenced intake noise levels for diesel truck engines at high idle vary between 70 dB and 85 dB, measured at 50 feet from the engine inlet. (Ref. 18).

5. Forward Engine Forward Control School Buses

In a forward control school bus the driver is located at the front most left side of the bus. The engine (either gasoline or diesel) is located to the right of the driver or under the floor between the two axles. The front of the bus is a flat front end. This configuration is not typical of gasoline or diesel-powered conventional school buses.

Current noise levels from forward engine buses made by Blue Bird for states other than California are shown in Table 4-23. The forward engine forward-control school buses sold in California are said to meet the state standard of an 83 dB exterior level under acceleration.

TABLE 4-22

Medium Duty Diesel Truck Exterior Noise Levels

Make	Model No.	Test RPM	dB 50 feet
Ford	F7000	2840	78.4
Ford	F700	2800	81.0
Ford	LN7000	2800	79.9
Int. Har.	1850	2600	81.7
Int. Har.	C01950	2600	81.8
Int. Har.	C01850B	2600	82.2
Int. Har.	1650	3000	81.2
Int. Har.	1750	3000	80.2
GMC	CD61403	2800	81.8

Source: EPA, Noise Enforcement Division

TABLE 4-23

Noise Levels from Diesel Powered Forward-Control

Forward Engine Buses by Blue Bird

(Sold in States Other Than California)

Type of Engine Used	Sound Levels dB Exterior (J366b Test)	Sound Levels dB Interior (BMCS* Test)
CAT 3208, 320A	86	90
Cummins V504, 504A	89	90
Detroit Diesel 6V53, 6V53A	92	95

*Bureau of Motor Carrier Safety

Source: Reference 5.

The noise level at the driver for front engine buses may be higher than for conventional school buses because of the close proximity of the engine to the driver.

6. Parcel Delivery Chassis Buses and Motor Home Chassis Buses

Carpenter Body Works' Cadet "CV" and Sheller-Globe's (Superior) "Pacemaker" models are built from parcel delivery vehicle chassis and motor home chassis. GMC recently introduced a motor home vehicle that is also offered as a bus, called Transmode.

Since these buses use the same engines as full size conventional school buses, the exterior and component noise levels are expected to be similar. The interior noise levels at the driver's seat may be higher than for conventional school buses because of the closer proximity of the engine to the driver. GMC measured the noise level of one Transmode Bus in accordance with the SAE J366b procedure as 81.7 dB. (Ref. 8)

7. Mid-Engine School Buses (Integral)

The only mid-engine integral school buses available today are made by Gillig Brothers and Crown Coach Corporation. Although the engine location and engine types for mid-engine buses differ from front and rear-engine school buses, their exterior noise characteristics are not significantly different. However, in contrast to the noise levels inside rear engine buses, the interior noise in a mid-engine bus would be higher in the front of the bus than in the rear because the engine is relatively closer to the front end.

Exterior noise levels from the Gillig buses, which were measured in 1975, (Ref. 19) and Crown buses which were measured in 1973, (Ref. 1) are shown in Table 4-24. These levels range from a low of 80.9 dB on the curbside to a high of 86.3 dB on the streetside.

TABLE 4-24

Exterior Noise Levels at 50 Feet From Diesel Powered Mid-Engine School Buses
Wide Open Throttle Acceleration Test

Bus Manufacturer	Engine	Exterior Sound Level, dB Curbside	Streetside
Gillig	Detroit Diesel 6-71	83.6	86.3
Gillig	Cummins Diesel NHHTC-240 Turbocharged	80.9	82.1
Crown	Detroit Diesel 6-71	82.6	84.9
Crown	Cummins Diesel NHHTC-270 Turbocharged	83.9	85.9

Source: References 1 and 19

For exterior noise considerations, mid-engine buses are similar to transit buses and rear-engine integral school buses. Interior noise, however, is expected to be higher for mid-engine buses because of the shape and position of the engine compartment. Crown Coach Corporation has indicated that the interior noise level at the driver's seat in their buses is about 87 dB when measured at 35 mph under full throttle conditions.

Component Noise Levels

Data on component levels for mid-engine school buses are not available. In order to meet the California exterior noise standard of 83 dB, Gillig provides sheet metal covers with noise damping insulation around the complete engine. (Ref. 19) The muffler is also wrapped with insulation. Fan speeds are said to be as low as their cooling requirements will allow. Crown Coach Corporation also provides sound absorbing insulation around their engine. Engine compartment doors are lined with 1.5 inch thick acoustical material. Exhaust noise from their turbocharged Cummins engine is said to be sufficiently low. Therefore, no special exhaust noise treatment is provided for that engine. However, for the Detroit Diesel 6-71 engine a heavier gauge muffler shell is used which, when tested, provided the same attenuation as a wrapped muffler. Crown also uses an acoustical floor in its buses. The floor, used since 1964, is made up of one-half inch "Celetex" sandwiched between two 1/4 inch and 5/8 inch thick plywood panels. (Celetex is a fire-resistant material made by Georgia Pacific.)

8. Rear Engine School Buses (Integral)

An integral rear engine school bus is constructed as a unit body. That is, the body and chassis are one unit with the engine either mounted on a subframe or directly on the body. This construction is like an urban transit and intercity bus. Gillig Brothers is the only manufacturer of rear engine integral school buses.

Although the integral rear engine school bus and the urban transit bus use different types of diesel engines, they have similar noise characteristics. While urban transit buses use Detroit Diesel's naturally aspirated 6V-71 and 8V-71 engines, the rear engine school buses produced by Gillig use either the naturally aspirated CAT 320S or the turbocharged Cummins 230 engine. Exterior noise levels for Gillig school buses are shown in Table 4-25.

TABLE 4-25

Exterior Noise Levels at 50 Feet from
Gillig Integral Rear Engine School Buses
(Wide Open Throttle Acceleration Test)

Type of Engine	Sound Levels, dB Curbside	Sound Levels, dB Streetside
<u>Cummins 230</u> (Turbocharged) -With grill on engine compartment doors	83.7	82.7
<u>CAT 3208</u> (Naturally aspirated) -With grill on engine doors	84.0	83.5
-With solid engine doors	81.3	82.5

Source: Reference 19

The streetside noise levels from the top two buses in Table 4-25 are slightly lower than those on the curbside because of an additional inner compartment wall on the streetside of the engine compartment. When Gillig replaced the grill on the engine doors with solid panels on the Caterpillar engine powered bus, the noise levels were reduced about 2 dB. Giving the same treatment to the Cummins engine-powered bus would probably provide similar reduction. Because of a lack of more detailed test data, the reason for attaining relatively greater noise reduction on the curbside from the Caterpillar engine-powered bus with solid engine doors is not clear.

Interior noise levels for rear engine school buses are not available but are expected to be similar to transit bus noise levels.

9. Rear Engine School Buses (Body-on-Chassis)

Rear engine school buses with body on chassis are constructed in two units. The chassis is built with the engine mounted on the rear of the chassis. The body is then bolted onto the chassis.

One bus in this category is offered not only with the rear-mounted engine, body-on-chassis (Carpenter Corsair Model), but also with a front-mounted engine (Carpenter Forward Control Model). No noise information is presently available for this type of bus.

Exterior, interior, and component noise levels are expected to be similar to diesel powered forward control school buses and rear engine (integral) school buses.

REFERENCES

SECTION 4

1. "An Assessment of the Technology for Bus Noise Abatement," Draft Final Report submitted by Booz, Allen Applied Research under EPA Contract No. 68-01-3509 prepared for the Office of Noise Abatement and Control, June 22, 1976.

2. Comments of General Motors Corporation With Respect To "The Technology and Costs of Reduced Noise Level Urban Transit Buses," (USG 350-76-52) submitted to the EPA - Office of Noise Abatement and Control, November 18, 1976.

3. General Motors Corporation Conference on Bus Noise Regulation, December 16-17, 1975. GMC Summary Report (USG 350-76-1) submitted to the EPA on January 15, 1976.

4. Correspondence, Flxible Co. to Booz, Allen Applied Research, dated October 8, 1975.

5. "Noise Control Retrofit of Pre-1970 General Motors Trucks and Coaches," Final Report, U.S. Department of Transportation, Office of Noise Abatement, October 1975.

6. "Sound Attenuation Kit for Diesel Powered Buses," Report R11-SAK-402-0101, by Rohr Industries (unpublished).

7. Warnix, J. L. and Sharp, Ben H., "Cost Effectiveness Study of Major Sources of Noise, Volume IV - Buses," Wyle Research Report WR-73-10, prepared for the EPA Office of Noise Abatement and Control, April 1974.

8. Comments of General Motors Corporation With Respect To Booz-Allen and Hamilton, Inc. Technology Study on Bus Noise Regulation performed under contract to the Office of Noise Abatement and Control, Environmental Protection Agency, GMC Report USG-350-76-5 submitted on January 23, 1976.

9. Correspondence, Motor Coach Industries to Booz, Allen Applied Research, dated January 21, 1976.

10. Private communication with Mr. Harry L. Cuthbert of Eagle International.

REFERENCES

SECTION 4

11. Leasure, William A., et al, "Truck Noise -1, Peak A-weighted Sound Levels Due to Truck Tires," Report No. OST/TST-72-1, U.S. Department of Transportation, July 1972.

12. "Noise Measurements of Arlington County School Buses," Booz, Allen & Hamilton, Inc., March 1979.

13. "Lima School Bus Test Report," Environmental Protection Agency, Noise Enforcement Facility (Sandusky, Ohio), June 1976.

14. Sheller-Globe.

15. "The Technology and Costing of Quieting Medium and Heavy Trucks, BBN Report No. 2710, prepared for the EPA Office of Noise Abatement and Control, October, 1974.

16. Burroughs, C.B., "Costs of Compliance for Regulations on New Medium and Heavy Trucks Noise Regulations," BBN Technical Memorandum, prepared for EPA Office of Noise Abatement and Control, January 1976.

17. "Background Document for Proposed Medium and Heavy Trucks Noise Regulations," U.S. Environmental Protection Agency, October 1974.

18. Kevala, R.J., Manning, J.E., et al,, "Noise Control Handbook for Diesel-Powered Vehicles," Interim Report No. DOT-TSC-OST-74-5, U.S. Department of Transportation, Office of Noise Abatement and Control, APril 1975 (Reprint)

19. Correspondence with Gillig Brothers to Booz-Allen Applied Research, January 19, 1976.

20. "Noise Levels of New MCI Buses," Booz-Allen & Hamilton Report submitted under EAP Control No. 68-01-3509 to the U.S. EPA Office of Noise Abatement and Control, October 7, 1976.

21. "Noise Levels of New Eagle Buses," Booz-Allen & Hamilton Report submitted under EAP Control No. 68-01-3509 to the U.S. EPA Office of Noise Abatement and Control, November 16, 1976.

REFERENCES

SECTION 4

22. Statements by GM Representatives at a meeting with EPA officials on May 31, 1979.

23. Correspondence with AM General Corporation to Francine Ely, EPA, July 12, 1979.

SECTION 5

NOISE ABATEMENT TECHNOLOGY

This chapter describes the technology required to quiet buses of current configurations to four study levels. These levels are:

- . Study Level I - 83 dB exterior, 86 dB interior
- . Study Level II - 80 dB exterior, 83 dB interior
- . Study Level III - 77 dB exterior, 80 dB interior
- . Study Level IV - 75 dB exterior, 78 dB interior.

Overall noise level reductions are achieved by quieting bus components in various combinations depending on their intensity as noise sources. This chapter will first discuss technologies available for quieting individual components and then will describe the noise treatment combinations required for each bus configuration to meet each of the four study levels. Finally, the technology considerations presented by the Acoustical Assurance Period (AAP) will be discussed.

1. Component Noise Abatement Technologies

The important noise-producing component systems on current technology buses are:

- . Exhaust
- . Cooling System
- . Engine Block and Transmission
- . Intake
- . Chassis.

The following sections describe the techniques available to reduce the noise levels for each of these systems.

(a) Exhaust System

Exhaust noise arises from pressure fluctuation in exhaust gases rauiated primarily as airborne noise from the exhaust pipe. It also arises from vibration of the muffler shell and exhaust piping and from leakage of gas from the muffler, exhaust manifold, exhaust pipe, and tailpipe.

Technological changes that will reduce noise include:

- Turbocharging
- Improved or larger mufflers
- Improved exhaust piping design
- Optimizing muffler location and exhaust system configuration.

Additional expansion of exhaust gases through a turbocharger reduce gas pressures through the muffler and tailpipe. Because of the inherently low exhaust noise levels of turbocharged engines, currently available mufflers or modifications thereof to allow for the greater air flow rates can be employed. However, mufflers of lower back pressure are required. On gasoline engines, advantages may not be as great.

Available methods to improve the sound attenuation of mufflers are:

- Increasing muffler volume
- Double-wrapping with acoustical absorption material
- Using manifold mufflers
- Adding a premuffler; i.e., resonator or wye muffler.

For a simple expansion chamber muffler, the transmission loss increases by a maximum of 7 dB for a doubling of expansion ratio. (Ref. 1) Increased expansion ratios can be obtained without increasing the minor diameter of the muffler by using elliptical cross sections.

Double wrapped mufflers are currently available for diesel truck applications from several manufacturers (Donaldson, Riker, and Stemco). Donaldson markets the "Silent Partner" muffler wrap which consists of an asbestos blanket held in place by a stainless steel wrap-together cover. These designs should be easily adaptable from their current use on vertical stack mufflers to horizontal mufflers such as those used on school buses.

For urban transit buses double-wrapped mufflers are available for both 6V-71 and 8V-71 engines. The design noise level of this muffler with a wye connection is 75 dB for 5-inch systems on the 8V-71 engine, giving a back pressure of only 3.4 inches mercury (Hg). GMC achieved exhaust noise levels of under 75 dB without exceeding the back pressure limitation on their T8H5305 coach by replacing the standard Nelson muffler with a Nelson T13680 muffler.

The Freightliner quiet truck employed a manifold muffler along with dual current production Donaldson mufflers and stack silencers. The engine was a turbocharged Cummins NTC-350, which is an in-line six cylinder engine. The experimental exhaust manifold muffler had a volume 4-1/2 times the volume of the standard manifold. For the V-form engines used in transit buses, two manifold mufflers would be required.

A premuffler or resonator may be used to obtain maximum attenuation over the broad range of frequencies characteristic of engine operation over a wide speed range. When used in series with a main muffler, a smaller-sized muffler will be required than if the entire silencing is to be achieved from a single muffler.

Heavier gauge exhaust and tailpipes with gastight exhaust joints will minimize shell radiation. Exhaust pipes may need to be wrapped with thermal acoustical material. One bus exhaust system manufacturer, AP Parts Co., is working on the development of double-walled exhaust pipes and reports promising results.

The overall design of the exhaust system can effectively reduce noise levels. For gasoline-powered school buses with the tailpipe outlet in the rear of the bus, extending the tailpipe at least 5 inches beyond the body wall will reduce noise. However, the long exhaust and tailpipe can still generate noise from the muffler shell and pipe walls. Horizontal muffler and tailpipe systems are inherently noisier than comparable vertical systems because of outlet directivity and ground reflections. The large bus floor undersurface also reflects the sound which escapes from the sides resulting in higher sound levels on both sides of the bus.

Exhaust pipe lengths between muffler elements is critical to obtaining optimum exhaust system level reductions. (Ref. 2, 3, 4) Changes in pipe coating, installation, etc., also have significant effects on diesel engine noise. (Ref. 5) Because of packaging problems, transit bus exhaust pipes often take winding routes between the two manifolds and the horizontal muffler. Newer model buses have a vertical tail pipe routed through the left side of the bus. Older buses have a short horizontal tail pipe exiting at the rear under the engine. The location of a muffler between the bus floor and pavement worsens the effect of muffler shell radiated noise. Special attention to the support system for the exhaust pipes and muffler can prevent transmission of vibrations to the chassis.

The use of a dual system allows greater expansion volume for the exhaust gases and hence greater reduction of the pulsations which are responsible for exhaust noise. The larger flow areas allowed by dual pipes will also reduce the existing velocity of gases which is responsible for the characteristic hiss of well-silenced exhaust systems of some of the current luxury automobiles.

For urban transit and intercity buses, rerouting the tailpipes to exit at the roof line will result in eye-level noise reduction.

(b) Cooling System

The fan is the predominant cooling system noise source. About one-third of the total energy of the fuel used in an internal combustion engine is released as heat to the cooling system. About one-third is released as heat to the exhaust or radiated directly to the atmosphere and the remaining one-third generates useful power. This ratio varies with engine configuration, compression ratio, cycle (2-stroke vs 4-stroke), valve timing, engine load and speed, and on gasoline engines, spark timing. The heat released to the cooling system is released to the atmosphere through the radiator. The fan draws air through the radiator to improve heat transfer.

Sound levels of fan noise at 50 feet vary from near 70 dB to 85 dB depending on fan blade tip speed. Noise from other cooling system components such as the water pump, belts and pulleys and air flow through the radiator contribute very little to the overall noise level.

The installation of the engine, radiator, shroud, cab and other components affects the cooling ability of the engine fan. It also affects the noise generated by the fan because of the effect which each component has on the air flow or the flow resistance against which the fan must operate. Studies conducted by two major heavy truck manufacturers under the DOT Quiet Truck Program have indicated that modifications to improve engine compartment layout are very effective in reducing fan noise levels because lower fan tip speeds can be achieved without a reduction in cooling ability. (Ref. 6, 7).

Fan noise reduction requires maximizing the cooling rate at a given fan speed, thereby minimizing fan speed required for adequate engine cooling. Thermostatically controlled fans are gaining wide acceptance as energy-efficient quiet fans (see Appendix B). Approaches to reducing fan noise are:

. Improved fan shrouds
. Fan redesign
. Increased cooling system pressures
. Radiator redesign.

A combination of these techniques has resulted in a fan noise level reduction from 81.5 dB to 66 dB on the streetside and from 80 dB to 68 dB on the curbside of an IHC model CF-4070A diesel cab-over truck without reducing the cooling capacity. (Ref. 6) A different combination of techniques reduced the fan noise level for a Freightliner cab-over truck with a Cummins NTC-350 engine (Ref. 7) from 80 dB to 64 dB.

The following noise level reductions have been demonstrated in the laboratory for a 20-inch 5-bladed truck fan:

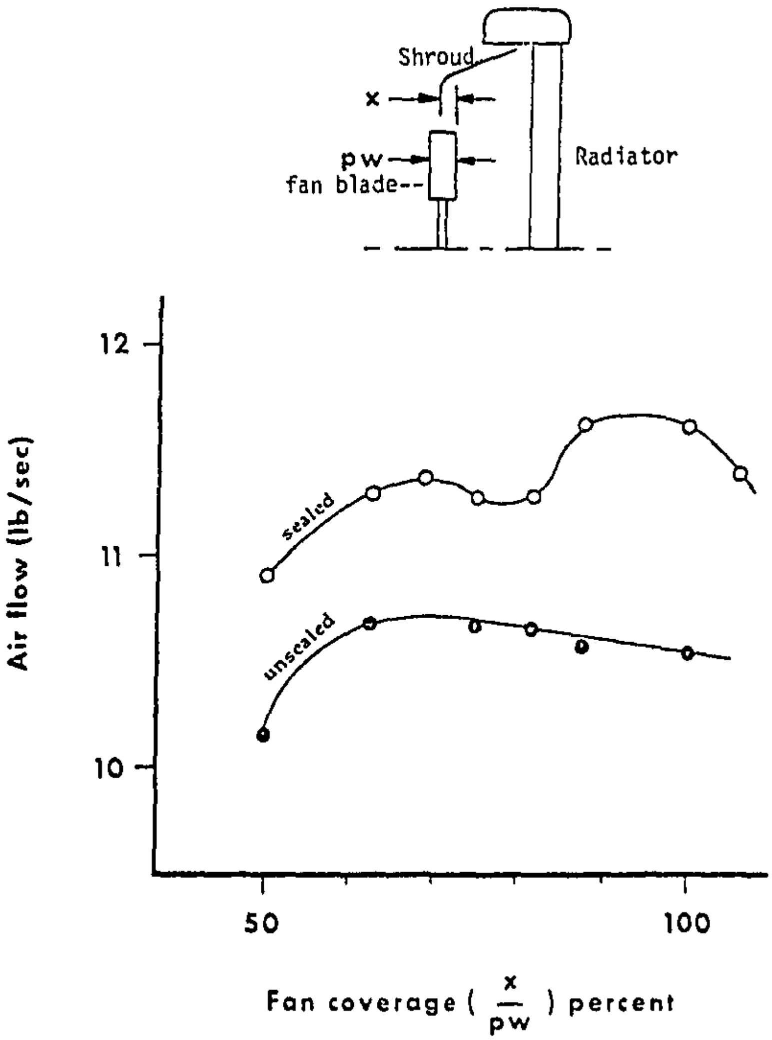
	Reduction dB
Sealed shrouds and optimized fan coverage	4.5
Optimum fan-to-radiator distance	.5
Engine mounted air deflector	4.0
Contoured shroud with 1/4-inch tip clearance	7.5
Optimized radiator heat transfer	2.0

These reductions are not always cumulative.

Without a shroud, used air recirculates around the blade tips so that the flow through the radiator is greatly reduced. In addition, the flow over the fan blades becomes more turbulent so that the fan noise level increases. Air flow across the radiator is maximized by careful sealing of the shroud to the radiator and by designing the shroud so that there is little clearance between the fan tips and the shroud. In tests conducted by International Harvester Company, the air flow rate was increased by this method from 10.66 lb/sec to 11.5 lb/sec (Figure 5-1). Optimum fan coverage for the sealed shroud was obtained at 90 to 100 percent coverage, while the original unsealed shroud gave maximum air flow rates at 65 percent coverage. The increased air flow rate allowed a reduction of fan speed to reduce overall noise level by as much as 5 dB. Optimization will help only to the extent of the actual departure in the present system.

Fan speed can be reduced further, but to a lesser extent, by replacing a rectangular shroud with a contoured or venturi shroud. This type of shroud is shown diagrammatically in Figure 5-2. Tests by the International Harvester Company have shown that the use of this shroud resulted in allowing fan speed to be reduced by 6 percent while 3 to 6 dB noise reduction was obtained in comparison to the noise level of the carefully sealed shroud. The shroud will need to be mounted in such a way as to maintain minimal clearance even when the engine moves relative to the radiator. This can be achieved by mounting part of the shroud to the engine and part to the radiator with the two sections connected by a flexible rubber boot. Recent road tests completed on a truck equipped with such a shroud have demonstrated the practicality of this design. (Ref. 8) The fan to radiator distance may also have to be changed to ensure optimum air flow distribution across the radiator.

Noise generated by an engine cooling fan can be decreased by changing the fan drive ratio to reduce the maximum speed. This change will also reduce the speed of the water pump and the fan speed at idle. Both of these



Fan Speed 2520 rpm.

Source: International Harvester Company

FIGURE 5-1. Effect of Fan Coverage on Air Flow With Shroud Sealed to Radiator

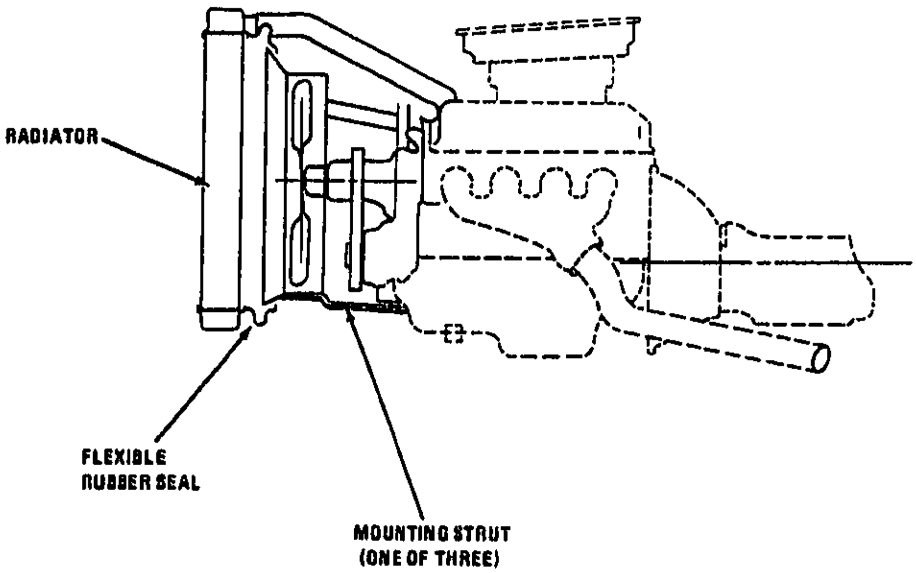


FIGURE 5-2. Engine-Mounted 1/4 Inch Tip Clearance Contoured Shroud

changes could cause some cooling performance problems. Water pump capacity may be recovered by increasing the diameter of the water pump impeller. Reducing fan capacity may require a larger radiator to maintain the same cooling performance.

In those cases where sealing the shroud and optimizing fan coverage does not result in sufficient noise reduction, flow rates may be increased by choosing a fan that will allow reduction in shaft speed. This again depends on the present fan on the vehicle. In most cases, increasing the number of blades and/or blade twist will result in achieving required air flow at reduced speeds. Use of a thermostatically controlled fan drive may be helpful in designing a fan system with reduced fan speed (with fan engagement) at maximum engine speed.

Fan design noise levels of 64 dB or less have been demonstrated by International Harvester and Freightliner quiet trucks. This is 13 to 18 dB under current bus fan noise levels. International Harvester Company was able to achieve a 66 dB fan noise level by employing a tight-fitting fan shroud along with an engine enclosure which reduces fan noise level by 2 dB and by replacing the original 4 row, 11 fin-per-inch, plate fin radiator by a 4 row, 14 fin-per-inch, serpentine fin radiator. Freightliner Corporation achieved a 64 dB estimated fan noise level by replacing the standard 28-inch six-bladed fan with a specially made 31-inch seven-bladed fan featuring staggered blade spacing manufactured by Schwitzer Corporation. The fan speed was lowered from 2100 rpm to 1280 rpm and the standard 1200 in^2 six-row radiator was replaced by a 2000 in^2 four-row radiator.

The radiator and fan on current design urban transit buses are located on the rear streetside of the bus left of the engine. There is little or no ram air through the radiator from the forward motion of the bus.

Motor Coach Industries (MCI) intercity buses have twin radiators with thermostatically controlled centrifugal fans at the top of the engine compartment directly above the engine. The fans are connected to the radiators by ducts. This results in a quiet cooling system with sound levels equal on both sides of the bus. MCI has reported that during actual operating tests on the highway, cooling fan airflow is 50% less than air flow measured during static tests.

Conventional gasoline engine school buses receive maximum cooling benefit from ram air. A thermostatically controlled fan drive will minimize fan power when cooling loads are less due to this ram air effect, and will result in a lower noise level.

The use of sealed engine belly pans on urban transit and intercity buses will cause some restriction of cooling air. To compensate, either the pressure rise across the fan may be increased so that volumetric air flow will be the same or the radiator and fan area may be increased to permit adequate cooling at the reduced air flow rate. Increasing the size of the radiator and fan may require a larger engine compartment. Modifying fan design to increase the pressure rise across the fan without increasing fan speed may be preferable.

MCI buses use centrifugal fans located in ducts above the engine. There are two radiators with shutters, one on each side of the bus, and two fans drawing air in through the radiator and discharging it over the engine. The fans are driven from a gear-box located between them and driven by a belt from the engine crankshaft. The duct between the fan housing and the radiator is sealed off from the engine compartment to maximize flow through the radiator. The engine air cleaner intake is located in the left side radiator opening. The relative locations of system components are shown in Figure 5-3.

Eagle buses also utilize a longitudinal engine arrangement. A standard 8-bladed 28-inch diameter axial flow fan located on the left side of the bus is used for engine cooling. The fan is driven off a 90° gearbox located in the rear center of the engine compartment. A 6-bladed fan, located on the right side of the engine compartment, provides air flow through the air conditioning system condenser. There is no thermostatic clutch arrangement for the fans. The layout is shown in Figure 5-4.

Centrifugal fans which MCI buses utilize are inherently quieter than axial fans for the same mass flow delivered. Also, the ducts are amenable to acoustic treatment to minimize the noise escaping through the radiator opening. The air flow velocity is higher and, hence, flow noise may become audible if other sources are quieted.

There are indications that all intercity bus manufacturers will soon begin to install thermostatically controlled fans because of rising fuel costs. MCI is likely to abandon the centrifugal fans and replace them with axial fans in order to accommodate the new fan drives. These drives will probably be wet clutch modulating drives.

Intercity bus radiators are larger than transit bus radiators because of continuous engine operation at high power factors and heavier bus loads due to baggage. However, the percentage changes in radiator and fan sizes to achieve equivalent noise reductions for intercity and transit buses should be similar.

FIGURE 5-3

Layout for MCI Engine Compartment

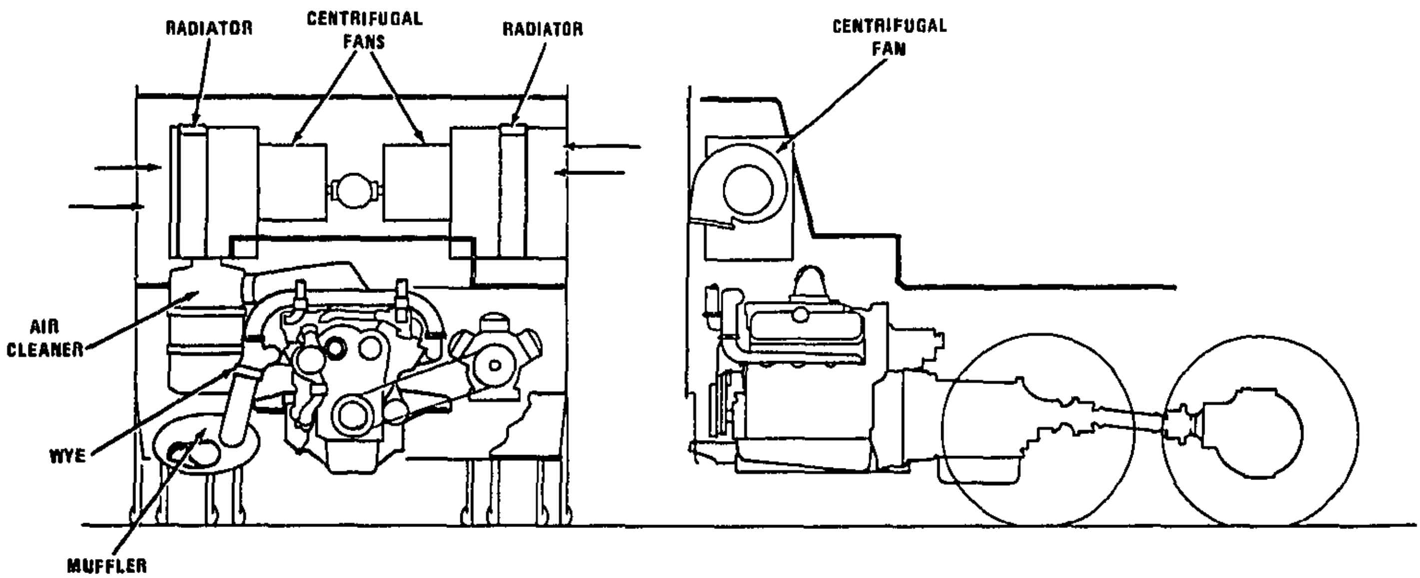
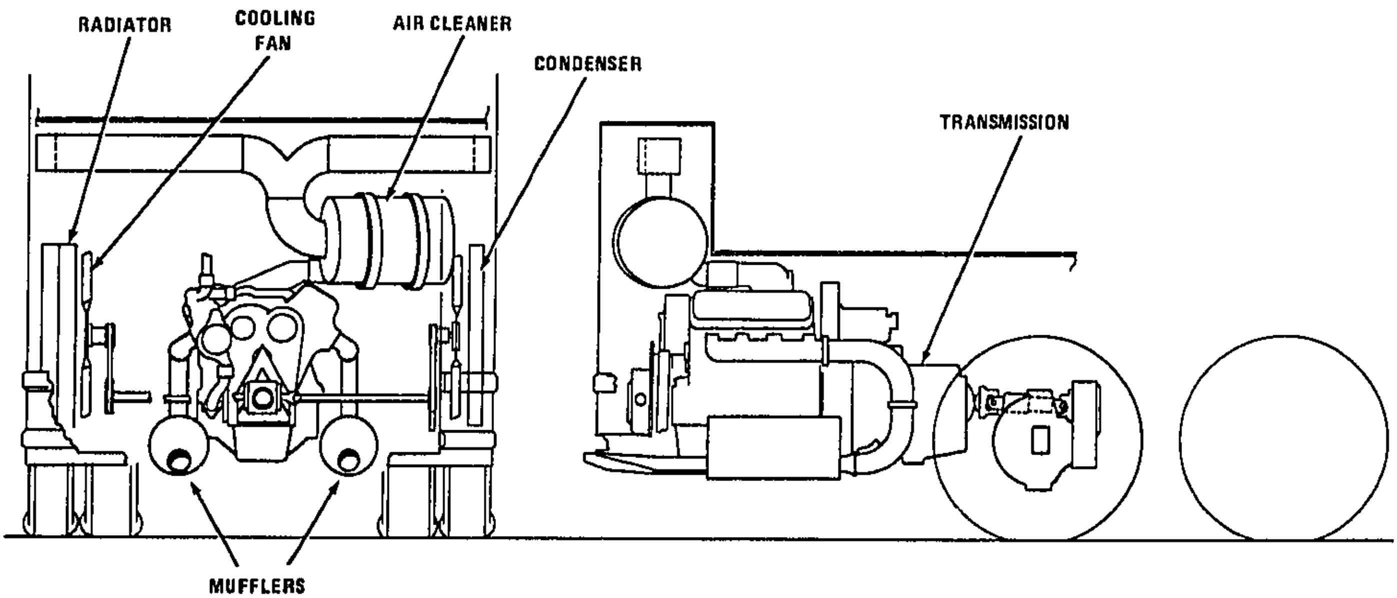


FIGURE 5-4

Layout of Eagle (Bus & Car) Engine Compartment



Conventional school buses use the same sheet metal as medium-duty trucks, but are seldom fitted with the largest engine that is available for trucks of the same load capacity. This would indicate that larger radiators are available than currently fitted to most school buses.

Air emission control requirements for gasoline engines also need to be taken into account. Current engine designs require highly retarded ignition timing which increases exhaust temperatures and heat rejection to the cooling system. The reduced compression ratios and changes in camshaft to delay exhaust valve opening and increase valve overlap also increase heat rejection. On the other hand, the use of higher coolant temperatures gives some relief.

The chief differences between the diesel truck application and conventional gasoline bus application are summarized in Table 5-1.

It should be noted that the cooling systems of forward control buses may require special attention. The technology in the DOT Quiet Truck Program is not directly applicable for such buses.

For current application to gasoline powered school buses, the suggested method of achieving the 64 dB fan noise level is to increase radiator frontal area by 20 percent and fan diameter by approximately 10 percent. An engine-mounted close-fitting shroud should be used along with an advanced serpentine-fin radiator with approximately 30 percent greater heat transfer area than a comparable plate-fin type radiator. The increased core thickness of the serpentine fin radiator will result in a slightly greater pressure drop across the radiator resulting in somewhat greater fan speed. However, the overall effect of all the improvements will allow fan rpm to be lowered to almost 50 percent of the original fan speed.

TABLE 5-1

Comparison of Cooling Fan Parameters for Gasoline and Diesel Engines

	Diesel Engine Truck	Conventional Gasoline Engine School Bus
Maximum engine rpm	2100	3600-4000
Heat rejection at idle	2 BTU/hp/min	7 BTU/hp/min
Heat rejection at maximum throttle	24 BTU/hp/min	27.5 BTU/hp/min
Load factor	Sustained operation at maximum engine speed	Under 20% of time at maximum engine speed
Coolant pressure	Atmospheric	14-16 psig
Shutters	Employed	Generally not employed
Air conditioners	Available	Rarely employed

With this low fan speed, the fan shaft, pulley, and belt system may need to be redesigned. The water pump could be mounted on a separate shaft independent of the fan shaft so as to make its redesign unnecessary.

(c) Engine Block and Transmission

Engine noise is the noise generated by the combustion process and the mechanical components of the engine and radiated by the engine block. This noise is a result of vibration of the engine structure, covers, and accessories and includes blower and transmission noise.

Several methods are available for lowering the contribution of engine noise to overall bus noise levels. All of these techniques have been successfully tested in the laboratory and some have been applied on diesel engines. (Ref. 9, 10) These techniques, and their expected noise level reductions, are summarized below:

	Noise Level Reduction
Covers and panels attached to the engine	3 to 5 dB
Close fitting engine covers	5 to 8 dB
Partial engine enclosures	5 to 10 dB
Complete engine enclosures	Up to 15 dB
Major structural engine modifications	4 to 7 dB

Diesel engine combustion forces (Ref. 6) are sufficient magnitude to distort or vibrate the engine block, crankcase and attachments. Primary combustion forces are at engine fundamental firing frequencies. These frequencies are relatively low, but the structure responds to all harmonics of the basic firing frequency. The steep pressure rise inherent in diesel cycle combustion results in the introduction of high-frequency components into the engine structure which are readily radiated by the sides of the block and rocker arm covers. Changes in the character of or reduction of combustion forces have been under investigation for a number of years. Precombustion chambers or indirect injection can be used to effectively lower combustion rate related noise levels. (Ref. 11) Indirect injection is commonly used in diesel engines powering light-duty vans and passenger cars. Retardation of injection timing has also proved to be effective in lowering noise levels. It also has advantages in terms of power, fuel economy, and emissions, (Ref. 12) but it increases exhaust smoke.

Turbocharging of diesel engines results in some engine noise reduction because of its smoothing effect on the rate of combustion pressure rise in the cylinder. This is not expected to be of significant benefit to gasoline engines. Turbocharging also increases the horsepower output for a given size engine and has advantages from the emissions viewpoint.

A common method of reducing engine radiated noise is by noise carrier panels attached to engine surfaces. These covers or panels are made of a high-density barrier material lined with a sound absorbent material, usually sheet metal lined with glass fiber or mineral wool. These shields must be designed specifically for each engine model since proper covering and edge sealing are quite important. Panels generally are attached to and cover each side of the engine block and oil sump. They must be contoured to the engine shape and be attached through isolation mountings. Experience has shown they are more effective on in-line engines than Vee engines because of the greater, flat, radiation area on in-line engines.

Engine covers have definite advantages and disadvantages. Panels can be applied without redesign or modification of the engine itself. They can be applied to present new engines or as retrofit packages to engines in service. This is much easier than making changes to the basic engine structure. Reductions of 3 to 8 dB in engine noise radiation are possible by means of close-fitting covers. However, from a practical standpoint, a set of panels giving 8 dB reduction would cover virtually all engine and engine-mounted accessory surfaces by many separate complex shaped panels. In general, a 4 dB reduction in overall engine sound levels is close to the practical limit for engine-mounted barrier panels.

Engine panels may increase slightly the time involved in engine service operations. The physical dimensions of the engine are increased, making installation in a vehicle more difficult. Heat radiation from engine surfaces is reduced, but this effect is minimal. (Ref. 12) Quality control must be maintained to assure seal of all panel edges and joints.

Thin-walled components such as oil pan, rocker arm covers, and manifolds can be isolated from the cylinder head casting by means of soft gaskets, rubber washers at mounting bolts, or in severe cases, by splitting the cover immediately above its mounting surface and joining together by a bonded rubber section. This is conceptually shown in Figure 5-5.

Special cooling systems treatments will be necessary for rear-engine buses with encapsulated engines or flow-through enclosures with openings on both sides of the engine compartment. Encapsulated engines will require two radiators placed in front of the engine enclosure with hydraulically or electrically driven thermostatically controlled fans or blowers. This technique is used in the Swedish Scania CR111M bus. Its limitations are discussed in the engine section of this chapter. Changes to improve volumetric air flow rates without increasing fan speeds, such as larger radiators, may be required.

The principals of flow-through enclosures have been studied for quiet trucks. If the engine compartment size is increased to accommodate the

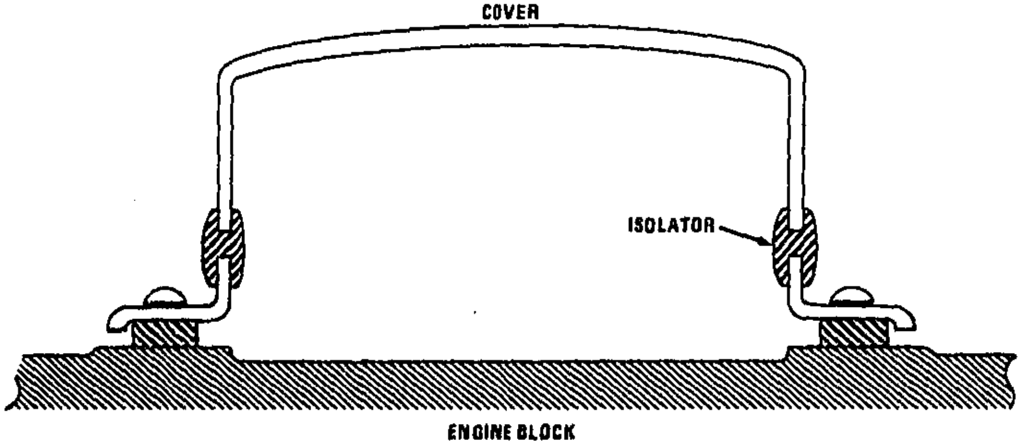


FIGURE 5-5. Isolated Rocker Arm Cover

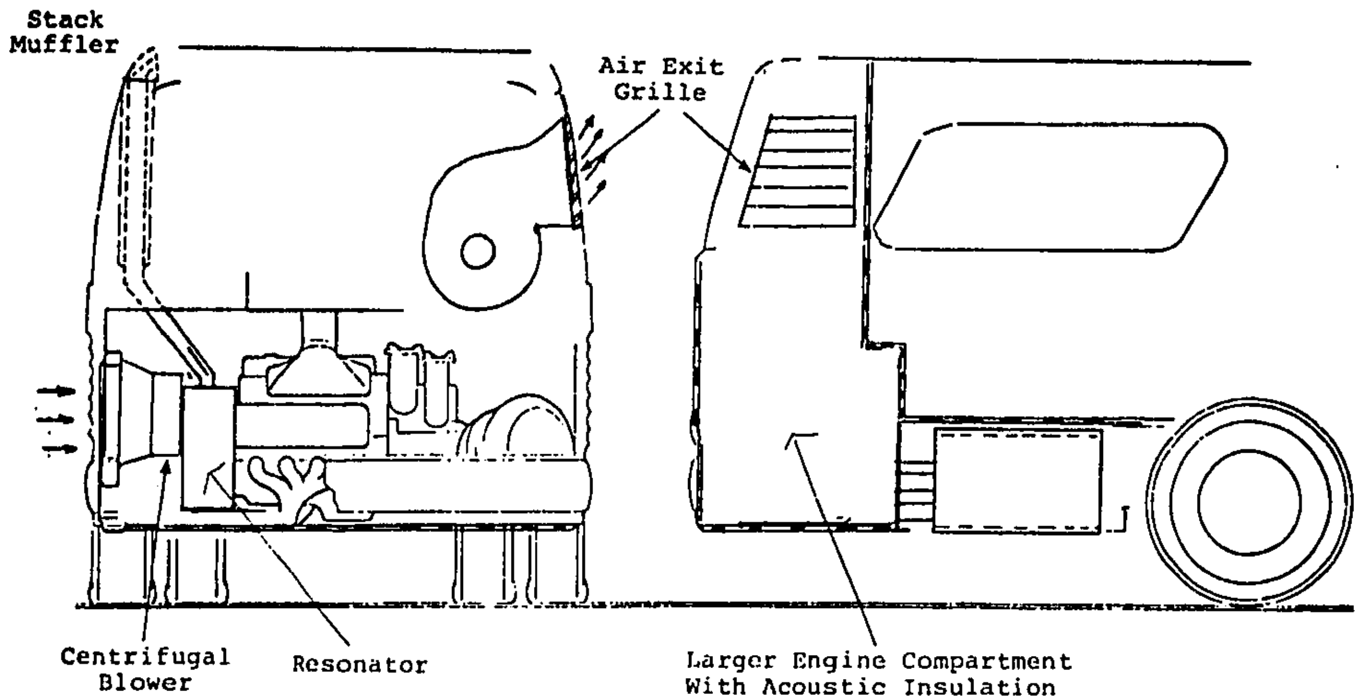
flow and blowers are substituted for fans, 65 dB cooling system noise levels appear achievable. By flowing cooling air through the enclosure, any heat radiated from the engine and transmission will be carried away. (Ref. 6) With proper placement of acoustical material, much of the sound will be absorbed before it escapes from the inlet or outlet. Multispeed thermostatic controls will be required to maintain optimized operation. Substituting an axial flow fan by multiple centrifugal blowers may be beneficial in minimizing sound and distributing the flow evenly over a rectangular radiator. MCI buses have been using a dual radiator and centrifugal fan system for engine cooling for the past twenty years.

For transit buses, the long, rectangular radiator may be located on the left side of the engine compartment with the larger side parallel to the ground. Two parallel blowers would draw the air in, directing it over the engine casing. Engine compartment ventilation will be achieved by another blower directing the air out on the curbside through louvers located high enough to direct air flow above bystander head level. The design of the louvers will be important to prevent leakage of engine noise to the outside. Such a system is shown conceptually in Figure 5-6. This type of enclosure has not been demonstrated for transit bus application. Current evaluation of feasibility is based on experience with IH quiet truck and on the assumption that engine compartment temperatures can be maintained by providing unrestricted cooling air flow rates.

Sound level reduction due to modified engine structure, reduced piston slap, damping, and isolation can be used in conjunction with barriers to produce overall reductions greater than 4 dB, although each additional decibel reduction is more difficult to achieve than the preceding one. When the

FIGURE 5-6

Flow Through Engine Compartment



panels are combined with a partial enclosure, the resultant reduction is often less than the sum of the separate reductions due to each method.

Engine quieting kits are available for diesel engines. These kits include covers for the sides of the engine block and oil pan, vibration isolation reference of the valve covers or air intake manifolds, and cross-overs or damping treatments for sheet metal covers.

Alternatively the engine compartment may be designed to serve as a small acoustical enclosure (either a partial or complete enclosure). Engine side shields for conventional school buses are illustrated in Figure 5-7. The shield may be made from 20 gauge steel sheets lined on the inside with a 2-inch layer of acoustical glass fiber. To keep the glass fiber from losing its effectiveness from saturation with oil, gasoline, or water, a 2-mil nonflammable plastic barrier should be provided. Finally, a perforated thin (22 gauge) metal cover should be added on the inside to minimize mechanical wear and tear. This is sketched in Figure 5-8. Glass fiber materials are relatively inexpensive. The study of currently available cowl and engine sizes for school buses indicates that sufficient space is available for such shields and no alteration in cowl design will be necessary.

Thin metal panels such as hood and sidewalls will require sound barrier material such as 1 lb/sq foot lead-lined vinyl. Alternatively, mylar-faced acoustical foam with lead septum and an insulation layer between the septum and the panel can be used for the entire area. This treatment is illustrated in Figure 5-9.

Shielding under the engine can be effective if the entire area under the engine is treated. Engine noise reaches the receiver by two routes: straight line from the engine area and reflection from the road beneath the vehicle. Belly pans are effective in blocking the reflective path and are currently available for all transit buses. A 2 dB reduction in the engine-

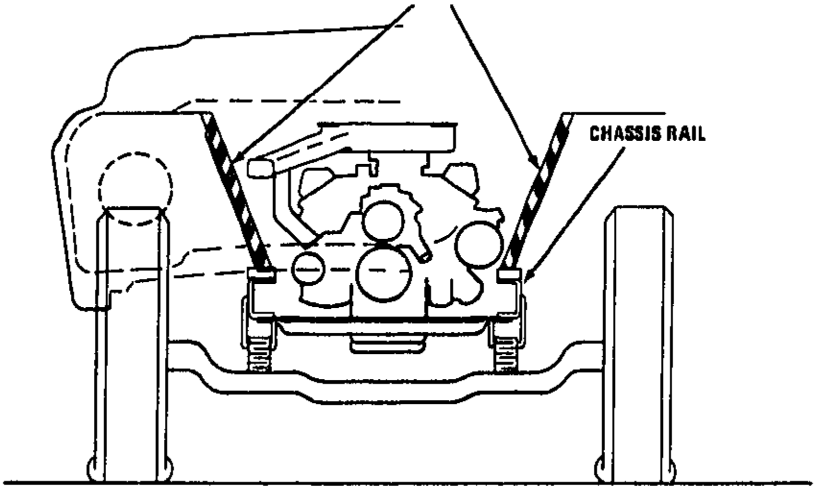


FIGURE 5-7. Engine Side Shields in Postion for Conventional School Buses

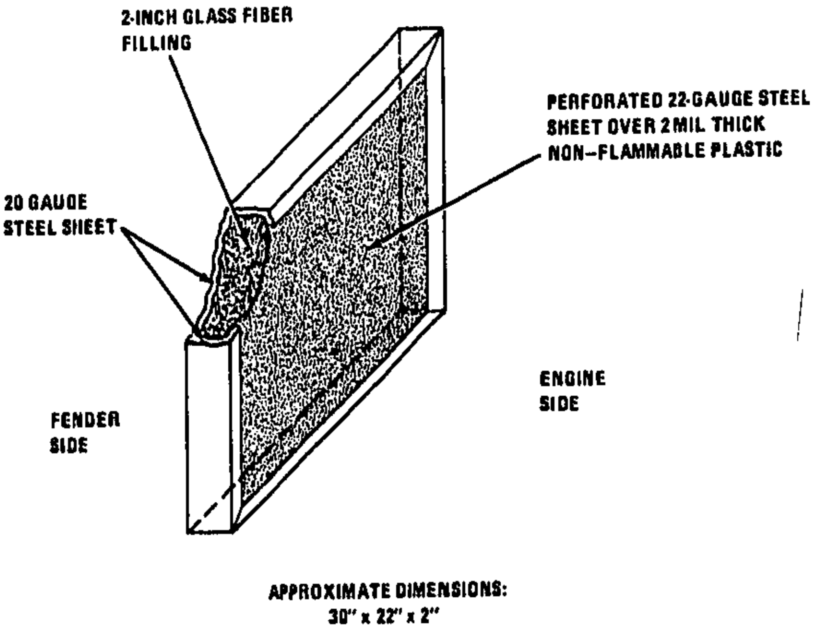


FIGURE 5-8. Detail of Side Shield Construction

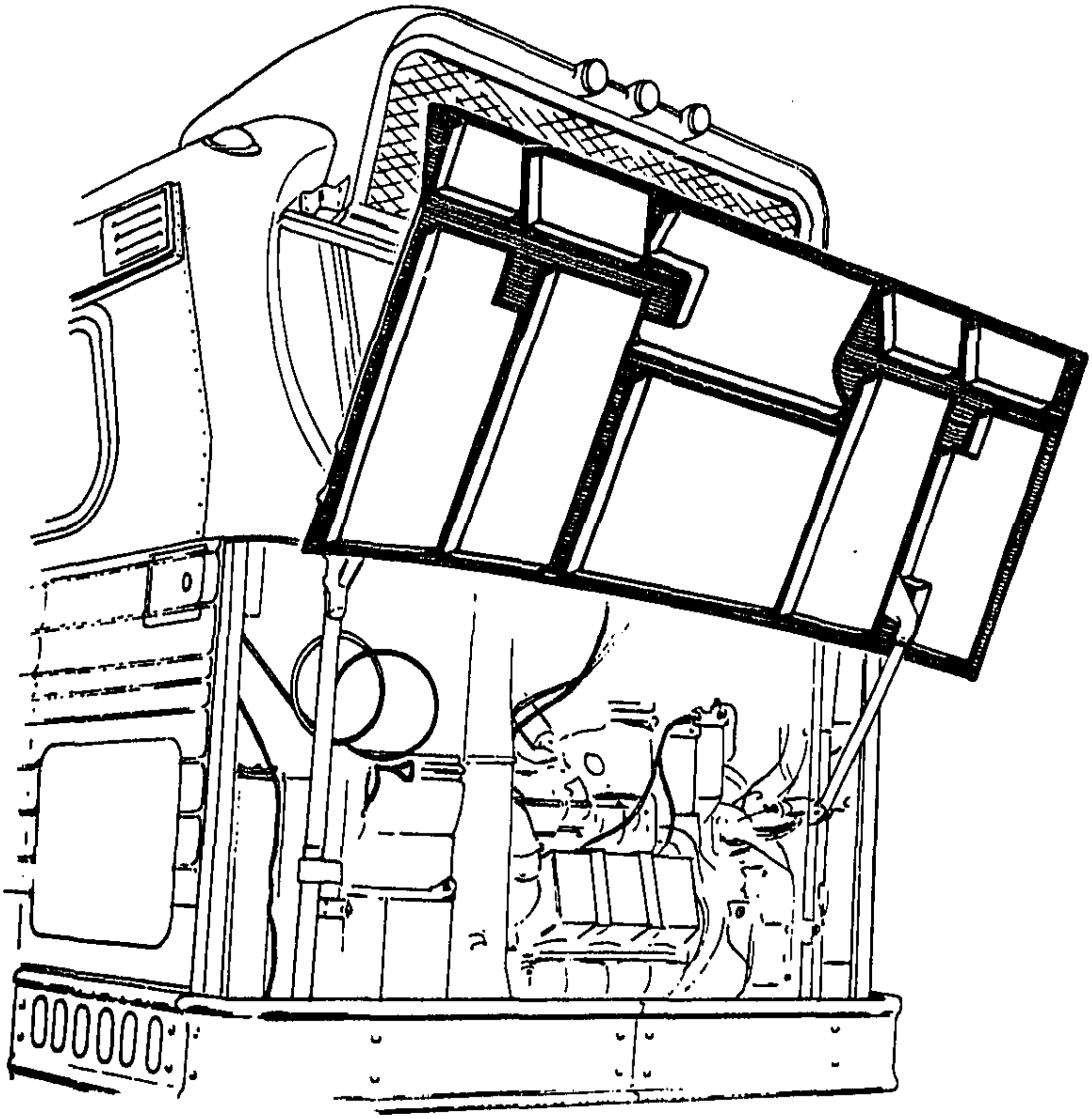


FIGURE 5-9. Acoustic Treatment of Engine Hood on a Flxible "New Look" Bus

contributed noise level can be expected by sealed belly pans. This is especially effective in reducing bystander and pedestrian ear level noise since the reflective sound path from the engine off the road surface toward the side of the bus is virtually eliminated. Belly pans are used widely in Europe, but are not specified or used extensively in the United States due to the added engine servicing problems, restriction of cooling air exit, and problems associated with sealing. When they have been applied by U.S. manufacturers, they have generally been discarded by operators.

Figure 5-10 depicts a belly pan configuration for conventional gasoline or diesel school buses and Figure 5-11 shows a configuration for transit and intercity buses. The belly pan shown in Figure 5-11 is designed with small removable panels to provide access for servicing from underneath, i.e., oil changes. Some provision is needed to ensure that the panels are replaced. This could be accomplished by warning labels or by hinging the panels so that they cannot be completely removed.

Hazards due to fuel or oil collection in the belly can be minimized by careful design so that the liquid flows to a small drain hole under all operating conditions.

When a belly pan such as that shown in Figure 5-11 is used, it is important to provide an adequate outlet area for engine compartment ventilation and cooling air. Such an outlet can be provided forward of the engine compartment between the floor and engine support rails. The outlet opening should be designed to minimize the radiated sound energy. This may be done by lining the inside of this duct with two inches of glass fiber or open-cell foam and providing louvers at the exit to minimize line-of-sight between the interior and the pavement. The drive-shaft opening will need careful design

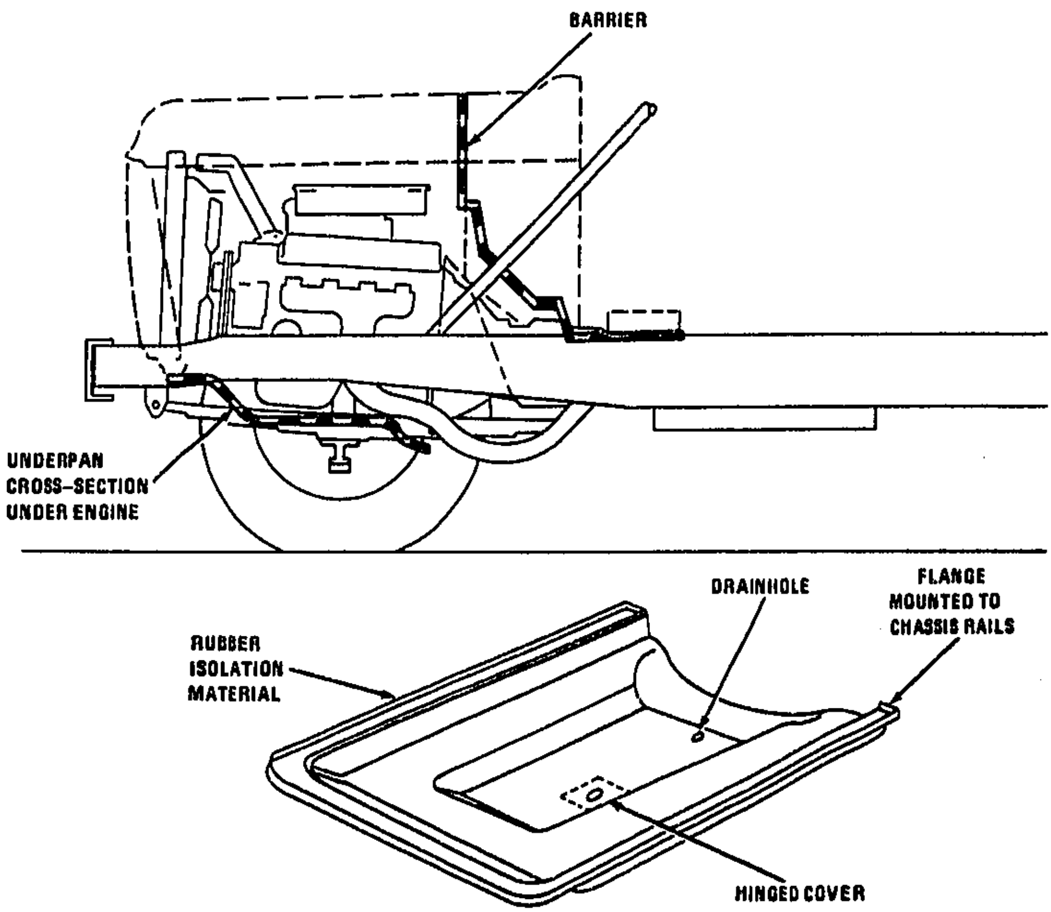
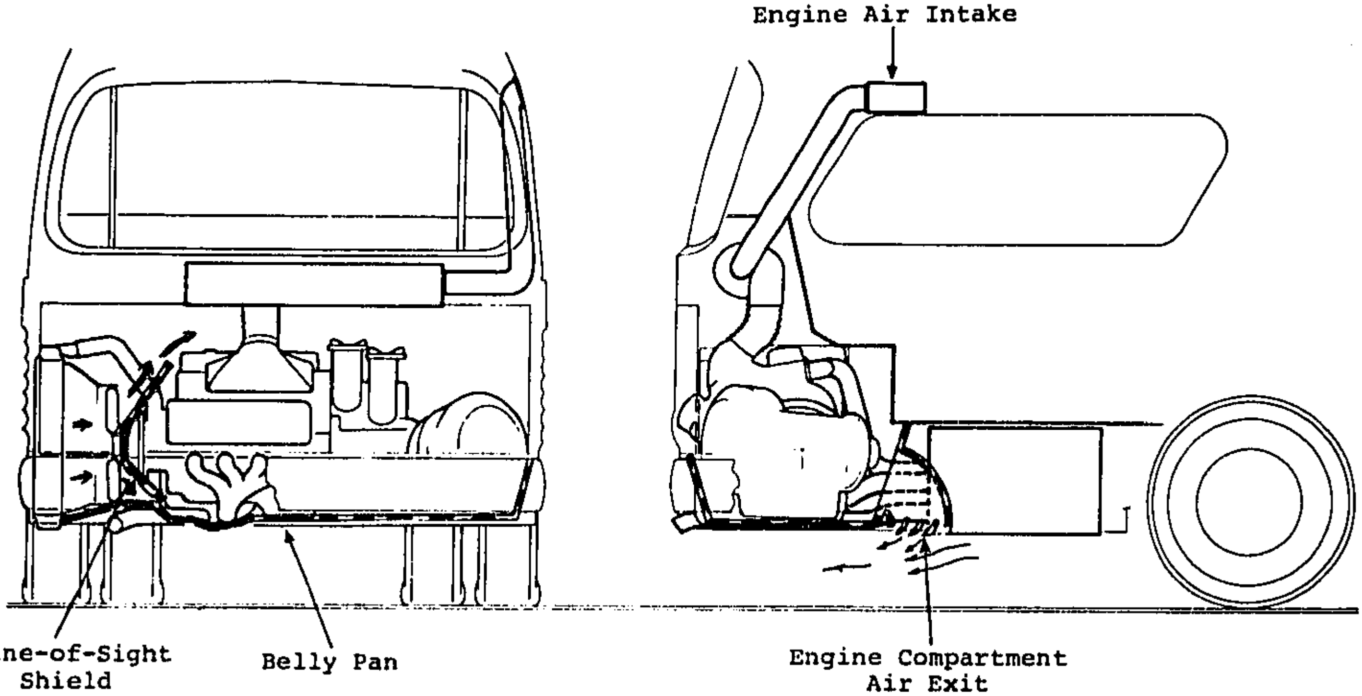


FIGURE 5-10. Possible Underpan Configuration

FIGURE 5-11

Engine Noise Reduction Package



to minimize sound escape. It is not admissible to allow any other opening in the belly pans, because that would render the belly pans ineffective. Refrigerant and other fluid lines should be routed through holes sealed with asphalt or rubber grommets. The design of the outlet ahead of the belly pan is critical. This type of treatment will require redesign of the cooling system.

To reduce interior school bus noise levels at the driver's location might require a barrier between the engine compartment and the driver. A suggested treatment is a layer of barrier-type acoustic insulation weighing 1 lb/ft^2 employed at the cowl face and under the floor extending about 5 feet as shown in Figure 5-12. All holes in the firewall for pedal linkages, steering column, etc., should be carefully sealed with heavy rubber boots.

Some European transit buses have full engine enclosures. Two types of enclosures are possible. Neither type of enclosure has been demonstrated on a bus meeting the performance specifications of U.S. urban transit buses.

One type of engine enclosure covers the cooling fan as well as the engine. Openings for cooling air inlet and exit greatly reduce the effectiveness of the enclosure. On the other hand, the enclosure provides some shielding to fan noise. The cooling system generally has to be adjusted to prevent overheating.

A flow-through type of enclosure may be incorporated. The square radiator can be replaced by a rectangular radiator of twice the frontal area. Two centrifugal blowers in the suction mode would draw in air. Centrifugal blowers allow better isolation of engine noise. The radiator and blowers would be enclosed in a duct. The seal between bus body sidewall and radiator is particularly important.

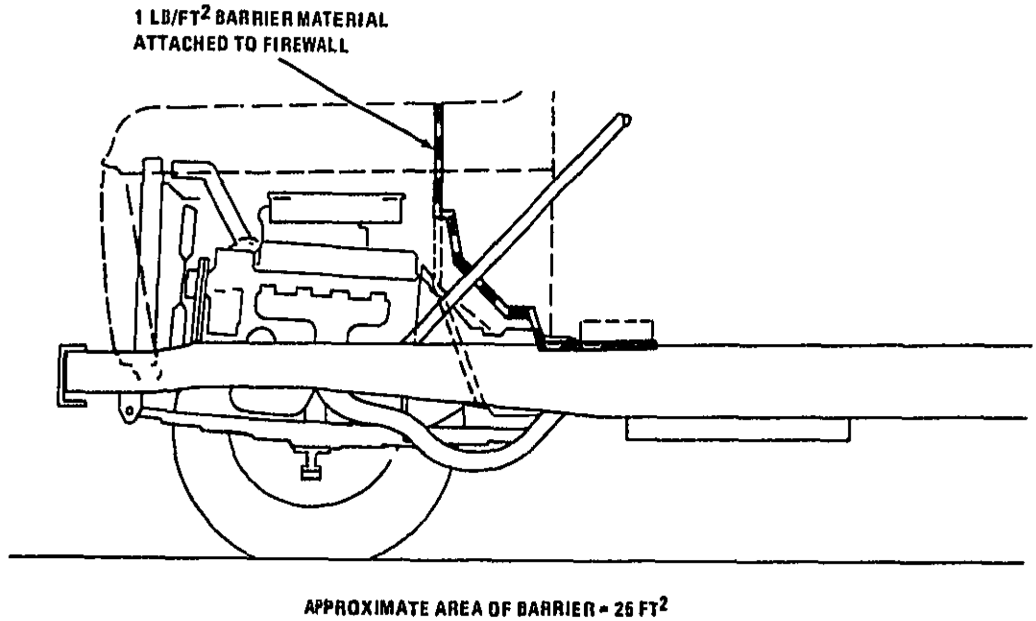


FIGURE 5-12. Engine Noise Abatement by Shielding

The air from the engine compartment would be allowed to exit through an acoustical treated opening on the curbside, at a height above normal pedestrian head level. The flow-through concept is sketched in Figure 5-13. Such an enclosure would result in source levels of 65 dB if the future diesel engines are at least 4 dB quieter than current engines without any treatment.

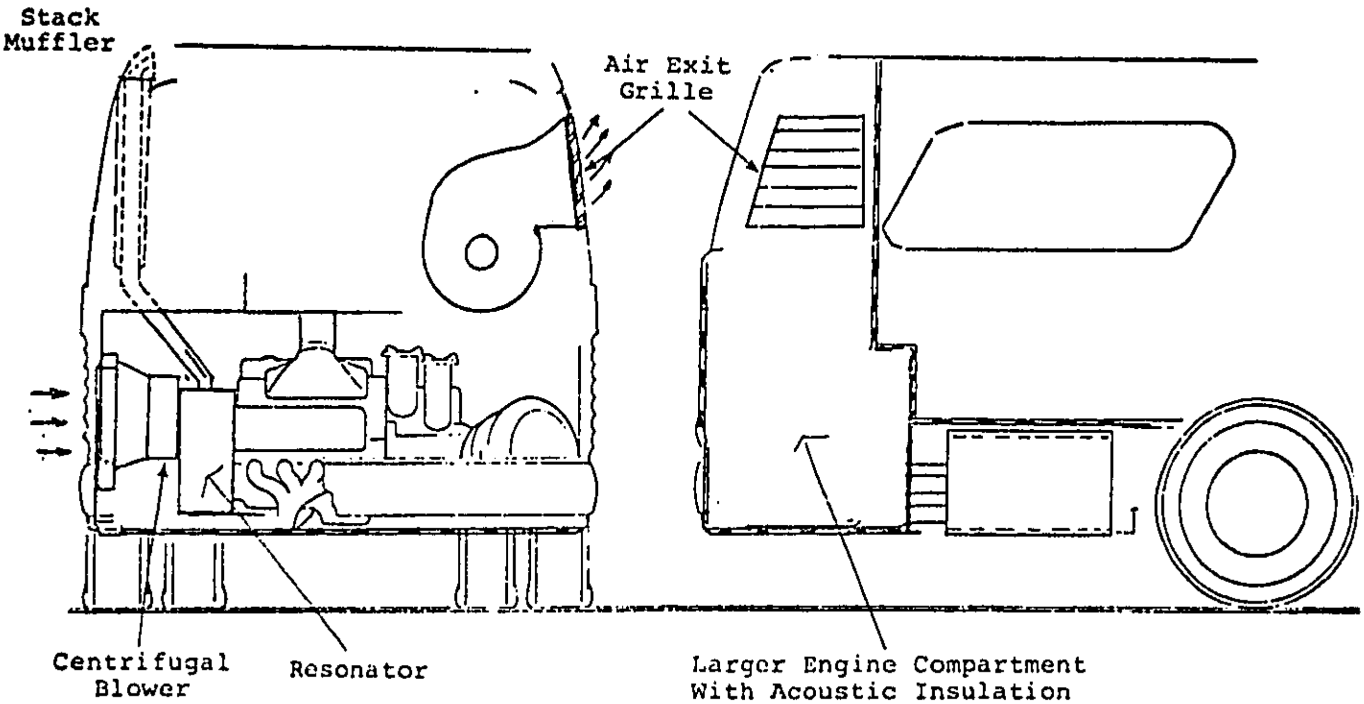
The second type of enclosure would place the cooling fan outside the enclosure, permitting greater reduction in engine noise. The radiator and fan would generally require relocation because of the restriction presented by the engine enclosure. This type of enclosure is used on production buses in Europe, such as the Scania CR111M. In the Scania buses, the engine compartment is completely sealed on all sides and is provided with a fan for ventilating the engine compartment. The air intake for ventilation is located on the roof of the bus. The single radiator on the left side is replaced by two radiators, one on each side of the bus located ahead of the closed engine compartment. Cooling air is drawn in by individual electrically operated fans at each radiator. The cooling system of the C111M is designed for an air-to-boil temperature of 85-90°F. This would not be acceptable for most climates in the United States. European bus technology is discussed in greater detail in Appendix A.

Engine enclosures may reduce accessibility to the engine compartment, add weight, in some cases reduce passenger and freight capacity due to increased engine compartment size, and pose a potential fire hazard.

Engine mountings are important on all buses since engine vibrations can be transmitted to the body framework and to the body panels through the mounts. Engine mount design technology is sufficiently advanced to provide good isolation at high frequencies between the engine and body frame or

FIGURE 5-13

Flow Through Engine Compartment for Achieving 65 dB Engine Noise Level



chassis while allowing the large torque forces to be transmitted to the transmission. Vibration isolation is important because current bus interior noise levels are dominated by floor and body side panel radiated noise which appears to be the result of engine vibration.

Transmission noise for diesel buses can be lowered by the application of damping material to reduce resonant amplification at troublesome frequencies, by stiffening or by weakening housing areas to shift resonance frequency components, by decoupling housing areas by slotting or adding mass dampers, and by altering panel geometrics. (Ref. 13) Engine shields can be extended to include the transmission housing in the case of buses. Transmission noise becomes an important noise contributor on gasoline engine vehicles only after the noise from the engine and the intake have been lowered below 70 dB.

(d) Intake

Current intake noise levels for diesel engines, which are considered noisier than gasoline engines, range from 56 to 75 dB. (Ref. 1) The intake noise level is relatively low in gasoline engines because the air intake filter is mounted directly on the engine carburetor and because of the inherently quieter air intake process.

In the case of diesel engines, intake noise includes the noise from the air inlet, the air cleaner shell and ducting, and leakage of the air intake system components. Intake noise is produced by the opening and the closing of the inlet valve. When the valve opens, a sharp pressure pulse sets the air in the inlet passage into oscillation at the natural frequency of the air column. This oscillation is rapidly damped by the changing volume caused by the piston's downward motion. When the inlet valve closes it produces similar pressure oscillations, which are relatively undamped. In the diesel engine, air inlet noise is generally observed in the low to middle frequencies (up to 1000 Hz). On gasoline engines, this inlet noise may be importanc at higher octave bands due to the flow noise produced in the carburetor.

Typical unsilenced intake noise levels for truck diesel engines at high idle vary between 70 dB and 85 dB, measured at 50 feet from the engine inlet. Production air filters used on most trucks provide an insertion loss (noise level reduction) of from 9 to 22 dB. In the case of eleven trucks with Detroit Diesel engines and production model intake filters, (Ref. 14) intake noise exceeded the noise levels from the remaining components in only one case. Six trucks had sufficiently quiet air intake that further reduction of intake noise would not be of any benefit to overall vehicle noise levels. The remaining trucks showed overall noise reductions of 0.5 to 3 dB for a 6 dB reduction of intake noise. If the noise from remaining components were lowered, intake noise would assume greater importance.

Intake filters act as silencers because of the sound absorption properties of the filter element and because of the area changes. Additional silencing may be provided by designing flow passages to restrict line-of-sight transmission.

Heavy duty oil bath cleaners used in transit buses are good noise suppressors. Cleaners that have large flat sections of sheet metal can radiate significant amounts of noise from mechanical vibrations. Use of rubber sections such as elbows, tubes or connectors in the air intake piping should be avoided as much as possible. Most rubber sections are not good acoustic barriers and radiate excessive amounts of noise because of their pulsating walls.

On the International Harvester Quiet Truck, the intake noise was reduced from 72 dB to 69 dB by replacing the intake rain cap with one with a better design. (Ref. 15).

For maximum quieting, an additional intake silencer can be installed between the air cleaner and the engine inlet. These devices are not particularly expensive, are easy to install, and will do a good job of absorbing higher frequency noises. The silencer should be installed as close to the engine inlet as possible. The additional space requirement may be a problem in transit and forward control school buses.

(e) <u>Chassis and Accessory Noise</u>

Chassis noise refers to that noise generated by a bus coasting with the engine idling and the transmission in neutral. It is dominated by tire noise but includes any wind or turbulent noise caused by the passage of the bus. It is considered to be the lowest level of noise attainable for a vehicle. The noise from such remaining minor sources as air conditioning and air brake compressors are included as accessory noise.

Motor Industries Research Association (MIRA) (Ref. 16) has collected data on coasting noise levels for a broad range of vehicles. Coasting noise depends on tire tread, road speed, road surface, axle loadings, and size or weight of vehicle. A useful general relationship for the coasting noise of a vehicle at 30 mph (44 fps) on a smooth, dry surface is given by the equation:

$$dBA = 65 + 7 \log_{10} W$$

where:

W = gross vehicle weight in tons

dBA = sound level 7-1/2 meters from vehicle centerline.

A typical school bus of 23,000 lb. GVWR according to this formula will produce 66 dB at 50 feet while coasting at 30 mph. A vehicle of 10,000 lbs. GVWR will produce 64 dB under the same conditions.

EPA conducted tests on the coasting levels of several school buses of 17,400 lb. to 23,000 lb. GVWR rating chassis. (Ref. 17) A 23,000 lb. GVWR bus measured 65 dB on the curbside and 69 dB on the streetside while coasting at 30 mph. A 17,400 lb. GVWR bus equipped with snow tires measured 73 dB on the curbside and 74 dB on the streetside while coasting at 30 mph. Both tests were conducted with the engine idling, the transmission in neutral, and all accessories on.

Current school bus chassis noise levels appear to be in the 65 to 74 dB range at 30 mph with the engine shut off. Coast-by noise levels for conventional school buses (without accessory noise) without snow tires are approximately 64 to 68 dB. Chassis noise levels can approach these coast-by levels by lowering the contributions from accessories and body vibrations.

Chassis noise levels of current transit buses range from 65 to 76 dB for 35 ft. and 40 ft. coaches. (Ref. 18) It is felt that chassis noise levels of 70 dB are achievable on today's 40-foot transit coach.

In the case of integral design transit buses, the outer skin panels are load-carrying members. Hence any road or engine vibrations transmitted through the suspension or engine mounts will be transmitted to the skin as stress and result in vibrations of the panels. These panels are acoustically efficient radiators of sound at audible frequencies. The mounting of accessories will need special care to avoid excitation of the body panels into resonance. The windows of the bus should also receive attention. Apart from rattles, loose window panes also result in large vibrating surfaces and hence chassis noise.

For school buses, to meet the 75 dB noise level wil require a chassis exterior design level of 65 dB or less. On buses over 23,000 GVWR, careful body design to minimize noise radiation from body panels will be required. Some critical body panels may need damping treatment or stiffening to make them inefficient radiators of sound energy at the troublesome frequencies peculiar to the body-chassis combination.

The isolation between the body and chassis will need improvement. School buses employ truck chassis with stiffer suspensions than those employed for automobiles. The number of isolation pads between the chassis and the body should be kept at a minimum since each pad provides a path for some of the chassis vibrations to the body. Doubling the thickness and halving the stiffness of the rubber pads, for example, will lower the critical frequency by a factor of 1.4 and improve the isolation over a greater range of frequencies.

(f) Interior Noise Levels

Current bus interior noise levels are dominated by floor and body side panel radiated noise which apears to be the result of engine vibration. Therefore, careful isolation of the engine from the chassis is necessary. Redesign of engine mounts on transit and intercity buses may be necessary.

Airborne engine noise may be blocked from the passenger compartment by barrier panels. On conventional school buses the acoustic insulation material should extend under the floor for about 5 feet. All holes in the firewall for pedal linkages, steering column, etc., should be carefully sealed with heavy rubber boots.

Floor transmitted noise can be reduced by floor insulation. One such treatment consists of an isolating layer of soft rubber between two boards.

On intercity buses the luggage compartment under the passenger compartment offers a partial barrier to tire noise transmitted to the interior. If resonant vibrations are present in body panels, damping treatment will be beneficial. Otherwise, sound radiation to the interior can be minimized by covering the interior surfaces with a limp, heavy acoustic material such as lead/vinyl sheeting. Another approach would be be to isolate the rear section body panels from the main integral body framework.

On conventional and forward-control school buses, special attention to the support system for the exhaust pipes and muffler under the bus floor may be necessary to prevent the transmission of vibration to the chassis.

Interior noise levels on all bus types may be reduced by carpeting, fabric covering of roof and body panels, and safety padding of seats.

2. Overall Vehicle Noise Abatement

Overall noise level reductions are achieved by quieting bus components in various combinations depending on their intensity as noise sources. The technology for quieting bus noise components, described in Section 5.1, is specified in this section for each type of bus:

- Urban transit buses
- Intercity buses
- School buses

for each of the four technology study levels. Component design noise levels required to achieve the overall bus noise design levels are presented for each type of bus for the four study levels.

Urban Transit and Intercity Buses

Urban transit buses and intercity buses are similar in terms of component noise levels required for achieving the overall vehicle design levels to meet the four study levels. The required noise abatement techniques are also similar, with intercity coaches requiring the same abatement treatments as urban transit transit buses plus a few additional treatments. Table 5-2 specifies the component noise levels required by design to achieve the four study levels for both diesel powered integral transit buses and diesel powered integral intercity buses.

Table 5-3 describes the noise abatement treatments for each component noise level required to achieve each of the four study levels for urban transit buses. Intercity buses require the same treatments for each noise source as well as additional treatments specified in the far right column of the table.

Table 5-4 specifies the required noise control treatments of the Advanced Design Buses (ADBs) using noise control treatments specified for urban transit buses. In order to quiet ADB's to meet the four study levels, additional noise control treatments besides those for transit buses, are required. These additional treatments are presented in Table 5-5.

It should be noted that for the ADB's to meet the 77/80 level the radiator and the engine cooling fan may need to be removed from the engine compartment. The cooling system may be located above the engine compartment along with the air conditioning condenser as shown in Figure 5-14. This layout will not impinge on present seating capacity of the ADB's. Centrifugal fans are inherently quieter than axial fans. They also change the air flow direction 90 degrees without the pressure loss that would result with axial fans. The cooling air is exhausted directly into the engine enclosure, so that a separate ventilating fan will not be required. (Ref. 20)

The basic noise control techniques suggested for conventional design transit buses also apply to the M.A.N. - AM General articulated buses.

TABLE 5-2
Component Noise Level Matrix for Diesel
Powered Integral Transit Buses

	Sound Level, SAE J366b Sound Test, dB			
	I	II	III	IV
Bus Exterior Study Level (Not-to-exceed level)	83	80	77	75
Bus Exterior Design Level	80.5	77.5	74.5	72.5
Engine and Transmission	75	71	71	65
Exhaust System	75	70	65	65
Cooling Fan	76	73	68	65
Intake	65	65	65	65
Chassis	70	70	68	68

Component Noise Level Matrix for
Diesel Powered Integral Intercity Buses

	Sound Level, SAE J366b Sound Test, dB			
	I	II	III	IV
Bus Exterior Study Level (Not-to-exceed level)	83	80	77	75
Bus Exterior Design Level	80.5	77.5	75.0	72.5
Engine and Transmission	75	71	71	65
Exhaust System	75	70	65	65
Cooling Fan	76	73	68	65
Intake	65	65	65	65
Chassis	70	70	68	68

TABLE 5-3

Noise Control Treatments for Urban

Transit Buses and Intercity Buses

Type of Bus	Study Level	Noise Source	Noise Control Treatment Urban Transit Buses	Additional Noise Control Treatments Intercity Buses
Urban Transit Buses	I (83-86)	Exhaust System	Resilient mount if vertical tail pipe used. Substitute single-wall muffler with advanced double-wrapped body mufflers.	Reroute tail pipe to exit at the roof line.
		Cooling System	Seal all leaks between engine compartment sidewall and radiator and between the radiator and shroud.	On MCI buses, acoustically treat air flow ducts.
		Engine, Diesel	Damped rocker arm covers. Acoustical material on existing parts of hood, engine compartment sidewall and forward bulkhead. Design of radiator grill to prevent line-of-sight sound transmission while maintaining adequate cooling. Seal all engine compartment holes. Line engine compartment with sound absorbent material. Block all engine borne noise from passenger compartment.	
		Intake	Best available air cleaner with careful sealing of all leaks.	
		Chassis and Accessories	Special care in mounting accessories to avoid excitation of body panels into resonance. Air conditioner compressor area may need some acoustical treatment.	
	II (80-83)	Exhaust System	Turbocharged engine or add a resonator. Adding a resonator requires the whole exhaust system to be redesigned with a premuffler in series with the main muffler. Seal all leaks in the exhaust system using gas-tight exhaust joints. If muffler is outside engine enclosure, use double-walled type.	Reroute tail pipe to exit at the roof line.

TABLE 5-3 (Cont.)

Noise Control Treatments for Urban

Transit Buses and Intercity Buses

Type of Bus	Study Level	Noise Source	Noise Control Treatment Urban Transit Buses	Additional Noise Control Treatments Intercity Buses
		Cooling System	Replace rectangular shrouds with contoured shrouds. Optimize fan coverage. Optimize air flow distribution across radiator by changing fan to radiator distance. If cooling air is restricted increase the pressure rise across the fan without decreasing the volumetric air flow rate. Alternatively, the radiator and fan may be increased to permit adequate cooling at the reduced air flow velocity.	On MCI buses, acoustically treat air flow ducts.
		Engine	Complete engine belly pans with two openings and line-of-sight shielding between engine and radiator opening. Line air outlet duct with 2 inches of glass fiber or open-cell foam. Provide louvers at the exit to minimize line-of-sight between the interior and the pavement. Carefully design drive shaft opening to minimize sound escape. Route refrigerants and lubricants through holes sealed with asphalt or rubber grommets. Turbocharged engines may require auxiliary engine compartment ventilation systems.	Eagle buses may need an additional shield between the engine and air conditioner condenser opening on the curbside.
		Intake, Chassis Accessories	Same treatment as for Level I.	
	III (77-80)	Exhaust System	The exhaust system for Level II with some added volume can be used. A turbocharged engine with large resonators as close to the manifolds as possible followed by the exhaust pipe and muffler wrapped with asbestos or mineral wool to provide acoustic/thermal insulation.	Reroute tail pipe to exit at the roof line.

TABLE 5-3 (Cont.)

Noise Control Treatments for Urban

Transit Buses and Intercity Buses

Type of Bus	Study Level	Noise Source	Noise Control Treatment Urban Transit Buses	Additional Noise Control Treatments Intercity Buses
		Engine (Cont)		between two boards. Another approach to interior noise reduction would be to isolate the rear section body panels from the main integral body framework. Addition of sound absorbing linings in the interior may minimize reverberation. Enclosure for the MCI buses may need an outlet near the axle. The enclosure will cover the entire tranmission casing. Additional suction fans may be needed at enclosure exit to minimize air flow through radiators.
		Intake, Chassis and Accessories	Same as for Level III.	

TABLE 5-4

Additional Noise Control Features for Advanced Design Buses

COMPONENT SYSTEM	STUDY LEVEL (dB)	NOISE CONTROL FEATURES	EXISTING ON M.A.N. BUSES
Engine & Transmission	80	Full engine underpan	No
	77	Complete engine enclosure	No
	75	Complete engine enclosure	No
Exhaust	80	Turbocharging	Yes
	77	Turbocharging	Yes
		Dual exhaust and double wrapped muffler	No
	75	Turbocharging	Yes
		Dual exhaust and double wrapped muffler	No
Cooling	80	Variable speed fan	Yes
		Downward outlet	Yes
	77	Remote radiators with centrifugal fan	N.A.
		Acoustical louvers	No
		Aerodynamic enclosure outlet	No
	75	Remote radiators with centrifugal fan	N.A.
		Acoustical louvers	No
		Water cooled manifolds	No
		Increased cooling capacity	No
		Cooling system sound insulation	No
		Aerodynamic enclosure outlet	No
Intake, Chassis and Accessories	80, 77 & 75	Intake silencer	Yes

TABLE 5-5

Required Noise Control Features Based On Current Technology Buses

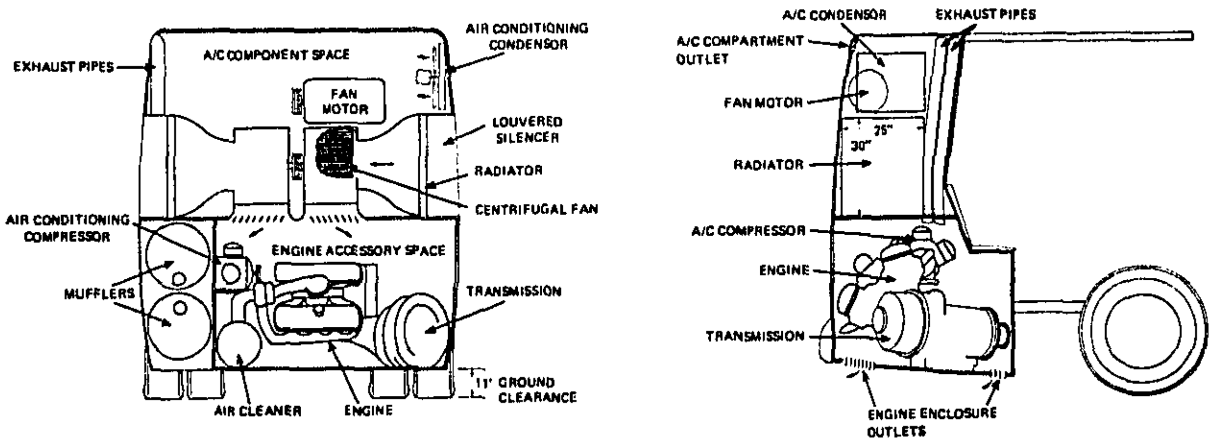
Component System	Study Level (dB)	Required Noise Control Feature	Existing Features ADB Flx	Existing Features GM
Engine & Transmission	80	Full Engine Underpan	No	No
	77	Complete Engine Enclosure	No	No
	75	Complete Engine Enclosure	No	No
Exhaust	80	Turbocharging	Yes*	Yes*
	77	Turbocharging	Yes*	Yes*
		Dual Exhaust and Double Wrapped Muffler	No	No
	75	Turbocharging	Yes*	Yes*
		Dual Exhaust and Double Wrapped Muffler	No	No
Cooling	80	Downward Outlet	Yes	Yes
	77	Remote Radiators With Centrifugal Fan	No	No
		Acoustical Louvers	No	No
		Aerodynamic Enclosure Outlet	No	No
	75	Remote Radiators with Centrifugal Fan	No	No
		Acoustical Louvers	No	No
		Water Cooled Manifolds	No	No
		Increased Cooling Capacity	No	No
		Cooling System Sound Insulation	No	No
		Aerodynamic Enclosure Outlet	No	No
Intake, Chassis and Accessories	80,77 & 75	Separation of Radiator & A/C Coils	Yes	No

*California Only Initially

Source: 19

FIGURE 5-14

Engine and Cooling System Layout



Some of these techniques, such as turbocharging and intake silencing, are already being employed on the articulated buses. There exists large amounts of unused space around the engine and the air-conditioning unit. The use of sound absorbing material in this space, combined with the replacement of the flexible exhaust pipe, should result in a significant noise reduction. The design of the M.A.N. buses is such tht the noise reduction required may be accomplished with relative small effort. Table 5-6 lists the suggested noise control treatments and indicates whether they are currently employed on the M.A.N. buses. (Ref. 21)

School Buses

There are five basic configurations of school buses:

- Conventional gasoline powered
- Conventional diesel powered
- Front-engine forward control
- Mid-engine
- Rear-engine.

Noise control treatments of the various noise sources vary from one school bus type to another. Component design noise levels also vary from one school bus type to another. Therefore, data on overall school bus noise abatement is distinguished by type of school bus, although in many cases treatments are identical. Table 5-7 specifies the component noise levels required by design to achieve the four study levels for the various types of school buses.

The specific noise abatement treatments of noise sources for the various types of school buses to achieve the four study levels are arrayed in Table 5-8. In many instances noise abatement techniques are common to more than one type of school bus.

TABLE 5-6

Comparison of Suggested Noise Control Features with those Currently Employed on M.A.N. Buses

COMPONENT SYSTEM	EXTERIOR LEVEL (dB)	NOISE CONTROL FEATURE	INCREMENTAL IMPACT OF IMPLEMENTATION
Engine and Transmission	80	Full Engine Underpan	Possible minor relocation of components for ease of maintenance
	77	Complete Engine Enclosure	Relatively minor changes
	75	Complete Engine Enclosure	Possible further minor changes
Exhaust	80	Turbocharging	Currently used for California buses; Relatively minor changes
	77	Turbocharging	No change from previous level
		Dual Exhaust and Double Wrapped Muffler	Possible layout redesign
	75	Turbocharging	No change from previous level
		Dual Exhaust and Double Wrapped Muffler	No change from previous level
Cooling	80	Retain Large Radiator With Slower Turning Fan	
		Smaller Radiator with Thermostatic Controlled Fan	Relatively minor change
		Downward Outlet	Possible minor relocation of components
	77	Remote Radiator with Increased Cooling Capacity	Layout redesign
		Aerodynamic Enclosure Outlet	Relatively minor change
	75	Remote Radiator with Increased Cooling Capacity	No change from previous level
		Acoustical Louvers	Relatively minor change
		Water Cooled Manifolds	Possible layout redesign
		Cooling System Enclosure	Relatively minor change
		Aerodynamic Enclosure Outlet	No change from previous level
Intake, Chassis and Accessories	80, 77	Separation of Radiator and A/C Condenser	Layout redesign at 80 dB level

Reference 20

TABLE 5-7

Design Levels of Component Noise Sources

<u>Component Noise Level Matrix for Gasoline-Powered Conventional School Buses and Front Engine Forward Control School Buses</u>

	Sound Level, SAE J366b Test, dB			
	I	II	III	IV
Bus Study Level (Not-to-exceed level)	83	80	77	75
Bus design level	80.0	77.5	74.5	72.0
Engine and intake	77	74	71	68
Exhaust	73	69	65	65
Cooling fan	73	70	64	64
Chassis and accessories	70	70	70	65

<u>Component Noise Level Matrix for Diesel-Powered Conventional School Buses</u>

	Sound Level, SAE J366b Test, dB			
	I	II	III	IV
Bus Study Level (Not-to-exceed level)	83	80	77	75
Exterior Design level	80.5	77.5	74.5	72.5
Engine	77	74	71	68
Exhaust	73	69	68	65
Fan	73	70	64	64
Intake	72	69	65	65
Chassis and Accessories	70	70	65	65

TABLE 5-7 (Cont.)

Component Noise Level Matrix for Mid-Engine School Buses

	Sound Level, SAE J366b Test, dB			
	I	II	III	IV
Bus Study Level (Not-to-exceed level)	83	80	77	75
Exterior Design Level	80.5	77.5	75.0	72.5
Engine	75	71	71	67
Exhaust	75	70	65	65
Cooling Fan	76	73	70	65
Intake	65	65	65	65
Chassis	70	70	65	65

Component Noise Level Matrix for Rear-Engine School Buses (Integral and Body-on-Chassis)

	Sound Level, SAE J366b Test, dB			
	I	II	III	IV
Bus Study Level (Not-to-exceed level)	83	80	77	75
Bus Exterior Design Level	80.5	77.5	75.0	72.5
Engine and Transmission	75	71	71	65
Exhaust System	75	70	65	65
Cooling Fan	76	73	68	65
Intake	65	65	65	65
Chassis	70	70	68	68

TABLE 5-8

Noise Control Treatments for School Buses

oise ource	Study Level	Noise Control Feature	Type of School Bus: Conventional Gasoline-Powered	Conventional Diesel-Powered	Front-Engine Forward Control Parcel Delivery Chassis and Motor Home Chassis	Mid-Engine	Rear-Engine
xhaust	I	Best Available Muffler	X		X		
		Advanced Double-Wrapped Muffler		X		X	X
		Premuffler May be Needed		X		X	
		Seal All Leaks Between Radiator, Bus Sidewalls and Shroud				X	X
	II	More Advanced Muffler (Almost Doubling of Muffler Volume)	X		X		
		Plywood Floor	X		X		
		Turbocharged Engine or Modified Diesel Truck Muffler		X			
		Large Resonator in Series With Main Muffler				X	
		Seal All Leaks in Exhaust System				X	X
		Turbocharged Engine or Add a Large Resonator in Series With Main Muffler					X
	III	Advanced Dual Horizontal Exhaust System With Double-Walled Muffler and Premufflers	X		X		
		Heavier Gauge Exhaust and Tail Pipe	X		X		
		Gas Tight Exhaust Joints	X		X		
		Wrap Exhaust Pipes With Thermal Acoustical Material		X			
		Add Large Resonator				X	
		Turbocharged Engine					X
		Manifold Mufflers or Improved Resonators and a Muffler With Stack Silencers					X

TABLE 5-8 (Cont.)

oise ource	Study Level	Noise Control Feature	Type of School Bus: Conventional Gasoline-Powered	Conventional Diesel-Powered	Front-Engine Forward Control Parcel Delivery Chassis and Motor Home Chassis	Mid-Engine	Rear-Engine
xhaust Cont.)	IV	No further Controls Required	X		X	X	X
		Manifold Mufflers or Advanced Double-Walled Dual Mufflers		X			
		Double-Wall Exhuast Piping		X			
		Pipe Joint Seals		X			
ooling an	I	Seal Shroud	X		X		
		Optimize Fan Coverage by the Shroud	X		X		
		Readjust Cooling System for Adequate Cooling With Sealed Engine Enclosure		X			
		No Treatment Required				X	X
	II	Contoured Shroud With 1/4-inch Tip Clearance or Increased Radiator and Fan Size	X	X	X		
		No Further Controls Required				X	
		Contoured Shroud					X
		Replace Fan to Handle Greater Total Head					X
	III	Increase Radiator Frontal Area by 20 Percent and Fan Diameter by 10 Percent	X	X	X		
		Engine Mounted Close Fitting Shroud	X	X	X		
		Advanced Serpentine-Fan Radiator	X	X	X		
		Redesign Fan Shaft, Pulley and Belt System	X	X	X		
		Increase Radiator by 10 Percent				X	X
		Engine Mounted Contoured Shroud With 1/4-inch Tip Clearance				X	X

TABLE 5-8 (Cont.)

ise urce	Study Level	Noise Control Feature	Type of School Bus: Conventional Gasoline-Powered	Conventional Diesel-Powered	Front-Engine Forward Control Parcel Delivery Chassis and Motor Home Chassis	Mid-Engine	Rear-Engine
oling) ont.)	IV	Readjust Cooling System	X	X	X		
		Increase Maximum Fan Speed	X	X	X		
		Redesign Engine Side Shields	X	X	X		
		May Require 2 Radiators on Either Side of Engine				X	
ine	I	No treatment Required	X		X		
		Engine Quieting Kit		X			
		Acoustically Treat Engine Hood		X			
		Damp Engine Covers				X	X
		Damp Oil Pan				X	X
		Acoustically Treat Engine Compartment				X	X
	II	Acoustically Treat Engine Hood	X		X		
		Acoustically Treat Cowl Face	X	X	X		
		Acoustically Treat Under-Floor	X	X	X		
		Seal Holes in Firewall With Heavy Rubber Boot	X	X	X		
		Engine Noise Shield		X			
		Belly Pan				X	
		Sealed Belly Pan					X
		Acoustically Seal Exit Duct					X
		Line-of-Sight Shield Between Engine and Fan					X
	III	Engine Side Shields	X		X		
		Cooling Fan Redesign	X		X		
		For Turbocharged Engine, Larger Engine Cab		X			

TABLE 5-8 (Cont.)

Noise Source	Study Level	Noise Control Feature	Type of School Bus: Conventional Gasoline-Powered	Conventional Diesel-Powered	Front-Engine Forward Control Parcel Delivery Chassis and Motor Home Chassis	Mid-Engine	Rear-Engine
	III (Cont.)	If Not Turbocharged, Belly Pan		X			
		May Require Flow-Through Engine Enclosure With Special Engine Mounts		X			
		Isolate Engine or Isolate Body From Chassis		X			
		Turbocharged Engine				X	X
	IV	Engine Side Shields	X		X		
		Belly Pan Between Radiator and Bell Housing	X		X		
		Cooling Capacity May Need to be Increased	X		X		
		Isolate Engine or Isolate Body From Chassis	X	X	X		
		Turbocharged Engine		X			
		Sealed Type Tunnel Flow-Through Enclosure		X			
		Major Redesign of Engine Cowl		X			
		Major Redesign of Cooling		X		X	
		Total Engine Encapsulation					X
		Total Engine Encapsulation or Flow-Through Engine Enclosure					X
		Urban Transit Bus Changes					X
		Floating Slab Floor					

3. <u>Acoustical Assurance Period (AAP)</u>

The noise abatement methods described in this chapter are based on existing noise control techniques for lowering noise emitted by currently designed buses. Many of these methods have been demonstrated on prototype trucks and transit buses, while some of the technology discussed has been incorporated into production model vehicles. The durability of these noise control technologies is of particular interest to the EPA.

To ensure that manufacturers develop and apply durable sound reduction measures to their products, EPA is establishing an Acoustical Assurance Period (AAP) of 2 years or 200,000 miles, whichever comes first. This means that the bus noise level must conform with the standard during this period provided that it is properly maintained.

If individual noise control components are not durable, total vehicle noise emission characteristics may be expected to degrade. Improved mufflers manufactured with comparable materials should deteriorate at about the same rate as those presently produced.

Diesel-engine-mounted shields have been thoroughly tested by Cummins, Detroit Diesel Allison, and Caterpiller. Degradation can normally be expected only if the panels are worked loose by vibration or if the acoustical materials become saturated with oil.

On conventional school buses, engine side shields integrated into the engine cowl can reduce the accessibility of the engine to servicing. Care should be taken during servicing to avoid damage to the panels by repair tools, oil contamination of the panels, and excessive vibration.

Belly pans can collect oil, are easily damaged by road surfaces, and reduce engine accessibility from under the vehicle. Removing belly pans may decrease the efficiency of certain vehicle systems. For example, the belly pans will change the air flow rate through the engine compartment and reduce the efficiency of a cooling system designed for an engine with belly pans. Therefore, belly pans should be designed for improved engine accessibility and either binged or have sufficient warning labels that they should not be permanently removed.

Degradation of noise levels from vehicles with totaily encapsulated engines is unlikely if the shielding is properly assembled.

Current transit industry practices may also impact bus noise levels. Those practices may include (Ref. 19):

- Engine access doors are often not latched.
- Covers used for engine enclosures may get damaged or not replaced during bus servicing.
- Steam cleaning and use of high pressure hot water for engine cleaning may cause acoustical insulation to break down.
- Bus operators often develop their own maintenance schedules, which although often based on manufacturer maintenance schedules, may differ from one operator to another.
- The quality of maintenance and repair differs significantly among bus operators.
- Bus noise levels may be significantly influenced by the type of operation and duty cycle. For example, streets that are in disrepair will tear up buses during normal operations due to excessive vibration.

Warranty costs for transit buses are considered a capital cost and subsidized 80 percent by the Federal government. Maintenance costs for transit buses are only subsidized 50 percent by the Federal government. New equipment is usually used more extensively in the fleet than older equipment.

With proper component design and maintenance procedures which incorporate checks on critical noise abatement devices, degradation should be minimal.

REFERENCES

SECTION 5

1. Noise and Vibration Control, edited by L.L. Beranek, McGraw Hill, 1971.

2. Correspondence, Flxible Co. to Booz Allen Applied Research, dated November 26, 1975.

3. Hunt, R.E., Kirkland, K.C. and Ryele, S.P., "Diesel Engine Exhaust and Air Intake Noise," Truck Noise IVA, Report No. DOT-TSC-OST-12, prepared for the U.S. Department of Transportation, July 1973.

4. Ratering, E.G., written response to questions submitted by Booz, Allen & Hamilton, dated January 23, 1976.

5. Kevala, R.J., Manning, J.E. and Lyon, R.H., "Noise Control Handbook for Diesel Powered Vehicles," prepared for the U.S. Department of Transportation, 1975. NTIS No. PB 2 6-382/AS.

6. Shrader, J.T. and Page, W.H., "The Reduction of Cooling System Noise on Heavy Duty Trucks," Truck Noise IV-C, Report No. DOT-TST-74-22, prepared for the U.S. Department of Transportation, 1974.

7. Bender, E.K. and Kaye, M.C., "Field Test of Freightliner Quieted Truck," Truck Noise III-G, Report No. DOT-TST-76-29, prepared for the U.S Department of Transportation, 1975.

8. Shrader, J.T., "Truck Noise-IV G-Field Test Results on a Heavy Duty, Diesel Truck Having Reduced Noise Emissions," prepared for the U.S. Department of Transportation, Office of Noise Abatement, December 1975.

9. Jenkins, S.H. and Kuehner, H.K., "Diesel Engine Noise Reduction Hardware for Vehicle Noise Control," SAE Paper No 73-681, Combined Vehicle Engineering and Operations and Powerplant Meetings, Chicago Illinois, June 1973.

10. Priede, T., "Noise Due to Combustion in Reciprocating Internal Combustion Engines," The Institute of Sound and Vibration Research, Southampton University.

11. "Diesel Engine Noise," SAE Special Publication SP-397, November 1975.

12. Staadt, Richard L., "Truck Noise Control," SAE Special Publication 386.

REFERENCES

SECTION 5

13. Dunlap, T.A. and Halvorsen, W.G., "Transmission Noise Reduction," SAE Paper No. 72035, 1972.

14. Law, R.M., "Diesel Engine and Highway Truck Noise Reduction," SAE Paper No. 730240, 1973.

15. "Noise Control Retrofit of Pre-1970 General Motors Trucks and Coaches," Report No. DOT-TSC-OST-75, U.S. Department of Transportation, Office of the Secretary, Washington, D.C., October 1975.

16. Mills, C.H.G., "Noise Emitted by Coasting Vehicles," MIRA Bulletin No. 3, May/June 1970.

17. "An Assessment of the Technology for Bus Noise Abatement," Draft Final Report submitted by Booz-Allen Applied Research under EPA Contract No. 68-01-3509, prepared for the Office of Noise Abatement and Control, June 22, 1976.

18. "Noise Control Retrofit of Pre-1970 General Motors Trucks and Coaches," Final Report, U.S. Department of Transportation, Office of Noise Abatement, October 1975.

19. "Evaluation of the Proposed Acoustical Assurance Period for Buses," Draft Report submitted by Booz-Allen and Hamilton, Inc. under EPA Contract No. 68-01-3509, prepared for the Office of Noise Abatement and Control, March 1979.

20. "Bus Noise Control Technology Assessment Future Advanced Design Buses and Transbus" revised Draft Report submitted by Booz-Allen and Hamilton, Inc. under Contract No. 68-01-3509, prepared for the Office of Noise Abatement and Control, April 28, 1978 (revised).

SECTION 6

EVALUATION OF EFFECTS OF BUS NOISE ON PUBLIC HEALTH AND WELFARE

Introduction

The purpose of this section of the regulatory analysis is to assess, in quantitative terms, the health and welfare impact of the noise emitted by buses, and the benefits or reductions in this impact to be expected from a regulation limiting the noise emissions from newly manufactured buses. Presented in this analysis are predictions of the potential health and welfare benefits of selected noise control options that cover a wide range of possible regulatory programs for buses.

Because of inherent differences in individual responses to noise, the wide range of situations and environments which relate to bus noise generation, and the complexity of the associated noise fields, it is not possible to precisely examine all situations of community exposure to bus noise. In this predictive analysis, certain stated assumptions have been made in order to approximate typical, or average, situations. The order of magnitude of the population that may be affected for each regulatory option is determined through statistical analysis. Some uncertainties with respect to individual cases or situations may remain.

Effects of Noise on People

The phrase "health and welfare," as used in this analysis and in the context of the Noise Control Act, is a broad term. It includes personal comfort and well-being and the absence of mental anguish, disturbances and annoyance, as well as the nonoccurrence of clinical symptoms such as hearing loss or demonstrable physiological injury (Reference 24). In other words, the term applies to the entire range of adverse effects that noise can have on people.

Improvements in public health and welfare are regarded as benefits of noise control. Public health and welfare benefits may be estimated both in terms of reductions in noise exposures and, more meaningfully, in terms of reductions in adverse effects. This analysis first estimates exterior and interior bus noise exposure (numbers of people exposed at different noise levels), and then translates this exposure into potential impacts on the community, bus passengers and drivers.

People are exposed to noise from buses in a variety of situations. Some examples are:

1. Inside a home, office or workplace
2. Outdoors at home, or in commercial and industrial areas
3. As a pedestrian or in transit in other vehicles
4. As a participant in recreational activities
5. As a bus driver or passenger

As measured from people's responses in questionnaires, there is no doubt that annoyance to bus noise does exist. In fact, in a survey of people's annoyance to motor vehicles, it was found that of those vehicles perceived as a noise problem, buses were noted to be the loudest and most intensely annoying of any of the major vehicle noises (Reference 6).

Noise affects people in many ways, although not all noise effects will occur at all levels. Noise associated with the operation of buses can produce the effects mentioned below, the extent to which depends on duration of exposures and specific exposure situations.

The best-known noise effect is probably noise-induced hearing loss. This is generally not a problem for a person with occasional exposure to traffic noise, but it can be a problem for some bus drivers or passengers. A characteristic of noise-induced hearing loss is that it first occurs in a high-frequency area of the auditory range, which has some importance for the understanding of speech. As a noise-induced hearing loss further develops, the sounds which lend meaning to speech become less and less discriminable. Eventually, while utterances are still heard, they become merely a series of low rumbles, and the intelligibility is lost. Noise-induced hearing loss is a permanent loss for which hearing aids and medical procedures cannot compensate.

Noise can cause stress. The body has a basic, primitive response mechanism which automatically reacts to noise as if to a warning or danger signal. A complex series of bodily reactions (sometimes called the "flight-or-fight" response) takes place; these reactions are beyond conscious control. When noise intrudes, these reactions can include elevation of blood pressure, changes in heart rate, secretions of certain hormones into the bloodstream, changes in digestive processes, and increased perspiration on the skin.

This stress response occurs with individual noise events, but it is not known yet whether the reactions seen in the short term become, or contribute to, long-term stress disease such as chronic high blood pressure.

Some of this stress response is believed to be reflected in what people express as "annoyance", "irritation", or "aggravation" and which the Agency has termed "general adverse response". Accordingly, this analysis estimates the generalized adverse responses of people to environmental noise. To the extent that physiological stress and verbalized annoyance are related, the "general adverse response" quantity is considered to be one metric for indicating the magnitude of human stress response.

The general adverse response relationship to noise levels is also seen as representing, in part, another area of noise effects: activity interference. There is considerable scientific data that demonstrates that noise interferes with many important daily activities such as sleep and communication (Reference 11). These effects (sleep disturbance and communication interference) can be estimated. Thus, computations of potential benefits, based on the potential of interference with human activities, are included as part of the analysis in this section. In expressing the causes of annoyance to noise, people often report that noise interferes with sleeping, relaxing, concentration, TV and radio listening, and face-to-face and telephone communications. Thus, the general adverse response quantity is considered an appropriate metric to indicate the severity to which noise interferes with everyday human activities.

Measures of Benefits to Public Health and Welfare

People are exposed to noise generated from buses both at and away from their residences. In general, it is anticipated that a reduction of noise emitted from buses will result in the following types of benefits:

1. Reduction in average traffic noise levels and associated cumulative long-term impact upon the exposed population.

2. Fewer human activities disrupted by individual, intense or intruding noise events.

3. General improvement in the quality of life, with quiet as an amenity resource.

4. Reduced annoyance in terms of less interference with speech communication inside buses, and reduced potential for hearing damage risk to bus drivers and passengers in combination with non-bus noise exposures.

The general approach taken in this health and welfare regulatory analysis is to estimate the adverse effects of bus noise on the U.S. population, and then quantitatively evaluate the potential benefits resulting from the reduction of noise from buses (both inside and outside) in terms of percentage reductions in adverse impact.

Estimates of traffic noise levels under various regulatory schedules are presented in terms of the noise levels associated with typical bus passbys. These estimates are derived by considering traffic mixes within different populated land areas. Possible reductions in average traffic noise levels from current conditions (i.e., without noise emission regulations for buses) are presented for several regulatory options for new buses, taking into account probable noise emission reductions of other traffic noise sources (References 50 and 51). Projections of the population adversely impacted, as well as the relative reductions in impact (benefits) from current conditions, are determined from the estimated reductions in average traffic noise levels.

However, estimating nationwide impact in terms of average urban traffic noise levels is not, in and of itself, totally indicative of the severity or extensiveness of the bus noise problem. The analysis does not fully describe individual disturbances or the extreme annoyance caused by single bus passbys in various environmental situations. This is because annoyance or other responses to noise frequently depend on the activities and locations of the people when exposed to bus noise. Thus, average traffic noise levels do not account for the more disruptive and annoying peak noise intrusions produced by individual bus passbys (frequently referred to as "single events"). Therefore, additional potential benefits should result from the consideration of reduced noise levels associated with these single events. These benefits are discussed in terms of the potential interference with people's activities resulting from exposure both to current bus noise emission levels, and to reduced single event levels associated with the regulatory options considered. Sleep interference and speech interference are considered in this analysis as indicators of potential activity interference and the associated adverse impact of bus noise. Furthermore, benefits of reducing interior noise levels of buses are examined.

The following analysis presents numeric values which represent both the numbers of people exposed to bus noise and the degree to which they are potentially impacted. Also presented are relative percentage reductions in impact from 1980 conditions. This analysis principally relies on relative percent reductions in noise impact rather than on absolute values of present or future impact since the latter is not readily quantifiable. The relative reductions in impacts are considered accurate indicators of what might be expected from the imposition of noise emission standards. For example, while it may not be possible to characterize completely the extensiveness and severity of the noise impact of current bus operations, relative reductions can be accurately calculated and are used for comparing various regulatory alternatives.

Regulatory Schedules

The health and welfare analysis carried out for buses examined the potential benefits of reducing bus noise based upon a broad range of the exterior and interior regulatory options. These regulatory options shown in Table 6-1 represents those regulatory options, as applied to both exterior and interior bus noise emissions, that were considered in arriving at the final regulatory levels and effective dates. Since a number of the options are to varying degrees dependent on each other, they are grouped accordingly.

With only one exception, each bus type is regulated to the same level. In Option 5, transit and intercity buses are regulated in accordance with Option 3, while school buses adhere to Option 2. Option Q (an idealized case) represents quieting buses to a level 10 dB below the most stringent regulatory option. This option is included for comparison purposes only to indicate an upper limit of potential benefits.

DESCRIPTION OF TRAFFIC NOISE IMPACT

This analysis presents projections of average traffic passby noise levels for scenarios that include both urban street traffic and highway traffic. Note that the benefits accrued from the regulatory schedules considered for new buses will be less for highway traffic than for urban street traffic for the following reasons:

- The number of people exposed to highway traffic noise is less than the number of people exposed to urban street traffic noise.
- The reductions in traffic noise levels resulting from the regulations on new buses will be less in freeway traffic than in urban street traffic.

As presented in Figure 6-1, the number of people exposed to outdoor noise levels that are greater than L_{dn} * of 55 dB dominated by urban street

---

* L_{dn} is the day-night sound level expressed in decibels. This is discussed in more detail in the following subsection "NOISE METRICS."

TABLE 6-1

POSSIBLE REGULATORY OPTIONS FOR NEW BUSES
(A-weighted sound levels and effective dates)

OPTION	YEAR	EXTERIOR (decibels)	INTERIOR (decibels)
BASELINE		NO REGULATION	
1	1981	83	86
2	1981	83	86
	1985	80	83
2A	1985	80	83
3	1981	83	86
	1985	80	83
	1987	77	80
3A	1985	80	83
	1987	77	80
3B	1987	77	80
4	1981	83	86
	1985	80	83
	1987	77	80
	1988	75	78
5	1981	83	86
	1985	80	83
	1987	77 (transit and inter-city buses)	80 (transit and intercity buses only)
Q* (Quiet)	1981	65	68

* Option Q is 10 dB below the most stringent regulatory option. It is an idealistic option intended for comparison purposes only.

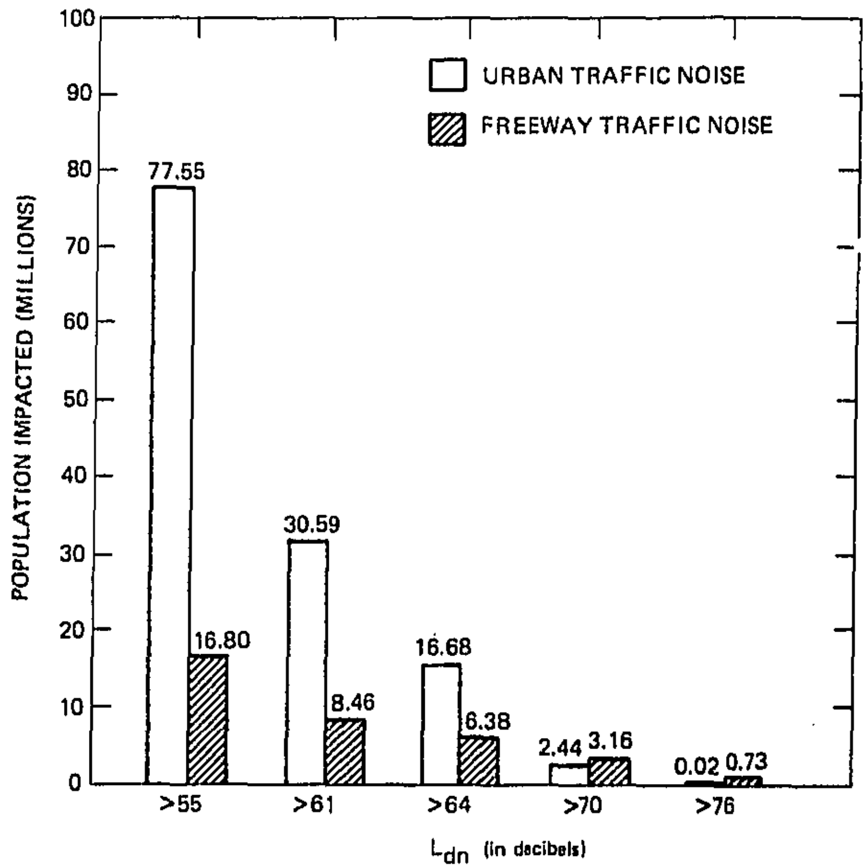


FIGURE 6-1. ESTIMATED NUMBER OF PEOPLE IN RESIDENTIAL AREAS CURRENTLY SUBJECTED TO TRAFFIC NOISE ABOVE L_{dn} = 55 dB.

by urban street traffic noise is significantly higher than the number exposed to highway and freeway traffic noise -- 78 million as opposed to 17 million. Thus, reducing urban street traffic noise will benefit significantly more people than will similar reductions in highway traffic noise.

NOISE METRICS

As discussed in the Introduction of this section, three methods are used to evaluate the health and welfare benefits of reduced bus noise emissions. These methods estimate the general adverse response due to noise associated with the operation of buses; the potential of everyday activity interference (sleep disturbances and speech communication interferences) attributable to individual bus passbys; and an interior bus noise analysis concerned with the potential of hearing damage risk and interference with speech communications.

Three noise metrics are principally used in these methods. The primary measures of noise exposure for general adverse response and annoyance are the Equivalent A-weighted Sound Level (L_{eq}) and the Day-Night Sound Level (L_{dn}). Potential sleep disturbances are computed using the Sound Exposure Level (L_s) of the individual event as the primary measure of noise impact. Speech interference is calculated using the L_{eq} over the duration of the individual noise event, while risk to hearing damage is examined using an L_{eq} measured over 24 hours. A brief description of these three noise metrics follows.

Equivalent Sound Level, L_{eq}

This analysis uses a noise measure that condenses the physical acoustic properties that are characteristic of a given noise environment into a simple indicator of the quality and quantity of noise. This general measure for environmental noise is the equivalent A-weighted sound level (L_{eq}) expressed in decibels (Reference 1). It correlates quite well with the overall long-term effects of environmental noise on public health and welfare.

The basic definition of L_{eq} is:

$$L_{eq} = 10 \log_{10} \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{p^2 (t)}{p_o{}^2} .dt \qquad (1)$$

where (t_2-t_1) is the interval of time over which the levels are evaluated, p(t) is the time-varying magnitude of the sound pressure, and p_o is a reference pressure standardized at 20 micropascals. When expressed in terms of A-weighted sound level, L_A, the equivalent A-weighted sound level, L_{eq}, is defined as:

$$L_{eq} = 10 \log_{10} \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} 10^{[L_A(t)/10]} .dt \qquad (2)$$

When associated with a specific short-time interval, (t_2-t_1), or T, the L_{eq} (T) represents the energy-averaged sound level over that interval of time. Commonly used time intervals are 24-hour, 8-hour, 1-hour, day and night, symbolized as $L_{eq\ (24)}$, $L_{eq\ (8)}$, $L_{eq\ (1)}$, L_d and L_n, respectively.

Day-Night Sound Level, L_{dn}

In describing the impact of noise on people, a measure called the day-night sound level (L_{dn}) is used. This is a 24-hour measure with a weighting applied to nighttime noise levels to account for the increased sensitivity of people to noise intruding at night. The L_{dn} is defined as the equivalent noise level during a 24-hour period, with a 10 dB weighting applied to the equivalent noise level during the nighttime hours of 10 p.m. to 7 a.m. The basic definition of L_{dn} in terms of the A-weighted sound level is:

$$L_{dn} = 10 \log_{10}\left[\frac{1}{24}\left(\int_{0700}^{2200} 10^{L_A(t)/10}\, dt + \int_{2200}^{0700} 10^{[L_A(t)+10]/10}\, dt\right)\right] \quad (3)$$

When values for average or equivalent sound levels during the daytime or nighttime hours (L_d and L_n, respectively) are given, L_{dn} may be expressed as:

$$L_{dn} = 10 \log_{10}\left[\frac{1}{24}\left(15 \times 10^{L_d/10} + 9 \times 10^{(L_n + 10)/10}\right)\right] \quad (4)$$

where L_d is the "daytime" equivalent level obtained between 7 a.m. and 10 p.m., and L_n is the "nighttime" equivalent level obtained between 10 p.m. and 7 a.m.

Sound Exposure Level, L_s

Most of the criteria which relate noise exposure to adverse human impact deals with people's exposure to noise over time rather than to discrete noise events. Specification of the noise environment in terms of day-night sound level is adequate for pervasive, long-term type noises, such as general traffic noise or aircraft noise. However, such measures may not be fully descriptive of the impact of the noise from single, isolated occurrences, such as a bus passing by. In this case, a single noise event may contribute an insignificant amount to the total environmental noise, yet be of significant adverse impact. Some effects of noise on people have been quantified in terms of sound level (such as L_{eq}) over a particular duration. Others have been quantified by a simple metric which measures total sound energy over the duration of the event, the Sound Exposure Level (L_s). The sound exposure level is the integral of the mean square weighted sound pressure received at a specified distance during a single occurrence of a noise-producing event. The sound exposure level is defined as:

$$L_s = 10 \log_{10} \int_0^T \frac{p^2(t)}{p_0^2} .dt \qquad (5)$$

where p(t) is the A-weighted sound pressure at time t, p_0 is the reference pressure (20 micropascals), and T is the duration of the noise event. For a typical bus passby, the approximation to the sound exposure level is:

$$L_s = L_{max} + 10 \log_{10} (T/3.5) \qquad (6)$$

where T is the time in seconds over which the sound is present, and L_{max} is the maximum A-weighted sound level of the event (see Appendix D for a more detailed description of the time history approximation.)

FRACTIONAL IMPACT METHOD: See Appendix C

HEALTH AND WELFARE CRITERIA - GENERAL ADVERSE RESPONSE

To project the potential benefits of reducing the noise from buses, it is necessary to describe statistically the noise-exposed population (on a national basis) both before and after implementation of the regulation. This statistical description characterizes the noise exposure distribution of the population by estimating the number of people exposed to different magnitudes of noise as defined by metrics such as day-night sound level. This is conceptually illustrated in Figure C-1 of Appendix C, which compares the estimated distribution of the noise exposed population before and after implementation of a hypothetical regulation. This type of approach provides a basis for evaluating the change in noise impact due to a given regulatory action.

It is also necessary to distinguish, in a quantitative manner, between the differing magnitudes of impact upon different individuals exposed to different values of L_{dn}. That is, the magnitude of human response to noise generally increases progressively from an identified "no response" threshold to some extreme maximum projected impact -- the greater the exposure, the more extreme the response. Hence, once the identified level is exceeded, the degree of human response associated with the noise will increase with increased noise exposure.

To assess the impact of traffic noise using the fractional impact procedure, one needs a relation between the changes in traffic noise and the responses of the people exposed to the noise. There exists some variability in human response measures due to a number of social and demographic factors. In the aggregate, however, for residential locations, the average response of groups of people is related quite well to cumulative noise exposure as expressed in a measure such as L_{dn}. For example, the different forms of response to noise such as hearing damage, speech or other activity interference, and annoyance were related to L_{eq} or L_{dn} in the EPA Levels Document (Reference 1). For the purposes of this part of the study, criteria based on L_{dn} presented in the EPA Levels Document are used. Furthermore, it is assumed for this analysis that if the outdoor level of L_{dn} is less than or equal to 55 dB, which is identified in the EPA Levels Document as requisite to protect the public health and welfare, no adverse impact in terms of general annoyance and community response exists.

The community reaction data presented in Appendix D of the EPA Levels Document (Reference 1) show that the expected reaction to an identifiable source of intruding noise changes from "none" to "vigorous" when the day-night sound level increases from 5 dB below the level existing without the presence of the intruding noise to about 20 dB above the level before intrusion. For this reason, a level of 20 dB above L_{dn} = 55 dB is considered to result in a vigorous reaction by the people exposed. At this level (L_{dn} = 75 dB), the percentage of the population which is "highly annoyed" by noise would be approximately 40 percent of the total exposed population. The data in the EPA Levels Document suggest that for environmental noise levels which are intermediate between 0 and 20 dB above L_{dn} = 55 dB, the impact varies linearly. That is, a 5 dB increase (L_{dn} = 60 dB) constitutes a 25 percent impact, and 10 dB increase (L_{dn} = 65 dB) constitutes a 50 percent impact, with a 20 dB increase representing maximum impact.

For convenience of calculation, a function for weighting the magnitude of noise impact with respect to general adverse reaction (annoyance) has been used (Figure 6-2). This function, normalized to unity at L_{dn} = 75 dB (a point of maximum expected impact for most communities), may be expressed as representing percentages of impact in accordance with the following equation (see Appendix C):

$$W(L_{dn}) = \begin{cases} 0.05\,(L_{dn} - C) & \text{for } L_{dn} \geq C \\ 0 & \text{for } L_{dn} < C \end{cases} \tag{7}$$

where $W(L_{dn})$ is the weighting function for general adverse response, L_{dn} is the measured or calculated commmunity noise level, and C is the identified

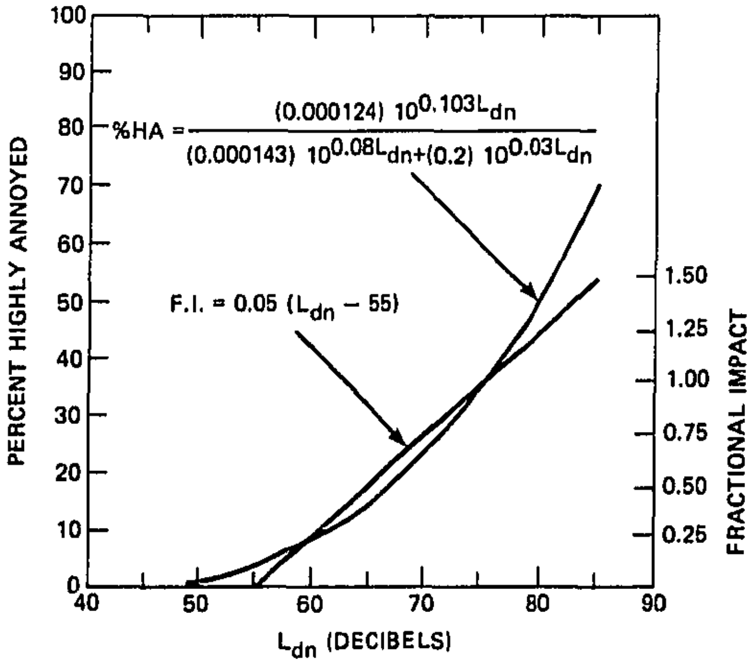


FIGURE 6-2 COMPARISON OF CURVILINEAR FUNCTION AND FRACTIONAL IMPACT LINEAR FUNCTION

threshold below which the public is not considered at risk (L_{dn} = 55 dB). Note that the weighting function for general adverse response can exceed unity at levels greater than L_{dn} = 75 dB.

A recent compilation (References 9 and 25) of 18 social surveys from 9 countries shows, in fact, that the response curve relating "percent highly annoyed" to the noise measured around respondents' homes is best represented by a curvilinear function. However, it has also been shown that the single linear function can be used with good accuracy in cases where day-night sound levels range between L_{dn} values of 55 dB to 80 dB (Figure 6-2).

By using the derived relationship between community noise exposure and general adverse response (Equation 7), the Level Weighted Population (LWP)* associated with a given level of traffic noise (L^{i}_{dn}) may be obtained (Reference 9). The procedure involves multiplying the number of people exposed to that level of traffic noise by the relative weighting associated with this level as follows:

$$LWP_i = W(L^{i}_{dn}) \times P_i \qquad (8)$$

where LWP_i is the magnitude of the impact on the population exposed to traffic noise L^{i}_{dn} and is numerically equal to the number of people who would all have a fractional impact equal to unity (100 percent impacted). $W(L^{i}_{dn})$ is the weighting associated with an equivalent traffic noise level of L^{i}_{dn} (from equation 7), and P_i is the population exposed to that level of traffic noise. To illustrate this concept, if there are 1000 people

* The procedures for deriving LWP were developed by the Committee on Hearing, Bioacoustics and Biomechanics of the National Academy of Sciences. Other terms such as Equivalent Population (Peq) and Equivalent Noise Impact (ENI) have been used interchangeably with LWP.

living in an area where the noise level exceeds the criterion level by 5 dB (and thus are considered to be 25 percent impacted, $W(L_{dn}) = 0.25$), the environmental noise impact for this group is the same as the impact on 250 people who are 100 percent impacted (1000 x 25% = 250 x 100%). A conceptual example is portrayed in Figure 6-3.

When the total impact associated with traffic noise is assessed, the observed levels of noise generally decrease as the distance between the source and receiver increases. The magnitude of the total impact may be computed by determining the partial impact at each level and summing over each of the levels. The total impact is given in terms of Level Weighted Population by the following formula:

$$LWP = \sum_i LWP_i = \sum_i [W(L^i_{dn}) \times P_i] \qquad (9)$$

where $W(L^i_{dn})$ is the fractional weighting associated with L^i_{dn}, and P_i is the population exposed at each L^i_{dn}.

The change in impact associated with regulations on the noise emissions from traffic vehicles may be assessed by comparing the magnitude of the impacts with and without regulations in terms of the Relative Change in Impact (RCI), which is calculated from the following expression:

$$RCI = 100 \times \frac{[LWP\ (before) - LWP\ (after)]}{LWP\ (before)} \qquad (10)$$

This basic fractional impact procedure is also used to compute noise impact employing a variety of additional criteria (e.g., activity interference, hearing damage risk, etc.) other than general adverse response (Reference 26).

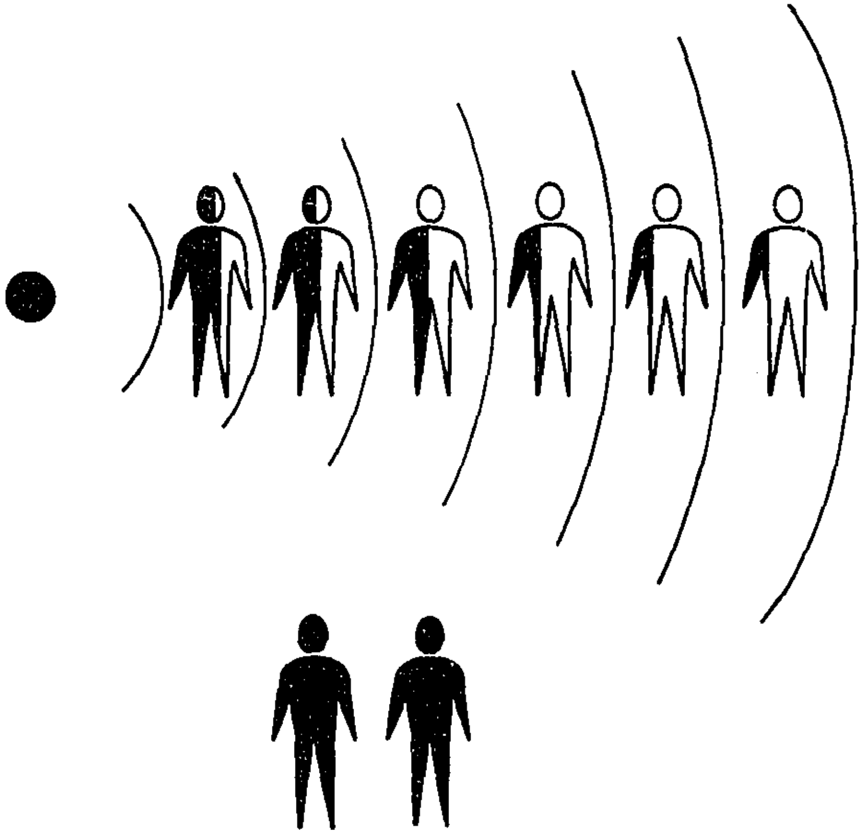


FIGURE 6-3 EXAMPLE OF FRACTIONAL IMPACT METHODOLOGY

THE COMPUTATION OF LWP ALLOWS ONE TO COMBINE THE NUMBER OF PEOPLE JEOPARDIZED BY NOISE ABOVE AN L_{dn} OF 55 dB WITH THE DEGREE OF IMPACT AT DIFFERENT NOISE LEVELS. THE CIRCLE IS A SOURCE WHICH EMITS NOISE TO A POPULATED AREA. THE VARIOUS PARTIAL AMOUNTS OF SHADING REPRESENT VARIOUS DEGREES OF PARTIAL IMPACT BY THE NOISE. THE PARTIAL IMPACTS ARE SUMMED TO GIVE THE LWP. IN THIS EXAMPLE, SIX PEOPLE WHO ARE ADVERSELY AFFECTED BY THE NOISE (PARTIALLY SHADED) RESULTS IN A LEVEL WEIGHTED POPULATION (LWP) OF TWO (TOTALLY SHADED).

As discussed previously, the concept of fractional impact, expressed in units of LWP, is most useful for describing relative changes in impact from a specified baseline for the purpose of comparing benefits of alternative regulatory schedules. In order to assess the absolute impact or benefits corresponding to any regulatory schedule, one must have information on the distribution of population as a function of noise environment. The derivation of this type of information is discussed in the following subsections entitled "EXTERIOR NOISE PREDICTION MODEL" and "INTERIOR NOISE PREDICTION MODEL."

HEALTH AND WELFARE CRITERIA - SINGLE EVENT RESPONSE

When the benefits of lessening the noise from buses are being examined, it is important to look beyond the contribution that buses make to overall average day-night traffic noise (L_{dn}). The impact contributions which are calculated in terms of average community response are somewhat generalized and do not necessarily represent specific impact situations. On some occasions, noise associated with buses will combine with other noises, as described by the General Adverse Response analysis. At other times or in other situations, one can expect that other noise sources will not be significant, and thus each bus passby will cause a distinct impact. The actual impact from buses is certainly due to a combination of various levels of bus noise and other environmental noise. Thus, the preceding criterion for general adverse response will not take into account the fact that almost the entire amount of daily acoustical energy contributed by buses in an area may be generated by only a few minutes of noise during many accelerations near a bus stop in the course of a day. Yet these intrusive, short, intense events may be some of the most annoying noise-related situations faced over the entire day by a large number of pedestrians, residents, or people waiting near a bus stop. Admittedly, such annoyance is a difficult reaction to measure. It may pass rapidly and the actual cause remain unnoticed. Or it may add to other agents causing stress and lead to physiological problems (References 5 and 11).

A loud, short-duration vehicle passby may also interrupt people's activities, such as conversation, sleeping, TV viewing, reading etc. In a study of the annoyance caused by different levels of simulated aircraft noise for people seated indoors watching television, annoyance was found to be dependent, at least in part, by speech interference (Reference 12). Not only is the TV program, or other person speaking, more difficult to hear during the time in which a noisy event is taking place, but it has been observed that the distraction which may occur from the conversation in which the person is engaged may contribute in itself to annoyance (References 12 and 32). The speaker may attempt to cope with the noise intrusion behaviorally, either by increasing his or her vocal effort, or in more severe cases, by discontinuing conversation altogether. Such behavioral reactions may be indicative of general annoyance and disturbance with the intrusive noise event.

Although interruptions of people's activities will lead to annoyance, such disturbances may also represent a degradation of health and welfare. For example, the reaction to a noise intrusion during sleep is, in many cases, a change in sleep stage (from a "deeper" to a "lighter" stage) or, if the intrusive noise is intense or of prolonged duration, an actual awakening may result. In either case, repeated disturbance of people's sleep can be expected to adversely affect health and well-being (References 27 and 28).

Several investigations have shown that expressed annoyance with noise correlates well with interference of activities due to noise (References 1, 7, 20, 21, 29, 30, 31). One survey found that reports of interferences with sleep and speech communication correlate more highly with feelings of generalized annoyance than with any other factor, including actual sound levels measured outdoors (Reference 27).

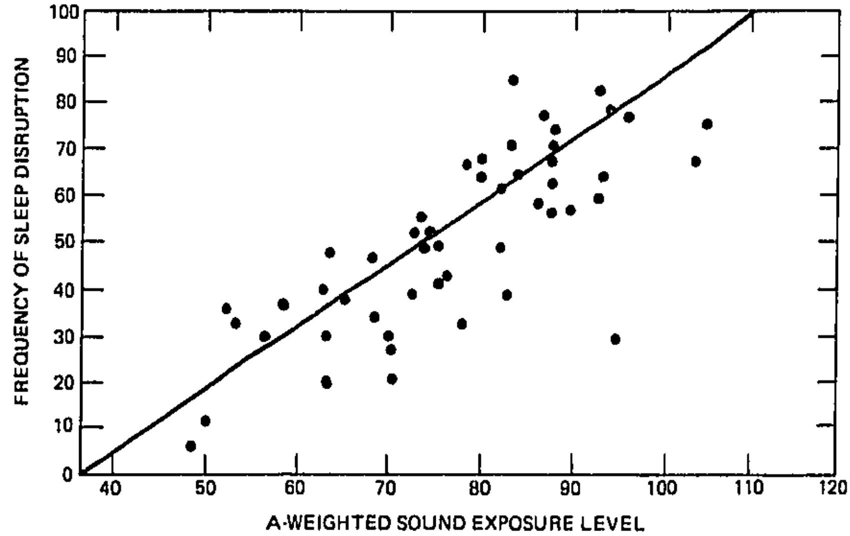
For these reasons, the analysis of vehicle passby impacts were examined in some detail to assess the significance of potential individual event exposures upon human activities (References 33 and 34), in particular, the activities of speech communication and sleep. The analysis was undertaken to determine both the direct effect bus noise may have on these activities, and to estimate the total potential annoyance attributable to bus noise. These single event noise intrusions are particularly important in overall assessment of the adverse effects of bus noise on public health and welfare.

Sleep Disturbance

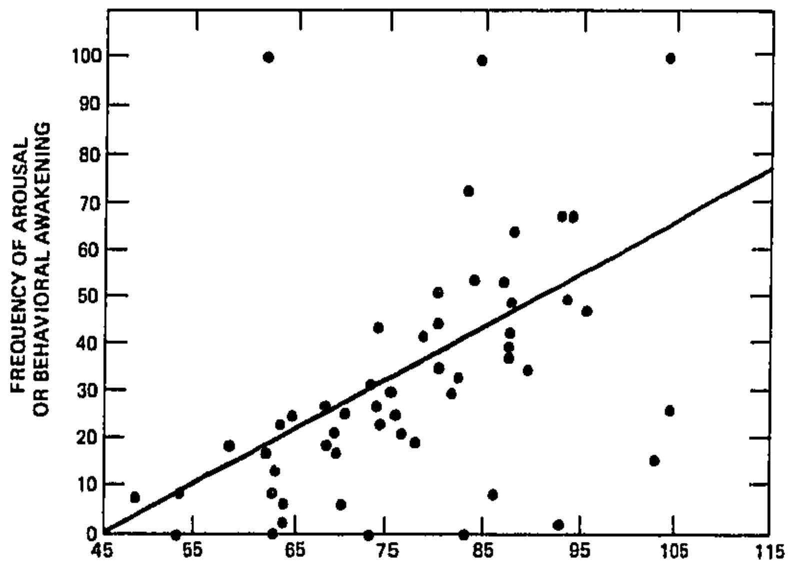
The sleep periods of humans are typically classified into five stages. In Stages I and II, sleep is light and the sleeper is easily awakened. Stages III and IV are states of deep sleep where a person is not as easily awakened by a given noise, but the sleep may shift to a lighter stage. An additional stage, termed rapid eye movement (REM), corresponds to the dream state. When exposed to an intrusive noise, a sleeper may (1) show response by a brief change in brainwave pattern, without shifting sleep stages; (2) shift to a lighter sleep stage; or (3) awaken. The greatest known impact occurs due to awakening, but there are also indications that disruption of the sleep cycle can cause impact (irritability, etc.) even though the sleeper may not awaken (Reference 11).

A recent study (References 13 and 14) has summarized and analyzed sleep disturbance data as gathered under experimental laboratory conditions. This study demonstrated a relationship between frequency of response (disturbance or awakening) and noise level, and further demonstrated that the duration of the noise stimulus was a critical parameter in predicting response. The study also showed that the frequency of sleep disruption is predicted by noise exposure better than is arousal or behavioral awakening. An important fact is that sleep disturbance is defined as any physiological change which occurs as a result of a stimulus. The person undergoing such disturbance may be completely unaware of being afflicted; however, the disturbance may adversely affect total sleep quality. This effect on overall sleep quality may lead to, in certain situations, undesirable behavioral or physiological consequences (Reference 11).

Data relating to the anticipated disruption of sleep caused by noise is shown in Figure 6-4 (top). These data illustrate the frequency of sleep disturbance (as measured by changes in sleep state, including behavioral awakening) as a function of the sound exposure level (L_S) of the intruding noise. The frequency of behavioral awakening as a function of sound exposure level is also shown in Figure 6-4 (bottom). These relationships, adapted from Figures 1 and 2 of Reference 13, consist of data derived from a review of most of the recent experimental data on sleep and noise relationships. These relationships show the approximate degree of expected impact (percent disruption or awakening) at given levels of noise. For example, in Figure 6-4, an indoor sound exposure level of 60 dB would be expected to result in a 31



PROBABILITY OF A NOISE INDUCED SLEEP STAGE CHANGE



PROBABILITY OF A NOISE INDUCED AWAKENING

FIGURE 6-4 WEIGHTING FUNCTIONS FOR NOISE INDUCED SLEEP DISRUPTION AND SLEEP AWAKENING

ADAPTED FROM REFERENCE 13

percent probability of a sleep disruption (change in depth of sleep). The probability of being awakened is less than that of being disturbed. For this example of a sound exposure level of 60 dB, the probability of being awakened is 17 percent (see Figure 6-4).

Note also that the noise data contained in the references cited were measured in terms of "effective perceived noise level" with a reference duration of 0.5 seconds, L_{EPN} (0.5 sec.). This level was converted to L_s by the following approximate relationship*:

$$L_s = L_{EPN} \text{ (0.5 sec.)} - 16 \text{ dB} \tag{11}$$

The impact weighting function scale for both disturbance and awakening is defined such that a probability of 100 percent disturbance or awakening has a Fractional Impact or weighting of 1.0, and a probability of zero percent has a weighting of zero. The Level Weighted Population for sleep disturbance and awakening was derived for each of the regulatory schedules and study years under investigation by using Equations 8 and 9, substituting $W(L_s)$ for $W(L_{dn})$. The impact weighting function for these two situations is calculated by using the following regression equations (from Figure 6-4):

$$W(L_s) = 0.0135 (L_s - 37) \text{ for sleep disturbance, and} \tag{12}$$

$$W(L_s) = 0.0110 (L_s - 45) \text{ for sleep awakening.} \tag{13}$$

---

* This equation accounts for the average difference of 13 dB between Perceived Noise Level and A-weighted sound level, and the 3 dB that results from the change in reference time from 0.5 seconds, used in Reference 13, to 1 second, used in sound exposure level.

Speech Interference

As is the case with sleep disruption, speech interference occurs as a result of individual noise events. The potential for speech interference (i.e., the interruption of conversation) due to bus noise occurs when externally-propagating noise exceeds certain levels. However, unlike sleep disruption, the impact of noise on speech interference is not cumulative. That is, the duration of the noise event causing speech interference does not affect the kind of interference, although it does, of course, affect the duration of the interference. This is in contrast to sleep disturbance, where the cumulative effect of noise can change the impact from one of sleep disturbance to actual sleep awakening. Therefore, the appropriate noise metric for measuring speech interference potential is an L_{eq} occurring for the duration of the event, rather than a sound exposure level which specifically considers the effect of the duration on the event.

Also, unlike sleep disruption, interference of speech may occur when people are either indoors or outdoors. The degree of speech interference from noise is dependent on the particular circumstances involved. Noise level and duration, separation distance of the conversers, and vocal effort are all factors that influence speech intelligibility (Reference 1). The criteria showing degrees of outdoor and indoor speech interference from noise are shown in Figures 6-5 and 6-6, respectively (Reference 1).

It should be recognized that the analysis does not assume that everyone is talking all the time. The procedure instead assesses a potential for speech interference and associated annoyance. Also, the relationships displayed in Figures 6-5 and 6-6 pertain to sentences known to listeners. All listeners are further assumed to have normal hearing. Under everyday

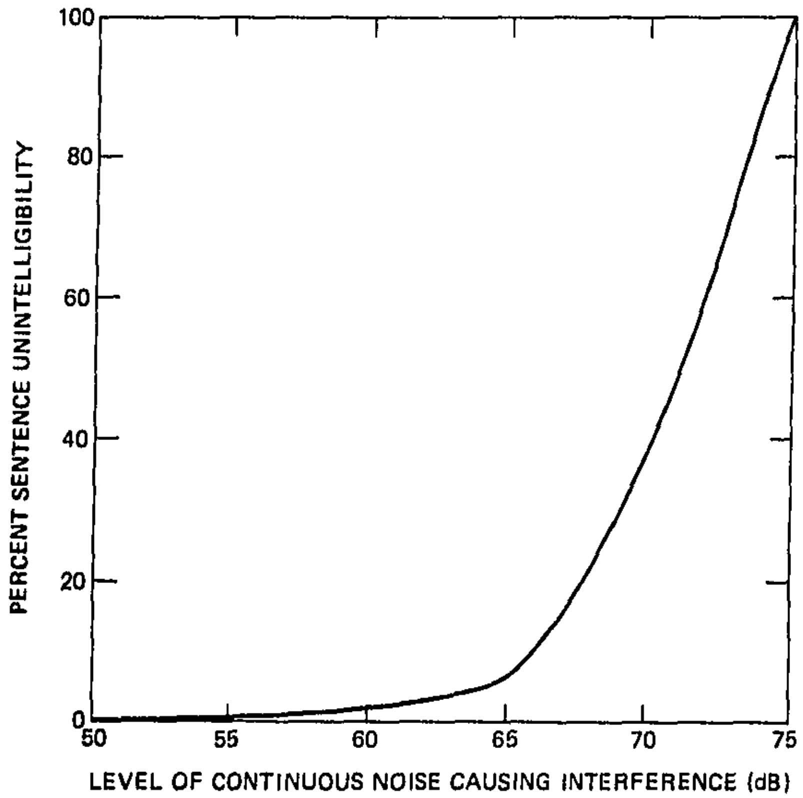


FIGURE 6-5 WEIGHTING FUNCTION FOR INDOOR SPEECH INTERFERENCE (RELAXED CONVERSATION AT GREATER THAN 1 METER SEPARATION, 45 dB BACKGROUND IN THE ABSENCE OF INTERFERING NOISE)

FROM REFERENCE 1

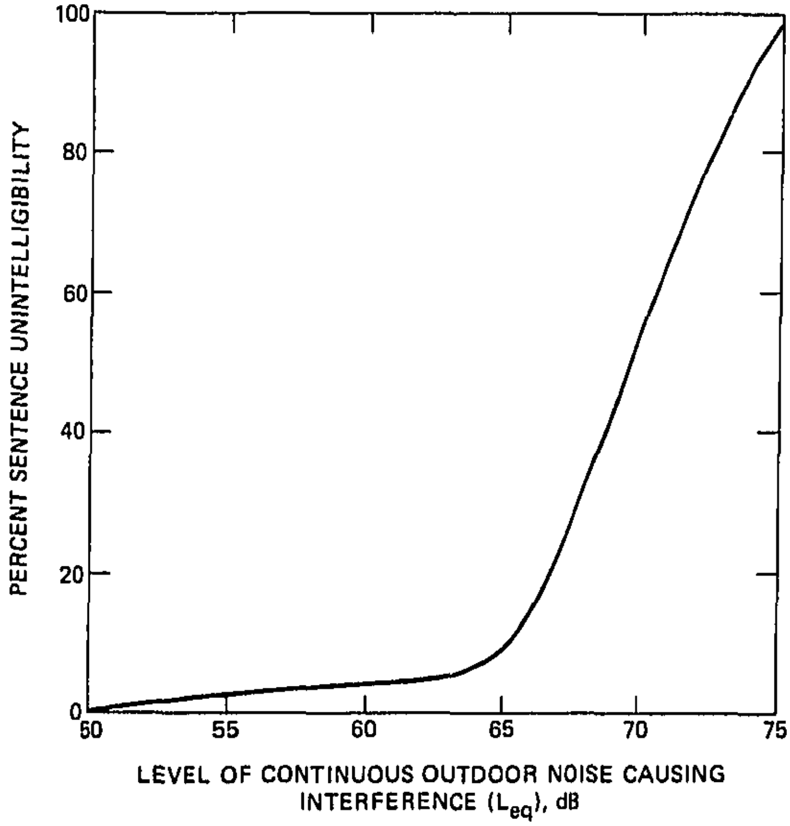


FIGURE 6-6 WEIGHTING FUNCTION FOR OUTDOOR SPEECH INTERFERENCE (NORMAL VOICE AT 2 METERS)

environmental conditions, it would be expected that communication intelligibility would be somewhat less than that portrayed in Figures 6-5 and 6-6. For those people suffering some hearing loss, background noise levels need to be up to 10 dB lower to attain the same degree of intelligibility (Reference 35).

People can have their conversations disrupted by externally propagated bus noise in at least three major settings during the day: as pedestrians on the street, as residents inside their homes, or as residents who are involved in activities just outside their homes. Three different approaches are required to assess the impact of these three different situations. Each approach will be examined separately. In the discussions that follow, "inside the home" and "outside the home" should be taken to mean, respectively, "inside any building" and "outside any building, but not along the street."

Indoor Speech Interference

Indoor speech interference is assumed to occur when bus noise propagates through walls of residences or buildings and peaks above a typical indoor background level of 45 dB. The criteria of impact for indoor speech interference is given in Figure 6-5. The curve is based on the reduction of sentence intelligibility (sentences known to listeners) relative to the intelligibility which wou[illegible] occur at 45 dB. For people conversing indoors during the time of a vehicle passby, Figure 6-5 shows the probability of a disruption in communication. The appropriate metric in Figure 6-5 is the equivalent sound level over the duration of the event. The Level Weighted Population for indoor speech interference is obtained by using equations 8 and 9, substituting $W(L_{eq(T)})$ for $W(L_{dn})$, and letting P_i represent the number of people exposed at each indoor sound level for each passby.

Outdoor Speech Interference

The population exposed to potential outdoor speech communication interference are those people who are outside of their homes but not along a street. This analysis does not take into account pedestrians or people engaged in other forms of transportation during the day. Rather, it is intended to include those time-periods in which people are relaxing or engaged in other activities outdoors.

Outdoor speech interference due to the operation of buses occurs when the maximum noise level of the pass-by exceeds an outdoor background level of 50 dB. Since the outdoor urban ambient noise (L_{dn}) in many areas may be greater than L_{dn} = 50 dB, a background level for use in this analysis of 55 dB is not inappropriate on a national basis. Such a level reflects desires of States and municipalities for a quieter environment and assumes that ambient levels will, in the future, be lowered by coordinated Federal, State and local efforts to reduce noise.

The criterion for outdoor speech interference is shown in Figure 6-6 as a function of the level of an interfering noise. Note that the appropriate noise metric against which percent speech interference (unintelligibility of sentences known to listeners) is plotted is an equivalent sound level over the duration of the pass-by. The Level Weighted Population for outdoor speech interference may be computed by using Figure 6-6 and equations 8 and 9.

Pedestrian Speech Interference

Speech communication may be especially difficult for pedestrians who are nearby roadway traffic. This is because pedestrians are typically located very close to the vehicles as they travel by. Pedestrian speech interference is calculated by considering a percentage of the population to be pedestrians located at the edge of clear zones associated with each roadway. Figure 6-6 and equations 8 and 9 are then used to evaluate the speech interference impact upon pedestrians.

Again, it should be noted that the single event noise analysis examines the effects of bus noise alone, and hence does not take into account the presence of other noise sources in the environment. It is obvious that other environmental noise sources create background noise at such levels in certain situations that bus noise may be masked. This analysis only represents the benefits accrued during those times when bus noise clearly intrudes over the ambient or background noise level. The overall absolute impact upon activities is, of course, dependent on the background level assumed. However, the calculated benefits are representative of the relative reduction in impact of exterior bus noise over any given ambient noise level.

HEALTH AND WELFARE CRITERIA - INTERIOR VEHICLE NOISE

Interior bus noise affects primarily two population groups, bus drivers and bus passengers. Transit and intercity bus drivers tend to spend more time each day driving their buses than school bus drivers since school transportation is usually only required during the opening and closing hours of school. Typical passenger exposure times are also different for each bus type. Intercity passengers tend to take infrequent but long trips, whereas short but recurrent trips are characteristic of transit and school bus passengers. Two kinds of impact may be associated with interior bus noise: risk of hearing damage for bus drivers and passengers, and the interference with conversations of bus passengers. The health and welfare criteria for determining the impact of noise on hearing is discussed in the following two subsections. To provide a quantitative measure of these impacts and to evaluate the relative changes in impact resulting from the different interior noise regulatory schedules presented in Table 6-1, analyses of both kinds of impact were undertaken. A detailed description of the methodology used in the development of these models and the results of the noise impact analyses are presented in later subsections of this chapter.

Noise-Induced Hearing Damage

Noise can cause damage to the inner ear, resulting in permanent hearing loss that may range from mild to severe, depending upon the level and duration of exposure. Dose-response relationships for 8-hour occupational exposures to noise have been well quantified with respect to hearing loss. We can estimate fairly accurately how much hearing loss will occur in what proportion of the population from various exposures to noise. Consequently, EPA has identified a safe level of 70 dB (A-weighted) to protect even the most susceptible people against small amounts of hearing loss (Reference 1). This is a 24-hour energy average level (L_{eq}) that can be experienced over a period of approximately 40 years with virtually no likelihood of hearing loss.

Observations in animals as well as in man show that noise reaching the inner ear directly attacks the hair cells of the hearing organ. As the intensity of the noise and the time to which the ear is exposed are increased, a greater proportion of hair cells are damaged or eventually destroyed. In general, progressive loss of hair cells is inevitable, accompanied by a progressive loss of hearing as measured audiometrically.

There is a great deal of individual variation in susceptibility to noise related hearing damage. However, any person exposed to noise of sufficient intensity is, in the long run, likely to suffer some degree of noise-induced hearing loss that is permanent and, so far as is presently known, irreversible.

Temporary hearing loss attributable to fatigue of the inner ear lasting from a few seconds to a few days can occur after brief exposure to high sound levels or from day-long exposure to more moderate levels of noise. The fact that this loss of hearing largely disappears within a short time tends to mislead people into believing that no permanent damage has been done by the noise. Permanent hearing loss is usually preceded by, and may be accompanied by, temporary hearing loss. Neither the subjective loudness of a noise, nor the extent to which the noise causes discomfort, annoyance, or interference with human activity, are reliable indicators of its potential danger to human hearing.

The typical pattern of permanent hearing loss occurs initially in hearing ability in the range of 4000 to 6000 Hz, and tends to worsen rather rapidly during the first 10 to 15 years of noise exposure. By contrast, hearing level sensitivity at the lower frequencies initially decrease more slowly, but continues to decrease in an essentially linear manner over exposure up to 40 years. Thus, noise-induced auditory deterioration takes place rapidly and mainly in the first 10 to 15 years of exposure, with, however, further deterioration in later years at the lower frequencies.

Hearing risk in terms of noise-induced permanent hearing loss is summarized in Table C-1 of Reference 1. In this analysis, Noise-Induced

Permanent Threshold Shift (NIPTS) is computed as the statistical average anticipated change in threshold, averaged over a 40-year period for the average of the frequencies 500, 1000, 2000, and 4000 Hz. The relationship between daily noise exposure and hearing threshold shift averaged over the four frequencies is shown in Figure 6-7. This is the amount of hearing loss suffered beyond the change which will occur due to the normal aging process. The value of NIPTS is approximately equal to the median degree of hearing loss suffered after 20 years of exposure.

Using the fractional impact procedure discussed in Appendix C, benefits derived from noise reductions may be quantified by calculating a Level Weighted Population for Hearing (LWP_H) (Reference 9). The weighting function used, shown in Figure 6-7, is based on a nonlinear relationship between hearing loss and occupational (8 hour) exposure to A-weighted equivalent sound levels ($L_{eq(8)}$) above 75 dB. The weighting function representing the four frequency average NIPTS is defined as (Reference 9):

$$W\ (L_{eq(8)}) = 0.025\ (L_{eq(8)} - 75)^2 \qquad (14)$$

Equivalently, over a 24-hour exposure,

$$W\ (L_{eq(24)}) = 0.025\ (L_{eq(24)} - 70)^2 \qquad (15)$$

This equation closely approximates the relationship between average noise-induced permanent threshold shift and daily average sound exposure.

LWP_H may then be computed from the weighting factors using equations 8 and 9 as appropriate, substituting $W(L_{eq(8)})$ or $W(L_{eq(24)})$ for $W(L_{dn})$.

As an example, a person exposed to $L_{eq(24)}$ = 75 dB over 40 years would be expected to lose a little less than 1 dB in hearing sensitivity

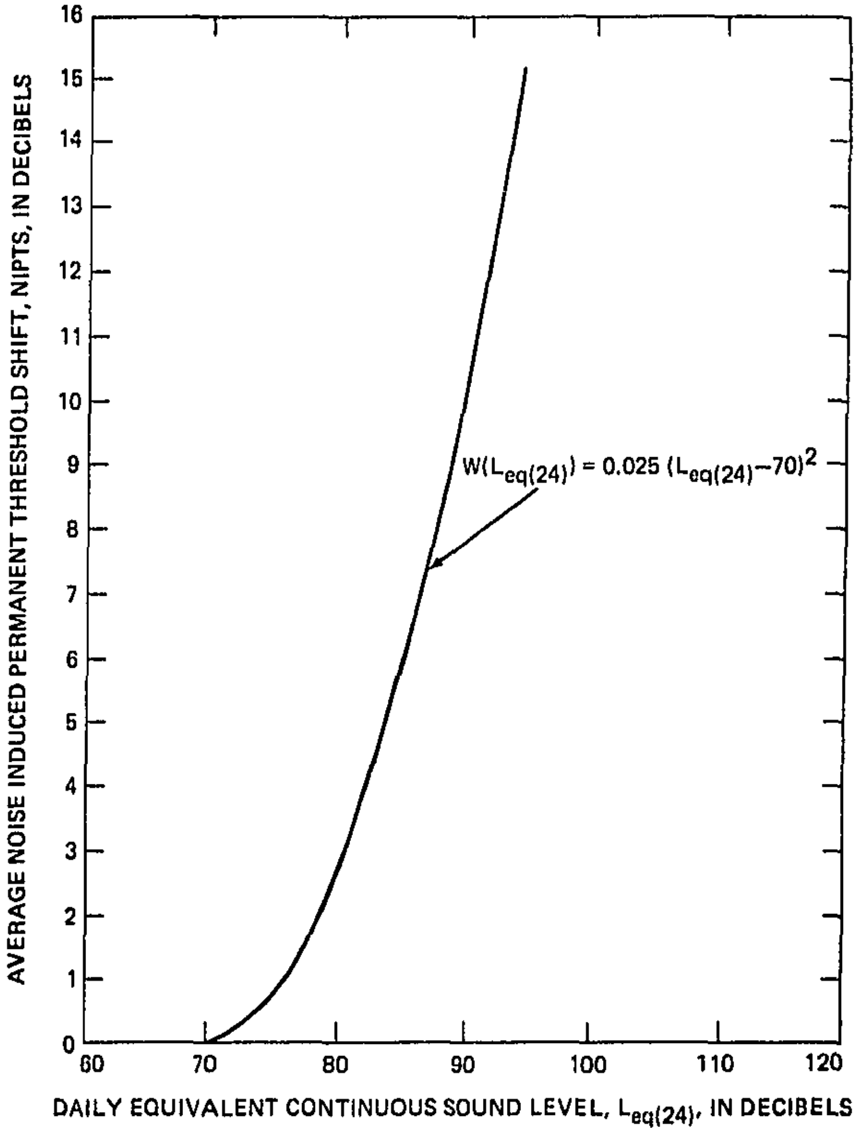


FIGURE 6-7 AVERAGE NIPTS AS A FUNCTION OF DAILY EQUIVALENT CONTINUO SOUND LEVEL

beyond that from normal aging averaged over the 40 year period. At an $L_{eq\ (24)}$ of 80 dB, this would translate into a 2.5 dB loss averaged over that time period.

Speech Communication

Interior bus noise may have an additional impact on people which must be considered - interference with conversational speech. Passenger conversations may be interrupted or a few words may be missed due to high interior bus noise levels. Moreover, passenger acceptance of interior vehicular noise is dependent upon the degree to which passengers are engaged or listening to speech communication (Reference 36)*. Further, the interruption of speech between passengers and the driver during an emergency situation could conceivably have critical implications. A school bus driver, for example, should be able to hear a child in need in the presence of typical child-generated noise on school buses.

EPA has identified 72 dB as the intruding A-weighted sound level at which a conversation at 0.5 meters with normal voice projection is considered to be satisfactorily intelligible (95 percent sentence intelligibility) in steady state noise (Reference 1). Thus, speech intelligibility criteria for this

*It has been suggested that the masking of speech between passengers not conversing with one another is a benefit of bus noise. Passengers are often reluctant to have their conversation overheard by others, and in cases where the bus level is quite low, they may compensate by lowering their voices unnaturally or by not talking at all due to the lack of privacy. While this argument may be somewhat valid, it cannot take precedence over a program to reduce the impact of interior bus noise on hearing or speech communication efficiency.

analysis is based on a speaker-to-listener separation distance of 0.5 meters (Reference 37).

Outdoor speech criteria rather than indoor speech criteria are used in this analysis to estimate the impact of speech disturbance inside buses. This is because the background level assumed for the estimation of outdoor speech disturbance is closer to the background level actually experienced by bus passengers. A typical outdoor equivalent sound level in many urban areas is 60 dB (Reference 38), which is the background level assumed in the outdoor speech disruption criteria, and is considered comparable to actual background levels inside buses: The indoor criteria uses 45 dB as a background level. Further, the setting inside a bus is not the typically relaxed environment one experiences indoors.

Based on data presented in Reference 1, a relationship between sentence intelligibility and average level of intruding sound was developed. This relationship is then used to assess the potential disruption of verbal communications upon passengers and drivers resulting from interior bus noise.

The potential disruption of speech is measured in terms of percentage of interference with sentence intelligibility of sentences known to listeners. This is depicted in Figure 6-8 which shows the approximate relationship between percentage speech intelligibility at 0.5 meters and average A-weighted sound level. Note that this is the same relationship illustrated in Figure 6-6 with the abscissa shifted by 12 dB, assuming 6 dB attenuation for each doubling of distance to account for the presumed conversational distance of 0.5 meters. Under everyday conditions it would be expected that communication

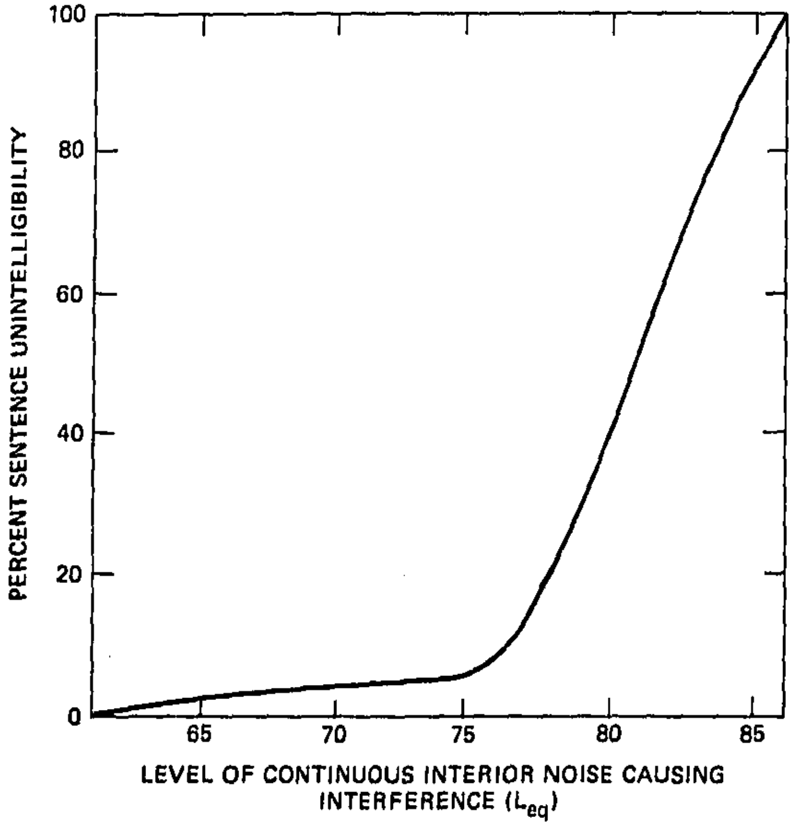


FIGURE 6-8 WEIGHTING FUNCTION FOR INTERIOR SPEECH INTERFERENCE (NORMAL VOICE AT 0.5 METERS)

ADAPTED FROM FIGURE 6-6

intelligibility would be less than that portrayed in Figure 6-8. The Level Weighted Population for interior speech interference is then determined by using equations 8 and 9, substituting the weighting value from Figure 6-8, and letting P_i represent the number of people exposed inside of buses at each sound level.

EXTERIOR NOISE PREDICTION MODEL

In this analysis, we will refer to noise effects which potentially impact people living on or near bus routes as "exterior" effects -- exterior to the bus itself--to distinguish these effects and this segment of the population from the effects of noise on drivers or passengers riding within the bus. "Exterior" effects encompass annoyance and task interference within and outside the home, and includes speaking, listening, or sleeping. Again, it should be noted that task interference at home becomes apparent when residents express high annoyance of a particular source of noise, or of noise in general.

The exterior prediction model used in this health and welfare analysis is titled, "The National Roadway Traffic Noise Exposure Model." This predictive model is a more sophisicated version of the original health and welfare model presented in the "Proposed Bus Noise Emission Regulation: Part 2, Background Document". The National Roadway Traffic Noise Exposure Model was recently developed under EPA sponsorship, for the purpose of more accurately estimating nationwide traffic noise impact. Its documentation is contained in a single volume report (Reference 42) available from the Office of Noise Abatement and Control, U.S. Environmental Protection Agency. Reference 42 explains the methodology used by the computer model. The data presented in reference 42 does not necessarily represent the updated data gathered for the bus study. The computer program itself is also available from EPA.

In this subsection we present an overview of the National Roadway Traffic Noise Exposure Model. Details of the model are presented in Appendix D, though not to the same detail as in the documentation report (Reference 42). Appendix D contains information on the data, the calculations, and the assumptions that underlie the model. Particular attention is given to those details critical to the analysis of bus noise emission regulatory alternatives. The discussion in Appendix D covers defined inputs, basic assumptions that underlie the computer predictions, and some of the prediction mathematics.

General Overview of the Model

The model consists of two parts: the General Adverse Response part and the Single Event Response part. These two parts of the model appear side-by-side in Figure 6-9, to emphasize their similarity.

Both parts of the model start with user-defined input, keyed as [U] in the figure. For example, such input includes the potential emission limits for newly manufactured buses as they are typically operated. Both parts of the model then mathematically combine this user-defined input with large quantities of additional data that reside within the computer program. These additional data include noise emissions of other vehicles, as well as traffic data, roadway configuration data, noise propagation data, and residential population data.*

Both parts of the model then combine these data to predict the particular noise levels of interest. The General Adverse Response part predicts the day-night noise level, L_{dn}, averaged over a full year. In a parallel manner, the Single Event Response part predicts both Sound Exposure Level, L_S and the single-event Equivalent Sound Level, $L_{eq(T)}$, for each vehicle passby on a typical day during the year.

---

* The remainder of the discussion will not distinguish between user defined input and input data that resides within the program. See reference 42 for further details.

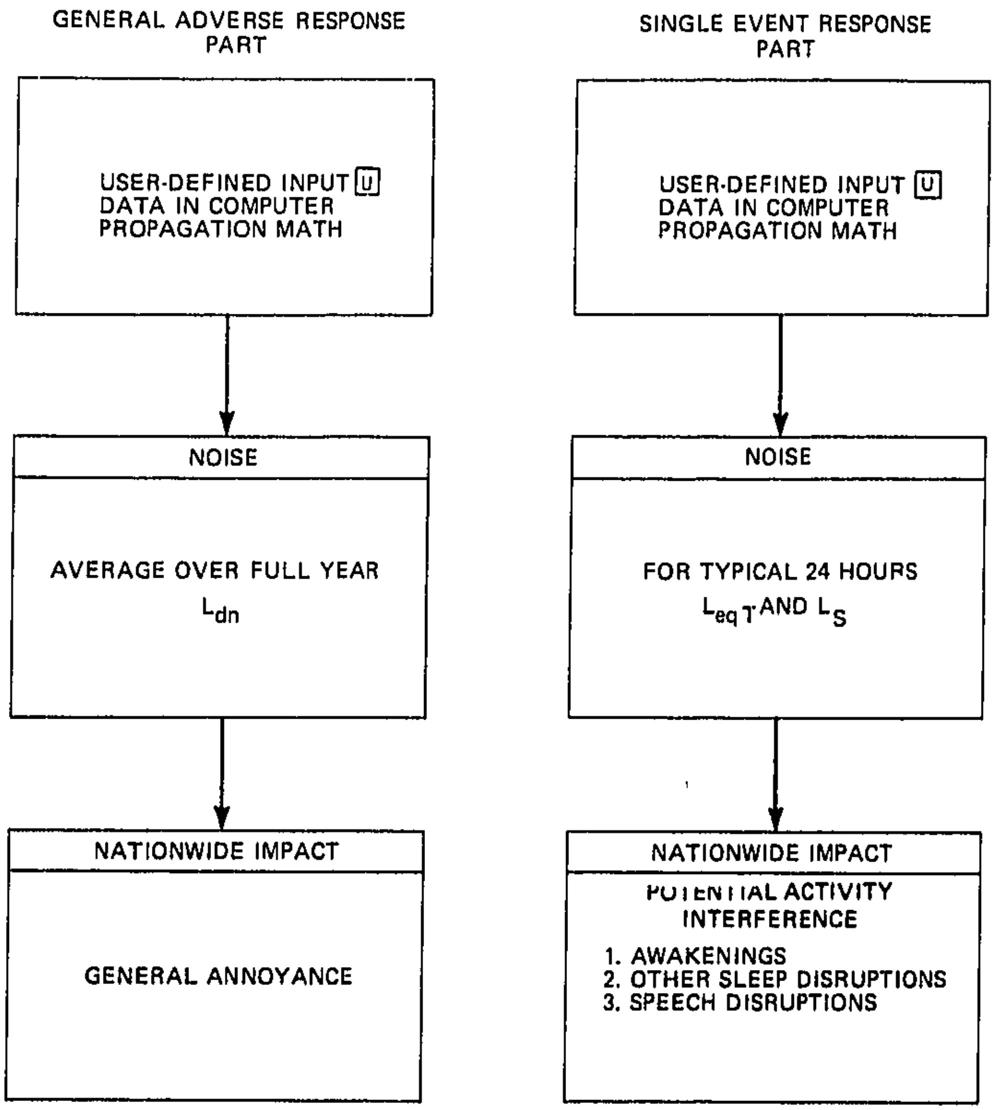


FIGURE 6-9 THE NATIONAL ROADWAY TRAFFIC NOISE EXPOSURE MODEL

As discussed previously, the yearly-average noise level correlates well with noise-induced annoyance in and around the home -- that is, with a person's general adverse response. On the other hand, the noise from individual vehicles, not averaged into the ambient noise background due to other sources, often predicts additional impact due to particularly noisy or isolated single events. These three noise descriptors -- L_{dn}, L_s, and $L_{eq(T)}$ -- were discussed in detail in the subsection entitled "NOISE METRICS."

As shown in the last module in Figure 6-9, the model converts the computed noise levels into measures of estimated impact. The General Adverse Response part of the model estimates the extent to which people in the United States will be highly annoyed by traffic noise experienced at or near their homes. The Single Event part estimates the potential of a single noise source (in this case buses) to awaken people from sleep, to otherwise disrupt their sleep, and to interfere with people's speech at home, both indoors and outdoors.

In summary, the flow in Figure 6-9 progresses from user-defined input, through the data and mathematics within the computer program, to the predicted noise levels -- and then estimates potential noise impacts. The two parts of the model estimate two different aspects of noise impact: yearly-average and single-event. Both aspects are estimated nationwide.

<u>Overview of the Noise Exposure Predictions: General Adverse Response</u>

Figure 6-10 illustrates the manner in which noise predictions are made for the National Roadway Traffic Noise Exposure Model, for General Adverse Response. The figure is keyed (1) through (3) to coordinate with the detailed discussions to follow.

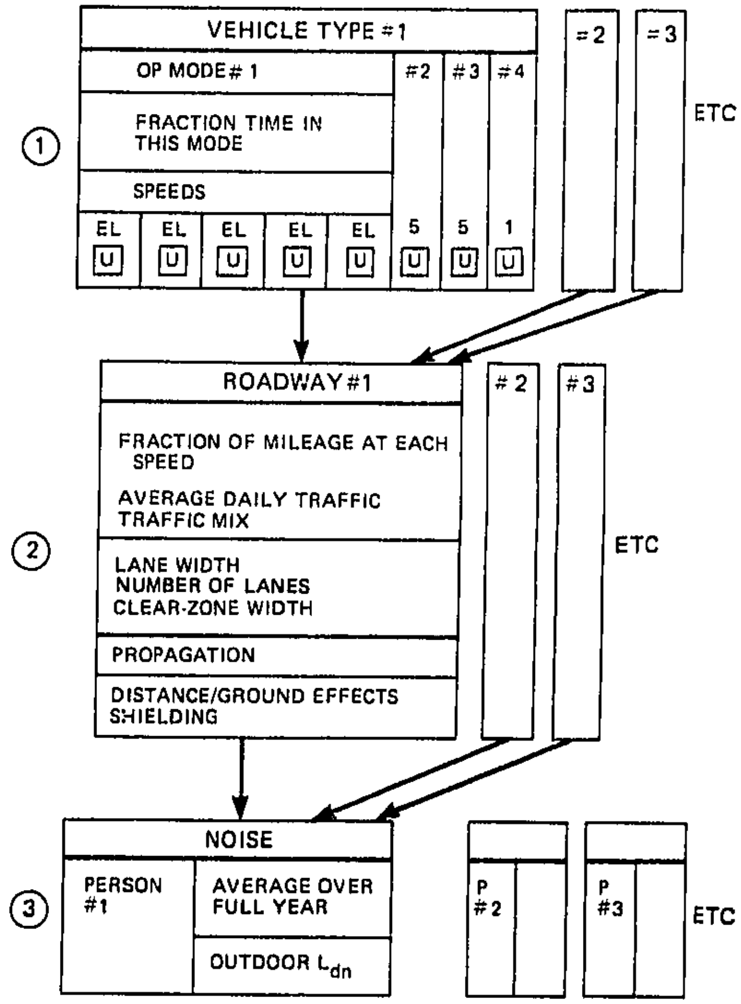


FIGURE 6-10. NOISE EXPOSURE PREDICTIONS: GENERAL ADVERSE RESPONSE

EL IS THE NOISE EMISSION LEVEL. EACH OF THE 5 SPEED RANGES HAS A SPECIFIC EL ASSOCIATED WITH IT. IDLE MODE HAS ONLY ONE EL.

This predicative procedure is best explained by starting with key (3) which addresses the predicted noise exposure for Person #1. As shown in Figure 6-10, noise exposures are predicated for Person #2, Person #3, etc. In essence, the model statistically predicts the noise for every person in the United States -- a 1974 total population of 216.7 million persons, and rising.

Rather than predicating the noise exposure of each individual, the computer groups people into homogeneous areas by city size and population density. Similar groupings occur throughout all blocks in Figure 6-10, though they are not indicated. The concepts involved in the prediction model are clearer without the details and approximations of grouping. These details and approximations are postponed for now.

In essence, then, the model statistically predicts the traffic noise environment experienced by everyone in the United States. The model does take into account population growth for future years.

The noise level at Person #1 emanates from <u>all</u> the roadways within his hearing. (Key (2) in Figure 6-10). Each roadway also has specified as input its average daily traffic and its average mix of vehicle types. Each roadway also has associated with it a large range of typical vehicle speeds. Although vehicle speeds vary on each roadway from moment to moment, the program considers their average speed for any given mile of roadway. The fractions of the total roadway mileage at each of five speed ranges are specific input used within the computer program, for each roadway.

In addition, each roadway has a specific lane width, a specific number of lanes, and a specific clear-zone width. The latter is generally the right-of-way width. It encloses the region within which no one lives.

Roadway noise, close by the roadway, is dependent upon vehicle speed, average daily traffic, traffic mix, lane width, number of lanes, and clear zone width. As this noise propagates outwards from the roadway to the person of interest, it is influenced by a number of propagation parameters. Two principal parameters are the distance between the person and the roadway, and the shielding that intervenes between the person and the roadway. These two parameters are specified for each person/roadway pair -- in groupings, as mentioned above.

From Key (3) to Key (2) the noise level at each person's residence depends upon the source strength of each roadway, and upon the propagation of the noise from the roadway.

In addition to the above parameters, roadway source strength also depends in part, on a number of other factors. As noted in Key (1) each roadway contains a series of vehicle types. Each vehicle type operates in four modes, numbered in the Figure. These modes are: acceleration, deceleration, cruise and idle. Each vehicle spends a definite fraction of its time in each of the four modes. These fractions are specified for each operating mode and separately for each vehicle type. Then each mode fraction is split into the five speed fractions specific to that roadway (Key (2) again).

The final entries at Key (1) are the noise emission levels. These differ for each of the four operating modes, and for each of the five speeds. These emission levels are a user-defined input, and are keyed therefore as [U] in the Figure. Specifically, the user defines the noise emission levels for new vehicle sales in any given year. Then the computer adds those vehicles to the ones already on the road, and depletes the general population of vehicles by those vehicles that retire from service.

The noise emission values put into the model constitute the mechanism by which we can investigate consequences (impacts) of a potential vehicle noise emission regulation. The model is applied for successive years, as more and more of the quieter vehicles are introduced into service. The year-to-year effect on predicted noise impact is a direct measure of the effectiveness of a regulation. (Figure 6-10 does not indicate this year-to-year application.)

In practice, then, Figure 6-10 flows from top to bottom. For the regulated vehicle type, emission levels corresponding to the regulatory levels are entered, separately for the four operating modes and separately for the five speed ranges within each operating mode (except idle). As shown in Figure 6-10, sixteen values of emission level are entered for each vehicle type.

These emissions are combined with the fractions of time spent by that vehicle type in each mode/speed, to obtain that vehicle's contribution to the traffic noise. The computer carries out these calculations for each vehicle type on that roadway. Then all vehicles are combined for Roadway #1, according to the average daily traffic and vehicle mix.

This process is repeated for each roadway type.

Each roadway's noise is then propagated to each person's residence. At each residence the noise levels from all roadways are combined into one total noise level.

This entire process is repeated for all persons in the United States (approximated by residential population density information), as shown to the right at Key (3) in Figure 6-10.

Overview of the Noise Exposure Predictions: Single Event Response

Figure 6-11 illustrates noise prediction flow chart for the Single Event Response portion of the model. Differences between Figure 6-10 and Figure 6-11 are few, but important. Here, only one vehicle type or class is examined at a time, since only its passby noise is assessed.

Key (1) data requirements are identical to the General Adverse Response portion of the model.

At Key (2) , only the average daily traffic for that vehicle type is required, rather than the full traffic and vehicle mix. Also at Key (2) , building noise isolation values are needed to propagate the noise from outdoors to indoors. These building noise isolation values are specified inputs.

The major differences between the Single Event and General Adverse Response portions of the model occur at Key (3) . For each person, the single-event equivalent sound level, $L_{eq(T)}$, is computed for indoors, both day and night, and for outdoors, day only. These predictions then apply to the fraction of time the average person is at home day/night and indoors/outdoors. In addition, the sound exposure level, L_S, is computed for indoors, both day and night -- and then applied to the fraction of time that person is asleep, either day or night.

Key (3) summarizes the types of noise calculations made.

Overview of Noise Impact Estimates: General Adverse Response

The flow chart for noise impact estimates of the General Adverse Response portion of National Roadway Traffic Noise Exposure Model is presented in Figure 6-12. The Figure is keyed (3) through (6) , to coordinate with the more detailed discussions that are presented in Appendix D.

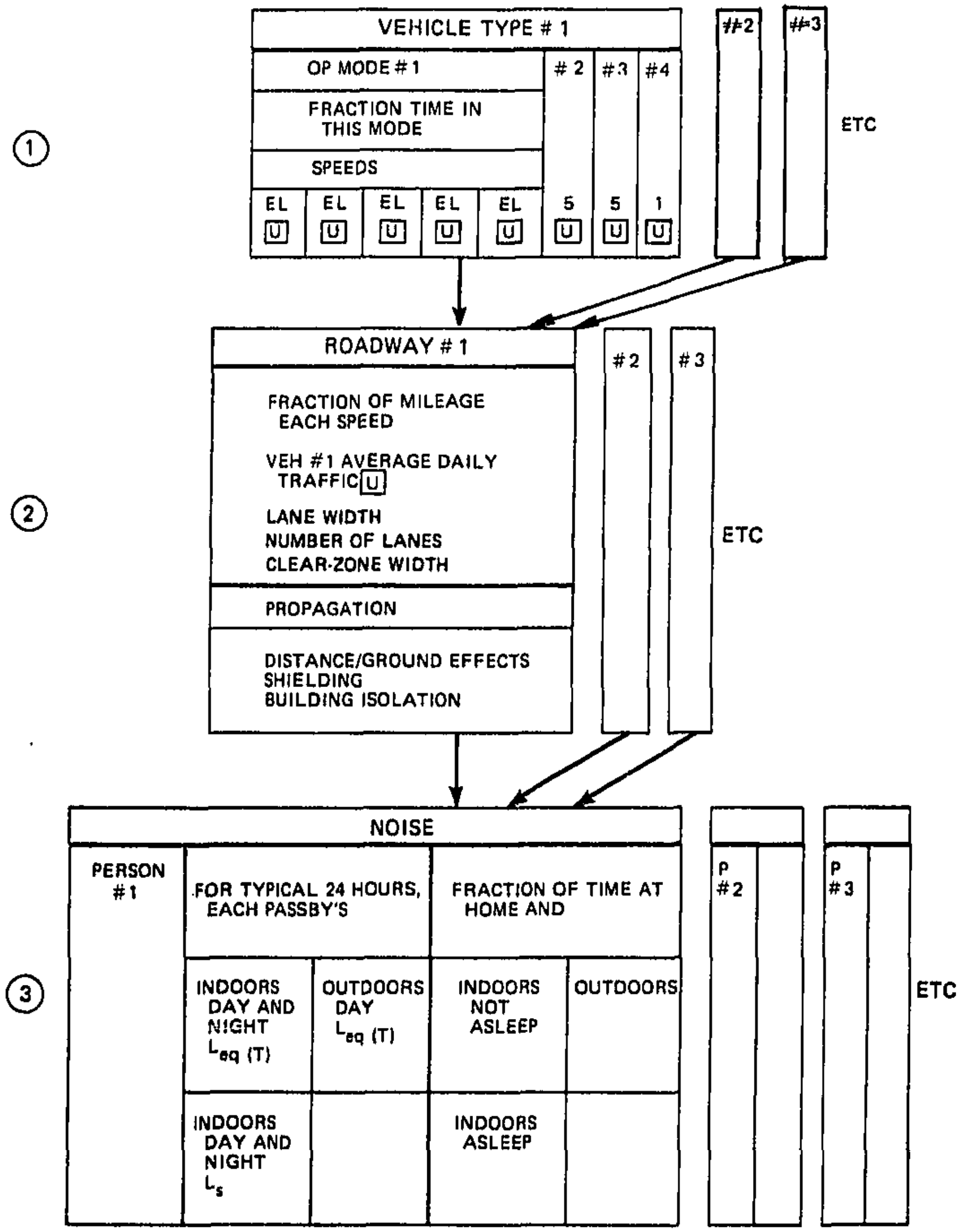


FIGURE 6-11 NOISE PREDICTIONS: SINGLE EVENT RESPONSE

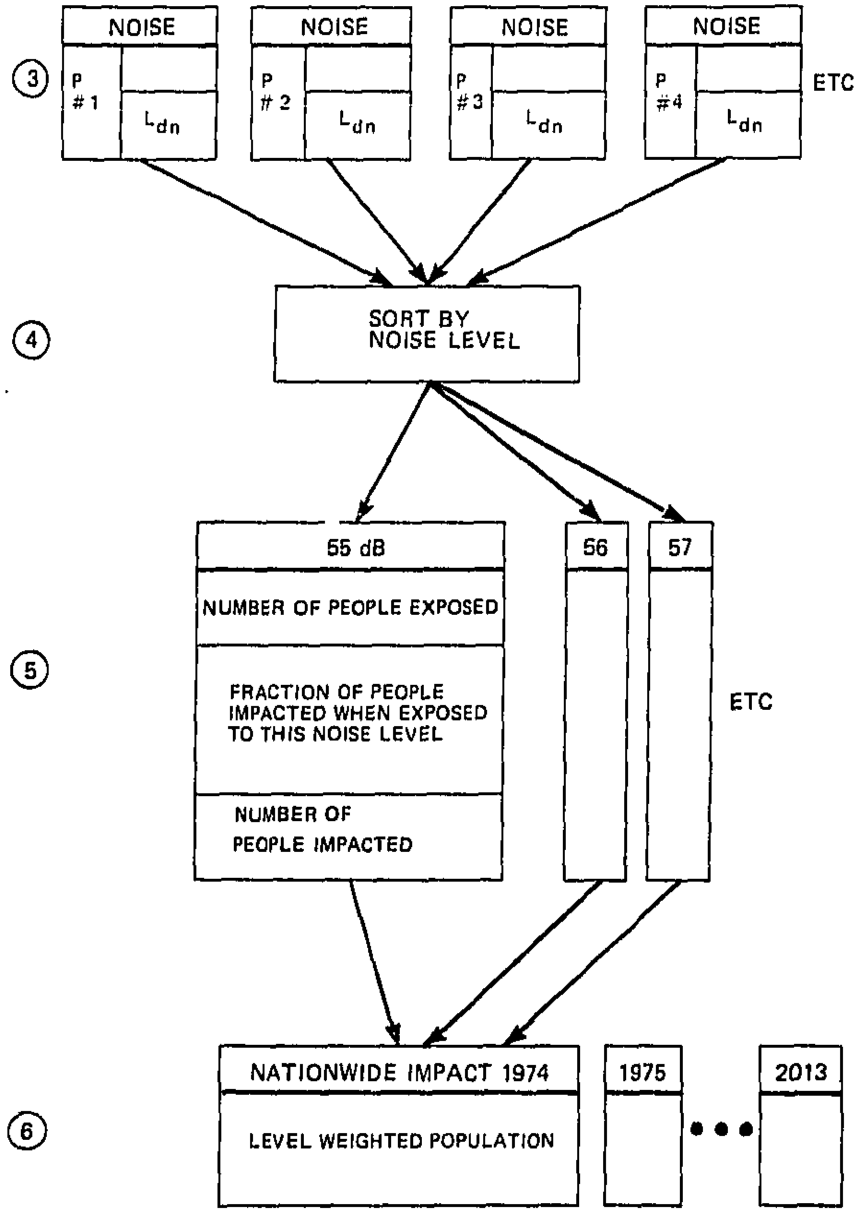


FIGURE 6-12 NOISE IMPACT ESTIMATES: GENERAL ADVERSE RESPONSE

The top set of modules, Key (3) duplicates the bottom set in Figure 6-10. It consists of all the person/noise pairs for the entire United States, as predicted by the model.

At Key (4), this very large set of person/noise pairs is sorted by noise level. For example, all the persons in the U.S. exposed to an outdoor L_{dn} of 55 dB are grouped together in this sorting process. The next set of boxes (top of Key (5)) results.

The top of each module in Key (5) contains all the persons exposed to that particular noise level. Noise impact is calculated by multiplying the number of people exposed at each noise level by the fractions next shown in the Figure (middle of Key (5)). These are the fractional weighting values used to represent the number of people expected to be highly annoyed by that particular noise level. (See the subsection entitled "HEALTH AND WELFARE CRITERIA - GENERAL ADVERSE RESPONSE" for explanation of the fractional weighting values.) These fractions are essentially zero at 55 dB, and increase to nearly unity around 75 dB.

To complete the mathematics at Key (5), the number of people exposed times the appropriate fraction or weighting equals the Level Weighted Population (LWP) for General Adverse Response (equation 8) for each noise exposure band. For example, if 28,000 people are exposed to an L_{dn} of 60 dB, then this number of people, times the fraction 0.25, yields an LWP of 7,000. This number shows that not everyone is impacted to the same degree primarily because some may be less susceptible to noise intrusion. These fractions summarize, therefore, the variability among all persons in their reactions to the same noise level.

As the final step in the impact estimate (Key (6)), the expected impacts at each exposure level are added to obtain the total expected impact in the

United States (equation 9). The resulting number is the total Level Weighted Population (LWP). It combines population and noise level into a single impact value.

Also at Key (6) in Figure 6-12 are the impact estimates for the remainder of the 40-year time stream. As more and more of the quieter vehicles are introduced into service, the estimated impact should drop. The change in this impact from year-to-year is a direct measure of the regulation's benefit.

To rerun the program for subsequent years, additional noise emission values must be entered. The computer will then add these quieter vehicles to the ones already on the road, and will deplete the general population of vehicles by those vehicles that retire from service. These sales and depletion rates reside in the computer. In addition, the model also accounts for changes in United States population each year.

Overview of Noise Impact Estimates: Single Event Response

Figure 6-13 illustrates the logic flow that provides impact estimates for the Single Event Response portion of the model. Differences between Figure 6-12 and Figure 6-13 are minor. Here, each person is exposed not just to one noise level, but to a series of single-event noise levels that occur over a typical 24 hour period. In other words, each person is paired with many noise levels, each predicted as described earlier. After sorting, then, the tabulation of Key (5) is not of persons, but is of noise events. A single person will be exposed to many noise events, all sorted by noise level.

The fractions in Key (5) are the fractions (or probability) of these single events that are expected to actually impact the person who is exposed. The measures used represent the potential to awaken people from sleep, or otherwise to disrupt sleep, or to interfere with one's speech communications. (See the subsection entitled "HEALTH AND WELFARE CRITERIA - SINGLE EVENT RESPONSE" for explanation of the fractions).

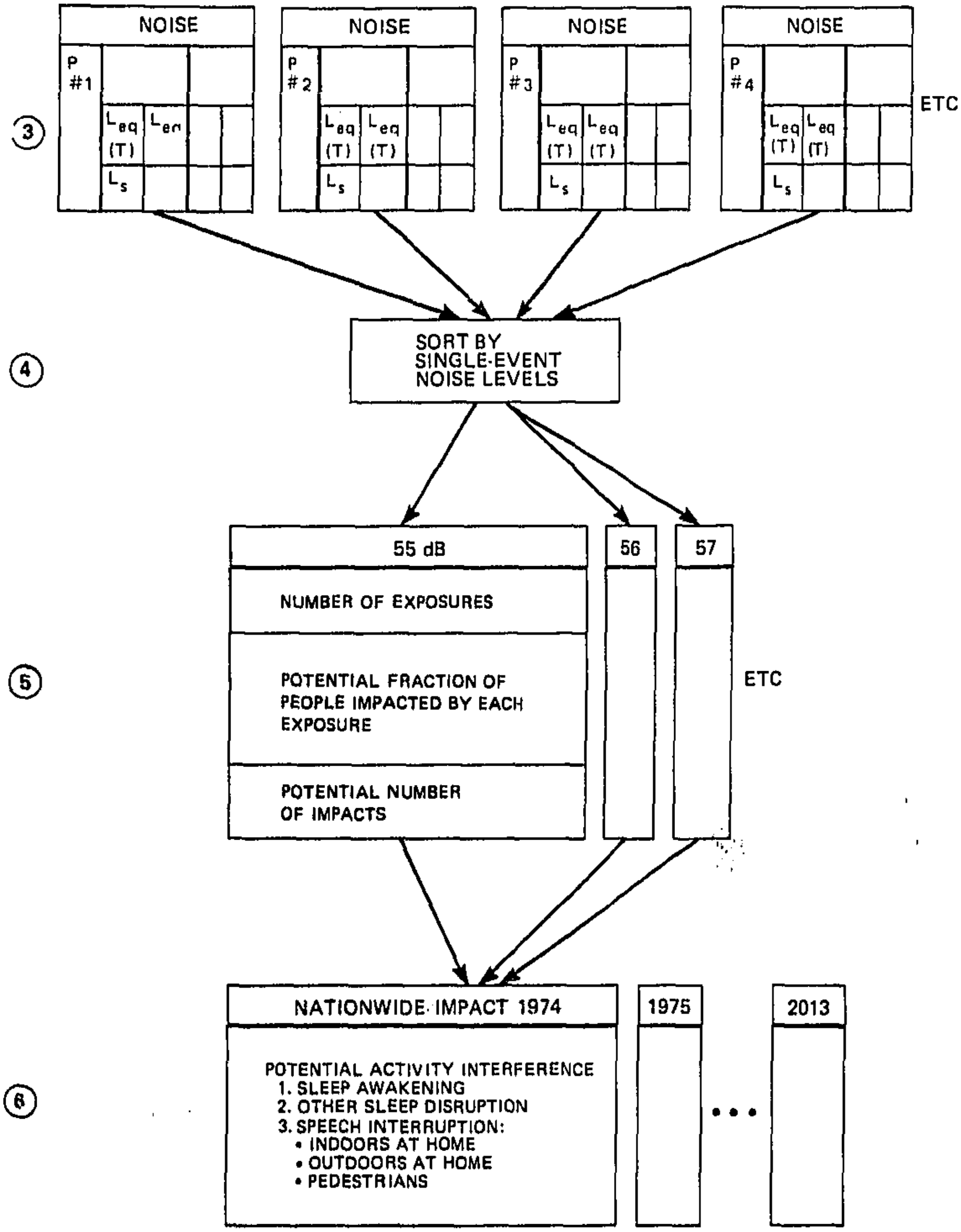


FIGURE 6-13 NOISE IMPACT ESTIMATES: SINGLE EVENT RESPONSE

Each of these distinct types of single-event impacts is estimated separately.

Data Groups

As mentioned earlier, the computer program groups much of its data. Such grouping occurs throughout all modules in Figures 6-10 and 6-11, though grouping is not indicated in either figure.

The grouping of data within the model appear in Table 6-2, for:

- The 14 vehicle types
- The 4 operating modes
- The 5 speed ranges
- The 6 roadway types
- The 9 population groups
- The 4 population/density groups
- The 33 population/density "cells"
- The 40 years of the time stream

Vehicle types were selected based on those used for all EPA studies of roadway noise. They are strongly suggested by similarity in noise emission within a type, due to similarity in engineering or operational characteristics.

Operating modes are based upon extensive vehicle noise tests and appropriate data reduction methods (References 43, 52, 53). Speed ranges are based upon these same tests.

Roadway types are the functional categories of the Federal Highway Administration (Reference 44).

Population groups are based on the data base assembled by the Federal Highway Administration (References 44-46), and were refined using 1970 census

TABLE 6 - 2 DATA GROUPS WITHIN THE MODEL

PARAMETER	GROUP NAME	TYPE DESCRIPTION
Vehicle Types	Car/8/automatic	Passenger car, 8 cylinder, gas, automatic
	Car/6/automatic	Passenger car, 6 cylinder, gas, automatic
	Car/manual	Passenger car, 6 or 8 cylinder, gas, manual
	Car–LT/auto	Passenger car and light truck, 4 cylinder, gas, automatic
	Car–LT/manual	Passenger car and light truck, 4 cylinder, gas, manual
	LT	Light truck, 6 and 8 cylinder, gas
	Car–LT/diesel	Passenger car and light truck, diesel
	MT	Medium truck, two axle (GVWR 10,000 lb)
	HT	Heavy truck, three or more axles (GVWR 26,000 lb)
	Intercity bus	Intercity bus
	Transit bus	Transit bus
	School bus	School bus
	Unmod MC	Unmodified motorcycle
	Mod MC	Modified motorcycle
Operating Modes	Acceleration	Acceleration from zero to speed "S"
	Deceleration	Deceleration from speed "S" to zero
	Cruise	Cruise at speed "S"
	Idle	Idle
Speed Ranges	20 mph	Less than 25 mph
	30 mph	Between 25 and 35 mph
	40 mph	Between 35 and 45 mph
	50 mph	Between 45 and 55 mph
	60 mph	More than 55 mph
Roadway Types	Interstate Highways	Per FHWA definition
	Freeways and Expressways	Per FHWA definition
	Major Arterials	Per FHWA definition
	Minor Arterials	Per FHWA definition
	Collectors	Per FHWA definition
	Local Roads and Streets	Per FHWA definition
Population Groups	Population over 2M	
	1M to 2M	
	500K to 1M	
	200K to 500K	
	100K to 200K	
	50K to 100K	
	25K to 50K	
	5K to 25K	
	Rural areas	

TABLE 6 - 2 DATA GROUPS WITHIN THE MODEL (CONTINUED)

PARAMETER	GROUP NAME	TYPE DESCRIPTION
Population Density Groups	1. High	More than 4,499 people per square mile
	2. Medium–to–High	3,000 to 4,499 people per square mile
	3. Low–to–Medium	1,500 to 2,999 people per square mile
	4. Low	Less than 1,500 people per square mile
Pop/density "cells"	1	Population over 2M, high density
	2	Same, medium–to–high density
	3	Same, low–to–medium density
	4	Same, low density
	5	1M to 2M, high density
	6	Same, medium–to–high density
	7	Same, low–to–medium density
	8	Same, low density
	9	500K to 1M, high density
	10	Same, medium–to–high density
	11	Same, low–to–medium density
	12	Same, low density
	...	
	29	5K to 25K, high density
	30	Same, medium–to–high density
	31	Same, low–to–medium density
	32	Same, low density
	33	Rural, low density only
Years	1974	For prediction of future impact
	1975	
	1976	
	1977	
	.	
	.	
	.	
	2013	

data (Reference 47). Population density groups were also based upon these same Federal Highway Administration and census publications.

These two latter groups are then combined into pop/density "cells" shown next in Table 6-2. Thirty-three of these pop/density "cells" result, since the rural population group is paired with only the low-density group. These pop/density "cells" contain among them the entire U.S. population and also the entire U.S. roadway mileage. They therefore provide the structure for matching each person in the United States with the roadways that produce the noise at his residence.

Lastly, Table 6-2 shows that calculations are performed for all years within a 40-year time stream. A baseline year is selected.* For that year, all data (such as traffic counts, roadway mileage, population densities) are explicitly put into the computer program. Then for future years, these data are factored upward, if appropriate, to account for growth.

The data groups within Table 6-2 interrelate within the model in complex ways as discussed in the more detailed discussions contained in Appendix D.

* For this analysis, much of the data was entered for 1974. These data were applied to later years after suitably adjusting for growth.

INTERIOR NOISE PREDICTION MODEL

Bus Noise Emissions

Average noise exposure levels measured in the driver's position and ı. the rear of the bus are presented in Tables 6-3 and 6-4. These data were obtained from a number of studies pertaining to interior bus noise as referenced in the tables. The noise level values presented represent arithmetic averages. An accurate description of the effects of interior bus noise must also include an assessment of those buses which are noisier and those which are quieter than these levels may suggest.

In developing the data contained in Tables 6-3 and 6-4, the following assumptions were made:

(1) The distribution of interior noise levels for all bus types can be considered to be normal;

(2) The mean acceleration test interior noise levels will be at least three standard deviations (i.e., 6 dB) below the not-to-exceed regulatory level;

(3) The difference between the acceleration noise level and the level for each of the other operational modes (cruise, deceleration, and idle) is constant for all not-to-exceed regulatory levels;

(4) Bus operations on street and highway roadway types do not exceed speeds of 30 mph and 55 mph, respectively.

TABLE 6-3

INTERIOR BUS NOISE LEVELS NEAR THE DRIVER
BY BUS TYPE AND OPERATIONAL MODE
(Data from Reference 2 unless noted)

Bus Type	Interior A-weighted Sound Levels Near Driver, in decibels: Acceleration	Deceleration and Cruise: 30 mph	Deceleration and Cruise: 55 mph	Idle	Energy Average Weighted Sound Levels, in decibels: Street *	Highway *	Street and Highway **
Transit							
Range	78-79	74	76-78	60(Ref.3)			
Mean	79	74	78	60	74.4	77.8	75.2
School (Gas)							
Range	80-90(Ref.16)	--	--	--			
Mean	85	(80)	(84)	(66)	77.9	83.8	79.[illegible]
School (Diesel)							
Range	87-95	(75)-80 (Ref.17)	(79)-(84)	(65)-70 (Ref.17)			
	89	77	81	67	79.5	81.9	80.0
Intercity							
Range	70-78	69-75 (Ref.3,15,19)	73-75 (Ref.15,19)	60 (Ref.18)			
Mean	74	72	74	60	71.8	73.9	73.7

* Weighted by percentage of time spent in each operational mode (Table 6-5).
** Weighted by percentage of time spent on each roadway type (Table 6-6).

Note: Data in parentheses extrapolated from transit bus data.

TABLE 6-4

INTERIOR BUS NOISE LEVELS NEAR THE REAR SEAT
BY BUS TYPE AND OPERATIONAL MODE
(Data from Reference 2 unless noted)

Bus Type	Interior A-weighted Sound Levels Near Rear Seat, in decibels				Energy Average Weighted Sound Levels, in decibels		
		Deceleration and Cruise					
	Acceleration	30 mph	55 mph	Idle	Street *	Highway *	Street and Highway **
Transit Range	80-90	81-84 (Ref.4)	83-85 (Ref.4)	69 (Ref.3)			
Mean	84	83	84	69	81.6	83.8	82.0
School (Gas) Range	77-84 (Ref.16)	--	--	69-78 (Ref.16)			
Mean	81	(80)	(81)	74	77.5	80.8	78.2
School (Diesel) Range	(87)-(92)	75-(80) (Ref. 17)	(76)-83 (Ref.8)	65-(70) (Ref.17)			
	89	77	78	67	79.5	79.9	79.6
Intercity Range	70-84	69-78 (Ref.4,15,19)	73-78 (Ref.15,19)	64-72 (Ref.4)			
Mean	79 (Ref.15,19)	73 (Ref.15,19)	75	68	74.1	75.2	75.1

* Weighted by percentage of time spent in each operational mode (Table 6-5).
** Weighted by percentage of time spent on each roadway type (Table 6-6).

Note: Data in parentheses extrapolated from transit bus data.

Based on these assumptions and the fraction of time spent in each operational mode and on street and highway roadways (presented in Tables 6-5 and 6-6) for each bus type, energy average front and rear interior noise levels are calculated. As an example, Table 6-7 is presented to show the computational procedure used to determine the average interior bus noise levels.

Based on data from EPA studies, interior noise levels have a standard deviation (σ) of about 2 dB for buses of the same bus type (Reference 2). Assuming that the interior sound level distributions among buses are normal, the approximate percentage of buses with interior noise levels relative to the mean level (L) of the distribution is assumed as shown in Table 6-8.

Passengers and drivers are therefore assumed to be distributed according to the sound level distribution in Table 6-8. Although it is possible that some bus drivers and passengers are exposed to a variety of bus noise levels and therefore receive the average noise exposure for a given type of bus over long period of time, in many cases passengers and drivers may receive higher-than-average or lower-than-average exposures. This would be the case, for example, if a school system were to purchase only one type of bus for its operations, or if bus drivers were assigned particular buses for long periods of time. Lacking information to the contrary, it is assumed that half of the population riding buses of a given type (transit, school, intercity) receive front seat exposures, and half receive rear seat exposures, i.e., half ride in the front of the bus and half ride in the rear.

TABLE 6-5

PERCENTAGE OF TIME SPENT IN EACH OPERATIONAL MODE BY BUSES ON STREETS AND HIGHWAYS

(Data from Reference 2 unless noted)

	Operational Mode			
Bus Type	Acceleration	Deceleration	Cruise	Idle
Transit				
Street	20	20	26	34
Highway	5	5	85	5
School				
Street	9	9	21	61
Highway	5	5	85	5
Intercity				
Street*	13	17	56	14
Highway	5	5	85	5

* Data based on typical urban street operational cycle for automobiles, Reference 10.

TABLE 6-6

PERCENTAGE OF TIME SPENT ON EACH ROADWAY TYPE
BY BUS TYPE

(Data from Reference 2 unless noted)

	Roadway Type	
Bus Type	Street	Highway
Transit	85	15
School	85	15
Intercity	5	95

TABLE 6-7

EXAMPLE OF COMPUTATIONAL PROCEDURE USED TO DETERMINE AVERAGE INTERIOR BUS NOISE LEVELS

Roadway Type	Operational Mode	Noise Level in Each Op. Mode, in decibels	Fraction of Time in Each Op. Mode	Avg. Noise Level for Each Rdwy Type, in decibels	Fraction of Time on Each Rdwy Type	Average Interior Bus Noise Level, in Decibels
	Acceleration	79	0.20			
Street	Decel. & Cruise	74	0.46	74.4	0.85	
	Idle	60	0.34			75.2
	Acceleration	79	0.05			
Highway	Decel. & Cruise	78	0.90	77.8	0.15	
	Idle	60	0.05			

TABLE 6-8

INTERIOR SOUND LEVEL DISTRIBUTIONS OF BUSES

Percentage of Buses	6.7	24.1	38.4	24.1	6.7
Interior Noise Level	L-2	L-1	L	L+1	L+2

The acceleration test interior noise levels resulting from the regulation of interior noise are determined by assuming that buses will be designed and built so that the mean test noise level will be at least three standard deviations (3σ) below the not-to-exceed regulation level. This assumption is based on two considerations. First, if the design noise level is set two standard deviations (2σ) below the not-to-exceed regulation level, approximately 97.7 percent of the buses manufactured should be below the regulatory level.* If ten percent of the buses tested are allowed to exceed the regulatory level, a design level of two standard deviations below the regulatory level should be low enough for compliance. Second, manufacturers will, most likely, include a noise level "safety factor" to account for design tolerances and noise level measurement uncertainties. This safety factor is assumed to be on the order of one standard deviation.

The acceleration test noise levels are assumed to be equal to the acceleration levels produced under actual operating conditions. The arithmetic difference between the acceleration noise level and the level for each of the other operational modes (cruise, deceleration, and idle) is assumed to be constant for all not-to-exceed regulatory options. These differences are calculated from the interior noise level data presented in Tables 6-3 and 6-4. In order to determine the average noise level over a typical drive cycle for each bus type, additional operational data are required. These data are: (1) percentage of time spent in each operational mode on street and highway roadways, and (2) percentage of time spent on each roadway type. The percentage values assumed for (1) and (2) above are presented in Tables 6-5 and 6-6, respectively.

---

* Assuming that the noise level distribution is approximately normal.

Based on the above discussion and the data presented in Tables 6-5 and 6-6, the calculations of energy average interior noise levels were made for each regulatory option for front and rear seat locations. These values are presented in Appendix E.

Bus Population

The bus population data used in the interior noise impact model are presented in Tables 6-9 through 6-12. For each bus type, fleet populations are distributed by calendar year and model year and in one year increments from 1980 to 2010. A baseline calendar year of 1980 is selected since, according to the regulation schedule, the first step of the regulation will not be implemented until 1981. The data presented in these tables are based on data of bus sales projections presented in Section 3, and attrition rates contained in References 55 and 56.* It is assumed that for each bus type, only 90 percent of the total fleet is operational at any given time. As a result, only 90 percent of the total bus population in any given calendar year is used in the interior noise impact analyses.

Numbers of Passengers and Drivers

Table 6-13 presents the average number of passengers per bus per day as a function of bus type and calendar year from 1980 to 2010. These data are derived from information presented in References 23 and 40. The average number of bus drivers per bus per day by bus type is presented in Table 6-14. The average number of drivers for transit and intercity buses is based on the total number of drivers and buses for each bus type, averaged over a three-year period.

* The gas/diesel breakdown for school buses is from J. Brandhuber, A. T. Kearney Corp., Personal Communication, April 20, 1976.

TABLE 6-9. Distribution of Bus Population by Calendar and Model Year (thousands) - Transit Buses

Calendar Year	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	8	09	10
1980	90.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1981	84.	13.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1982	79.	13.	13.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1983	74.	13.	13.	13.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1984	67.	12.	13.	13.	13.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1985	60.	12.	13.	13.	13.	13.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1986	52.	12.	12.	13.	13.	13.	13.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1987	44.	11.	12.	12.	13.	13.	13.	14.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1988	36.	10.	11.	12.	13.	13.	13.	14.	14.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1989	28.	9.	10.	11.	12.	13.	13.	14.	14.	14.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1990	22.	8.	9.	10.	11.	12.	13.	13.	14.	14.	14.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1991	16.	7.	8.	9.	11.	12.	13.	13.	14.	14.	14.	14.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1992	11.	6.	7.	8.	9.	11.	12.	13.	13.	14.	14.	14.	15.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1993	7.	4.	6.	7.	8.	10.	11.	12.	13.	14.	14.	14.	15.	15.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1994	4.	3.	4.	6.	7.	8.	10.	11.	12.	13.	14.	14.	15.	15.	15.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1995	2.	2.	3.	4.	6.	7.	9.	10.	11.	12.	13.	14.	15.	15.	15.	15.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1996	1.	1.	2.	3.	5.	6.	7.	9.	10.	11.	12.	13.	14.	15.	15.	15.	15.	[illegible]	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1997	0.	1.	1.	2.	3.	5.	6.	7.	9.	10.	12.	13.	14.	14.	15.	15.	15.	16.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1998	0.	0.	1.	1.	2.	3.	5.	6.	7.	9.	10.	12.	13.	14.	14.	15.	15.	16.	16.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1999	0.	0.	0.	1.	1.	2.	3.	5.	6.	8.	9.	10.	12.	13.	14.	15.	15.	16.	16.	16.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2000	0.	0.	0.	0.	1.	1.	2.	3.	5.	6.	8.	9.	11.	12.	13.	14.	15.	15.	16.	16.	16.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2001	0.	0.	0.	0.	0.	1.	1.	2.	4.	5.	6.	8.	9.	11.	12.	13.	14.	15.	16.	16.	16.	16.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2002	0.	0.	0.	0.	0.	0.	1.	2.	2.	4.	5.	6.	8.	9.	11.	12.	13.	14.	15.	16.	16.	16.	17.	0.	0.	0.	0.	0.	0.	0.	0.
2003	0.	0.	0.	0.	0.	0.	0.	1.	2.	3.	4.	5.	6.	8.	9.	11.	12.	14.	15.	15.	16.	16.	17.	17.	0.	0.	0.	0.	0.	0.	0.
2004	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.	3.	4.	5.	7.	8.	10.	11.	13.	14.	15.	16.	16.	16.	17.	17.	0.	0.	0.	0.	0.	0.
2005	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.	3.	4.	5.	7.	8.	10.	11.	13.	14.	15.	16.	16.	17.	17.	17.	0.	0.	0.	0.	0.
2006	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.	3.	4.	5.	7.	8.	10.	11.	13.	14.	15.	16.	17.	17.	17.	17.	0.	0.	0.	0.
2007	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.	3.	4.	5.	7.	8.	10.	12.	13.	14.	15.	16.	17.	17.	17.	17.	0.	0.	0.
2008	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.	3.	4.	5.	7.	8.	10.	12.	13.	14.	16.	16.	17.	17.	17.	18.	0.	0.
2009	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.	3.	4.	5.	7.	9.	10.	12.	13.	15.	16.	17.	17.	17.	18.	18.	0.
2010	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.	3.	4.	5.	7.	9.	10.	12.	14.	15.	16.	17.	17.	18.	18.	18.

TABLE 6-10. Distribution of Bus Population by Calendar and Model Year (thousands) - Intercity Buses

Calendar Year	Model Year 80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
1980	16.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1981	15.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1982	14.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1983	13.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1984	11.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1985	10.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1986	9.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1987	7.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1988	6.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1989	5.	1.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1990	4.	1.	2.	2.	2.	2.	2.	2.	2.	2.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1991	3.	1.	1.	2.	2.	2.	2.	2.	2.	2.	3.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1992	2.	1.	1.	1.	2.	2.	2.	2.	2.	2.	3.	3.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1993	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	3.	3.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1994	1.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	3.	3.	3.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1995	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	3.	3.	3.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1996	0.	0.	0.	1.	1.	1.	1.	2.	2.	2.	2.	2.	3.	3.	3.	3.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1997	0.	0.	0.	0.	1.	1.	1.	1.	2.	2.	2.	2.	2.	3.	3.	3.	3.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1998	0.	0.	0.	0.	0.	1.	1.	1.	1.	2.	2.	2.	2.	2.	3.	3.	3.	3.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1999	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	2.	2.	2.	2.	3.	3.	2.	3.	3.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2000	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	2.	2.	2.	2.	3.	3.	3.	3.	3.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2001	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	2.	2.	2.	2.	3.	3.	3.	3.	3.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2002	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	2.	2.	2.	2.	3.	3.	3.	3.	3.	3.	0.	0.	0.	0.	0.	0.	0.	0.
2003	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	2.	2.	2.	3.	3.	3.	3.	3.	3.	3.	0.	0.	0.	0.	0.	0.	0.
2004	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	2.	2.	2.	3.	3.	3.	3.	3.	3.	3.	0.	0.	0.	0.	0.	0.
2005	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	2.	2.	2.	2.	3.	3.	3.	3.	3.	3.	3.	0.	0.	0.	0.	0.
2006	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	2.	2.	2.	2.	3.	3.	3.	3.	3.	3.	3.	0.	0.	0.	0.
2007	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	2.	2.	2.	2.	3.	3.	3.	3.	3.	3.	3.	0.	0.	0.
2008	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	2.	2.	2.	3.	3.	3.	3.	3.	3.	3.	3.	0.	0.
2009	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	2.	2.	2.	3.	3.	3.	3.	3.	3.	3.	4.	0.
2010	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	2.	2.	2.	3.	3.	3.	3.	3.	3.	4.	4.

TABLE 6-11. Distribution of Bus Population by Calendar and Model Year (thousands) - School Buses (Gas)

Calendar Year	Model Year 80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	8	09	10
1980	475.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1981	447.	58.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1982	419.	58.	58.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1983	388.	58.	58.	59.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1984	352.	58.	58.	59.	60.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1985	312.	56.	58.	59.	60.	60.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1986	270.	54.	57.	59.	60.	60.	60.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1987	227.	51.	55.	57.	59.	60.	60.	61.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1988	186.	47.	51.	55.	58.	60.	60.	61.	62.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1989	147.	42.	47.	52.	56.	58.	60.	61.	62.	62.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1990	112.	37.	43.	48.	52.	56.	59.	61.	62.	62.	62.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1991	81.	31.	37.	43.	48.	53.	56.	59.	61.	62.	62.	63.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1992	56.	26.	32.	38.	43.	49.	53.	57.	60.	61.	62.	63.	63.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1993	37.	20.	26.	32.	38.	44.	49.	54.	57.	60.	62.	63.	63.	64.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1994	22.	15.	20.	26.	32.	38.	44.	49.	54.	58.	60.	62.	63.	64.	64.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1995	12.	10.	15.	20.	26.	32.	38.	44.	50.	54.	58.	61.	63.	64.	64.	65.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1996	5.	6.	10.	15.	21.	27.	33.	39.	45.	50.	55.	59.	62.	63.	64.	65.	65.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1997	2.	3.	7.	11.	15.	21.	27.	33.	39.	45.	50.	55.	59.	62.	64.	65.	65.	66.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1998	1.	1.	3.	7.	11.	15.	21.	27.	33.	39.	45.	51.	56.	60.	62.	64.	65.	66.	66.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1999	0.	0.	1.	4.	7.	11.	16.	21.	27.	33.	40.	46.	51.	56.	60.	63.	65.	66.	66.	67.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2000	0.	0.	0.	1.	4.	7.	11.	16.	21.	27.	34.	40.	46.	52.	56.	60.	63.	65.	66.	67.	67.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2001	0.	0.	0.	0.	1.	4.	7.	11.	16.	21.	28.	34.	40.	46.	52.	57.	61.	64.	66.	67.	67.	68.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2002	0.	0.	0.	0.	0.	1.	4.	7.	11.	16.	22.	28.	34.	41.	47.	52.	57.	61.	64.	66.	67.	68.	68.	0.	0.	0.	0.	0.	0.	0.	0.
2003	0.	0.	0.	0.	0.	0.	1.	4.	7.	11.	16.	22.	28.	34.	41.	47.	53.	58.	62.	65.	67.	68.	68.	69.	0.	0.	0.	0.	0.	0.	0.
2004	0.	0.	0.	0.	0.	0.	0.	2.	4.	7.	11.	16.	22.	28.	35.	41.	48.	53.	58.	62.	65.	67.	68.	69.	69.	0.	0.	0.	0.	0.	0.
2005	0.	0.	0.	0.	0.	0.	0.	0.	2.	4.	7.	11.	16.	22.	28.	35.	42.	48.	53.	59.	63.	66.	68.	69.	69.	70.	0.	0.	0.	0.	0.
2006	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	4.	7.	11.	16.	22.	29.	35.	42.	48.	54.	59.	63.	66.	68.	69.	70.	70.	0.	0.	0.	0.
2007	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	4.	7.	11.	17.	22.	29.	35.	42.	48.	54.	59.	64.	67.	69.	70.	70.	70.	0.	0.	0.
2008	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	4.	7.	11.	17.	23.	29.	36.	42.	49.	55.	60.	64.	67.	69.	70.	70.	71.	0.	0.
2009	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	4.	7.	12.	17.	23.	29.	36.	43.	49.	55.	60.	64.	68.	69.	70.	71.	71.	0.
2010	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	4.	7.	12.	17.	23.	29.	36.	43.	50.	55.	61.	65.	68.	70.	71.	71.	72.

TABLE 6-12. Distribution of Bus Population by Calendar and Model Year (thousands) - School Buses (Diesel)

Calendar Year	Model Year 80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	8	09	10
1980	16.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1981	15.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1982	14.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1983	13.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1984	12.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1985	11.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1986	9.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1987	8.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1988	6.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1989	5.	1.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1990	4.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1991	3.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1992	2.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1993	1.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1994	1.	1.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1995	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1996	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1997	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1998	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1999	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2000	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2001	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2002	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.
2003	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.	0.
2004	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.	0.
2005	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.	0.
2006	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.	0.
2007	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.	0.
2008	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.	0.
2009	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.	0.
2010	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.	2.	2.

TABLE 6-13. Average Number of Passengers Per Bus Per Day as a Function of Bus Type and Calendar Year

Calendar Year	Bus Type		
	Transit*	School*	Intercity
1980	247	62	82
1981	247	62	86
1982	245	61	90
1983	245	61	93
1984	243	60	97
1985	243	60	101
1986	243	60	104
1987	242	59	108
1988	242	59	112
1989	240	58	115
1990	240	58	119
1991	240	58	123
1992	240	57	126
1993	238	57	130
1994	238	56	134
1995	238	56	137
1996	238	56	141
1997	238	56	145
1998	237	56	148
1999	237	55	152
2000	237	55	156
2001	237	55	159
2002	237	55	163
2003	235	55	167
2004	235	55	170
2005	235	55	174
2006	235	55	178
2007	235	55	182
2008	235	54	185
2009	234	54	189
2010	234	54	193

* Assuming two trips per passenger

TABLE 6-14

AVERAGE NUMBER OF DRIVERS PER BUS BY BUS TYPE

Bus Type	Total Number of Drivers	Total Number of Buses	Average Number of Drivers Per Bus
Transit	89,700 1/	50,600 1/	1.77 1/
School	-	-	1.00 2/
Intercity	16,000 3/	9,600 3/	1.67 3/

1/ Computed from data presented in Ref. 3; represents average over three-year period: 1974, 1975, and 1976.

2/ Assuming one driver per bus.

3/ Computed from data presented in Ref. 4; represents average over three-year period: 1972, 1973, and 1974.

The total number of bus drivers and passengers riding in each type of bus by year is given in Table 6-15. The data in this table is obtained by multiplying the number of passengers and drivers per bus per day given in Tables 6-13 and 6-14 by 90 percent of the number of buses in operation each year (Tables 6-9 to 6-12).

Bus Ride Characteristics

It is assumed that transit bus passengers and drivers and intercity bus drivers receive interior bus noise exposure 225 days per year. Based on EPA survey data, it was determined that the typical intercity bus passenger takes approximately six round-trips annually, or 12 single bus noise exposures per year. Additionally, it is assumed that school bus passengers and drivers receive interior bus noise exposure 180 days per year.

The assumed duration of daily noise exposure received by passengers and drivers of each bus type is presented in Table 6-16. References, assumptions, computational procedures, and relevant data used to determine these durations are also presented.

Hearing Loss Impact

To estimate the $L_{eq}(24)$ experienced by passengers and drivers, it is necessary to ascertain the daily exposures received by these people while off the bus. While some data have been collected in this regard for workers in manufacturing industries, very little data are available which would enable an accurate prediction of the daily average exposures experienced by the great majority of the population. In order to proceed with the estimate of $L_{eq}(24)$, three non-bus exposures have been chosen in order to cover a

TABLE 6-15

NUMBER OF BUS DRIVERS (D) AND PASSENGERS (P) PER DAY FOR EACH BUS TYPE
(in thousands)

Calendar Year	Transit D	Transit P	School D	School P	Intercity D	Intercity P
1980	143	20,007	442	27,398	24	1,181
1985	198	27,119	563	33,804	30	1,818
1988	217	29,621	596	35,152	33	2,218
1990	223	30,240	608	35,287	36	2,570
1993	239	32,130	622	35,448	39	3,042
1995	244	32,773	629	35,230	41	3,329
2000	260	34,768	653	35,937	45	4,212
2010	296	39,172	701	37,859	54	6,253

TABLE 6-16

Duration of Daily Noise Exposure Experienced by Drivers and Passengers, by Bus Type

Exposure Per Day (Hours)						
Passengers			Drivers			
T	S	I	T	S	I	Basis for Estimate
2	2	4	2	2	4	Reference 37
-	-	-	8	8	8	Assuming a full work day
-	1.5	-	-	1.5	-	Derived below 1/
-	-	1.6	-	-	-	Derived below 2/
-	-	-	-	-	5	Derived below 3/
2	2	2	5	2	6	Assumed for this report

Key: T Transit
S School
I Intercity

(1) $\frac{(2 \text{ billion bus miles/yr}) \div (22.5 \text{ mph})^{*}}{(330{,}000 \text{ buses}) \times (180 \text{ school days/yr})}$
= 1.5 hours/driver or passenger/day

(2) $\frac{(25.6 \text{ billion revenue passenger miles/yr}) \div (40 \text{ mph})^{**}}{(0.4 \text{ billion revenue passengers/yr})}$
= 1.6 hours/driver/day

(3) $\frac{(0.71 \text{ billion bus miles/yr}) \div (40 \text{ mph})}{(16{,}000 \text{ drivers}) \times (225 \text{ work days/yr})}$
= 5 hours/driver/day

* Average speed for range of 15 to 30 mph.
** Average speed for range of 30 to 50 mph.

range of values which are likely to occur: 60 dB, 70 dB, and 80 dB. The yearly $L_{eq\ (24)}$ is then calculated using the following equation:

$$L_{eq}(24)_{(yearly)} = 10 \log_{10} \left\{ \frac{D}{365}\left[\frac{tb}{24}\ 10^{L_b/10} + \frac{24-tb}{24}\ 10^{L_t/10}\right] + \frac{365-D}{365}\ 10^{L_t/10} \right\} \qquad (16)$$

where: tb is the duration of daily bus noise exposure (from Table 6-16)

24-tb is the duration of daily non-bus noise exposure

L_b is the average level of interior bus noise (from Tables 6-3, 6-4, and Appendix E)

L_t is the average level of non-bus noise (60 dB, 70 dB, or 80 dB)

D is the average number of days of exposure per year (225 days/yr)

After the yearly equivalent continuous sound levels experienced by drivers and passengers are derived, the hearing loss impact is determined. Two measures are used to assess the hearing loss impact: (1) Level Weighted Population for Hearing (LWP_H); and (2) Relative Change in Impact (RCI). LWP_H is simply the product of the expected hearing loss resulting from a given $L_{eq\ (24)}$ (from Figure 6-7 or equation 15) and the number of people exposed to that level. LWP_H is computed using Equations 8 and 9. The units of LWP_H are therefore expressed in people-decibels of hearing loss. The total LWP_H for passengers or drivers is computed by summing the hearing loss impacts, weighted by the distributions of interior noise levels as shown in Table 6-8. The total numbers of passengers and drivers by bus type are taken from Table 6-15, and apportioned as in Tables 6-9 to 6-12.

To evaluate the relative changes in impact resulting from the different interior noise regulatory options, the relative change in impact is determined from equation 10. The percent reduction comparisons were derived from LWP_H impact measures.

Evaluation of Partial Exposure to Hearing Damage Risk

To account for the fact that most noise exposures are not steady, but vary with time, the Levels Document (Reference 1) recommended that hearing damage risk be evaluated in terms of the whole time-varying pattern of sound levels.

Accordingly, in the Levels Document, an equivalent sound level (L_{eq}) was defined and used to arrive at the criterion level over which there may be risk of hearing damage from environmental noise.

The level identified by EPA as a point below which there is no risk to hearing damage ($L_{eq(24)}$=70 dB), when considered with the equal energy hypothesis which states that equal amounts of acoustic energy will cause equal amounts of noise-induced hearing damage, provides a convenient way of comparing the exposures of people to different noise levels and durations. This is done by comparing the exposure time due to the operation of a given product to the allowable safe exposure of an individual who is exposed to a steady state noise for 24 hours at the criterion level. The reference level is the A-weighted sound level of 70 dB; thus, an exposure to a steady level of 70 dB for 24 hours would have a partial exposure of 100 percent. Similarly, an exposure to a level of 73 dB for 12 hours would also yield a partial exposure of 100 percent, as would an exposure lasting 6 hours at 76 dB.

Since the criterion level identified by EPA represents the safe level of exposure and is computed on a yearly basis, the partial exposure to a source must also be computed on a yearly basis and take into account the length of each exposure and the number of exposures that occur during the whole year.

Partial exposure may be computed using the following equation:

$$\text{Partial exposure (in percent)} = 100 \times \begin{cases} 10^{(L_{eq}^{i} - 70)/10} & L_{eq}^{i} < 70 \text{ dB} \\ 1 & L_{eq}^{i} \geq 70 \text{ dB} \end{cases} \qquad (17)$$

where L_{eq}^{i} represents the yearly average level for the i-th sub-population due to the noise from the source of concern.

Whenever the partial exposure exceeds 100 percent, a potential impact upon hearing exists. However, when a partial exposure is less than 100 percent, it may not have a direct impact upon hearing but a certain amount of the allowable yearly dose is consumed, thereby decreasing the remaining amount of exposures allowed for the rest of the year. A combination of exposures to different sources, each exposure less than 100 percent, may result in a combined equivalent sound level of greater than 70 dB, and thus presents a hearing damage risk.

For example, suppose a person operates a home tool that produces an A-weighted level of 90 dB at the ear of the operator for 2 hours a day, 25 days per year. Then, the yearly equivalent level for the tool alone is given by:

$$L_{eq} = 90 + 10 \log_{10} \frac{2 \times 25}{24 \times 365} = 67.6 \text{ dB}.$$

<u>A priori</u> the tool would appear to be safe. However, another way to look at the risk involved is to consider that use of this tool for only 2 hours a day, 25 days a year, consumes 58 percent of the person's allowable yearly dose, leaving therefore little room for other exposures. From equation 17, this is calculated as:

$$\text{Partial Exposure} = 100 \times 10^{(67.6 - 70)/10} = 58\%$$

<u>Speech Communication Impact</u>

Using the values for (a) average interior front and rear noise levels given in Tables 6-3 and 6-4 for unregulated buses, and in Appendix E for regulated buses, (b) the passenger and driver population data contained in Tables 6-14 and 6-15, apportioned as per Tables 6-9 to 6-12, (c) the interior sound level distribution of buses as shown in Table 6-8 (with a 2 dB standard deviation), as well as (d) the criteria presented in Figure 6-8, the LWP for interior speech communication impact is computed using equations 8 and 9.

An Example

To illustrate the procedures used to calculate interior noise impact, the following example is presented. In this example, we wish to determine the noise exposure distribution of passengers who will ride transit buses in the year 1990 under regulatory option number 2. This encompasses buses manufactured between 1981 and 1984 that meet an 86 dB regulatory interior level, and 1985-1990 model year transit buses that meet an 83 dB interior level. 1980 buses are not regulated. From the last column in Tables 6-3 and 6-4 (for 1980 buses), and Tables E-1 through E-4 of Appendix E (86 dB for 1981-1984 buses and 83 dB for 1985-1990 buses), the median front and rear interior noise levels are found and listed in Table 6-17.

From Table 6-9 it is noted that 140,000 buses are projected to be in service in the year 1990. These are distributed such that 16 percent of those vehicles in service were manufactured in 1980, 27 percent from 1981 to 1984, and 57 percent from 1985 to 1990.

From Table 6-15, it is projected that there will be a total of 30,240,000 passengers riding transit buses per day in 1990. Using the distribution of vehicles in service in 1990 as noted above, it is projected that 4,848,000 passengers would ride a 1980 model bus on any given day; 8,165,000 on buses manufactured between 1981 and 1984; and 17,237,000 on a transit bus produced between 1985 and 1990 (see Table 6-17). It is assumed that half of the passengers would ride near the front, and half near the rear. Assuming that passenger noise exposure is distributed normally with a standard deviation of 2 dB (from Table 6-8), the distribution of transit bus passengers as a func-

TABLE 6-17

Interior Transit Bus Noise Levels in 1990

Regulatory Level	Model Years	Passengers	Median Level Front	Rear
No Regulation	1980	4,838,000	75.2 dB	82 dB
86 dB	1981-1984	8,165,000	75.2 dB	78 dB
83 dB	1985-1990	17,237,000	73.2 dB	75 dB

tion of interior noise level experienced on any given day would be as presented in Table 6-18.

Using the population and noise exposure distribution information presented in Table 6-18, the Level Weighted Population for interior speech communication impact may be obtained by using Figure 6-7 (to derive the fractional weighting value) and equations 8 and 9. It should be noted that in this situation speech interferences occur over a two hour duration (see Table 6-16).

The distribution of interior noise levels presented in Table 6-18 may also be used to determine partial exposure (consumable yearly dose) substituting the interior exposure levels for L_{eq}^{i} in equation 17.

To determine risk of hearing damage in terms of Level Weighted Population for Hearing, yearly $L_{eq(24)}$ values must be calculated. In this example, a 70 dB daily exposure to non-bus noise is assumed. Using equation 16 with 225 days of exposure per year, 2 hours per day, a 70 dB non-bus exposure, and the interior noise level values in Table 6-18, yields the passenger noise exposure distribution shown in Table 6-19. Level Weighted Population for Hearing may then be computed using Figure 6-7 or equation 15, and equations 8 and 9.

TABLE 6-18

Distribution of Transit Bus Passenger Interior Noise Exposure on Any Given Day*
(2 hour exposure per day from Table 6-16)

Interior Noise Level (in decibels)	Number of Passengers
69-70	739,000
71-72	3,090,000
73-74	7,227,000
75-76	8,867,000
77-78	5,789,000
79-80	2,580.000
81-82	1,203,000
83-84	583,000
85-86	162,000
TOTAL	30,240,000

* The values cited represent approximations for purposes of illustration.

TABLE 6-19

Distribution of Transit Bus Passenger Yearly Noise Exposure ($L_{eq(24)}$) Assuming a Daily Non-Bus Noise Exposure of 70 dB*

Yearly At-Ear Noise Exposure (in decibels)	Number of Passengers
≤ 70	739,000
70-71	23,405,000
71-72	4,148,000
72-73	1,202,000
73-74	584,000
74-75	162,000

* The values cited represent approximations for purposes of illustration.

RESULTS OF ANALYSIS

As discussed in the subsections entitled "HEALTH AND WELFARE CRITERIA", results of the impact analysis for buses center around two measures: (1) the Level Weighted Population, LWP, and (2) the Relative Change in Impact, RCI. LWP is an index which represents the total number of persons in the United States who are impacted by roadway noise during any given year of interest and the degree or severity of that impact upon each person. The RCI values represent the percentage change in LWP between a baseline year and a specified year in the future. A decrease in LWP results in a positive RCI -- that is, a benefit in terms of a percentage reduction in extent and severity of impact.

For the impact analysis presented here, two different baseline conditions have been adopted -- resulting in two separate sets of values for RCI. First, the year 1980 is used as the baseline condition, and the results tabulated as "RCI" (without an asterisk). Thus, RCI describes projected benefits relative to current day (1980) conditions. For example, an RCI of 25 percent in 1995 is interpreted as a benefit of 25 percent reduction in impact from that occurring in 1980 with no regulation in effect. Similarly, an RCI of negative 15 percent represents a worsening of adverse impact by 15 percent. These values of RCI include the effects of all changes between 1980 and the specified year in the future. These RCI values reflect the impact of the bus noise emission regulation and the influence of such factors as increased traffic volume, noise regulation of other vehicles, increase number of buses and increase growth of the U.S. population.

Values of RCI have also been computed for a second baseline condition: the same year as the year of interest, but without EPA regulation of bus noise emissions. These values of RCI are labeled as RCI* in the text and tables that follow. For a given year of interest, the RCI* values reflect the benefits attributable only to the bus noise regulation--that is, benefits that will occur relative to that specific year if there were no bus regulation. For example, an RCI* of 40 percent in 1995 is interpreted as a reduction in impact of 40 percent in 1995 from that which would occur in 1995 with no regulation. In brief,

- o RCI compares the impact in the year-of-interest (with regulation) to the impact in the year 1980, during which there is no regulation, less traffic, fewer bus operations and lower population.

- o RCI* compares the impact in the year-of-interest (with regulation) to the same year, without regulation.

The RCI and RCI* values are considered to be more accurate predictors of actual benefits to be realized than the LWP values reported. This is because the RCI and the RCI* involve changes from a baseline condition. In the computation of RCI and RCI*, inaccuracies in the year-of-interest LWP tend to cancel, by direct subtraction, the same inaccuracies in the baseline LWP.

With these indices of noise impact -- LWP, RCI, and RCI* -- three distinct types of impact are assessed: (1) General Adverse Response, based upon L_{dn}, (2) Single Event Activity Interference, based upon L_S for sleep interference and upon $L_{eq(T)}$ for speech interference, and (3) Interior Impact based upon $L_{eq(24)}$ for hearing damage risk and $L_{eq(T)}$ for speech interference. In the discussions that follow, these three distinct types of impact are addressed separately. For each, the results are tabulated for a series of future years (through the year 2010), and for a series of possible regulatory options (Table 6-1). Option Q represents the maximum benefits achievable and can be used as an upper limit guide. Additional tabulations are included separately in Appendix F for the three types of buses: transit, intercity, and school buses.

General Adverse Response

The General Adverse Response portion of the model assesses the impact from the bus noise emission regulation on a national aggregate basis. It does not assess the reduction in terms of specific street type vehicular mix or other location specific criteria which may yield substantially greater benefits.

The results of the General Adverse Response analysis appear in table 6-20 and 6-21. The LWP, RCI and RCI* values are presented for six years (1980, 1985, 1990, 1995, 2000, and 2010) for each of the regulatory options. (see Table 6-1)

Table 6-20 presents the results of the analysis in terms of Level Weighted Population. First, note that the LWP's increase in future years even as more stringent regulations are imposed. This increase in impact does show that the projected benefits from reducing bus noise emissions may be overpowered by the anticipated increase in vehicular traffic as well as population growth in the U.S. between 1980 and the year 2010.

Also, Table 6-20 shows that in terms of overall traffic noise impact, the regulation of buses results in small overall traffic noise reduction due to the small bus population and the dominance of trucks and automobiles in the overall traffic stream.

Table 6-21 presents the RCI values. In the absence of a bus noise emission regulation, this value between 1980 and 2010 reaches a negative 56

TABLE 6-20

General Adverse Response

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (MILLIONS)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	28.91	28.91	28.91	28.91	28.91	28.91	28.91	28.91	28.91	28.91
1985	29.64	29.64	29.61	29.62	29.61	29.62	29.64	29.61	29.61	29.38
1990	30.43	30.42	30.27	30.27	30.21	30.22	30.26	30.20	30.22	29.91
1995	33.13	33.12	32.85	32.85	32.72	32.72	32.75	32.67	32.73	32.44
2000	37.09	37.08	36.76	36.76	36.58	36.58	36.59	36.52	36.59	36.34
2010	45.91	45.90	45.51	45.51	45.30	45.30	45.30	45.21	45.31	45.02

TABLE 6-21

General Adverse Response

YEARS	REGULATORY OPTIONS, RELATIVE CHANGE IN IMPACT (RCI)																			
	Baseline		Option 1		Option 2		Option 2A		Option 3		Option 3A		Option 3B		Option 4		Option 5		Option Q	
	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*
1980	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
1985	-2.52	0.00	-2.52	0.00	-2.42	0.10	-2.45	0.07	-2.42	0.10	-2.45	0.02	-2.52	0.00	-2.42	0.10	-2.42	0.10	-1.63	0.88
1990	-5.26	0.00	-5.22	0.03	-4.70	0.53	-4.70	0.53	-4.50	0.72	-4.53	0.69	-4.67	0.56	-4.46	0.76	-4.53	0.69	-3.46	1.77
1995	-14.60	0.00	-14.56	0.03	-13.63	0.85	-13.63	0.85	-13.18	1.24	-13.18	1.24	-13.28	1.15	-13.01	1.39	-13.21	1.21	-12.21	2.08
2000	-28.29	0.00	-28.26	0.03	-27.15	0.89	-27.15	0.89	-26.53	1.38	-26.53	1.38	-26.57	1.35	-26.32	1.54	-26.57	1.35	-25.70	2.02
2010	-58.80	0.00	-58.77	0.02	-57.42	0.87	-57.42	0.87	-56.69	1.33	-56.69	1.33	-56.69	1.33	-56.38	1.52	-56.73	1.31	-55.72	1.94

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.
RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

percent (noise impact worsens). This increase in impact is again due to projected increases in vehicular traffic and anticipated U.S. population growth. It must be reemphasized that these estimates are for impact on a nationwide aggregate basis. Such aggregate reductions on a national basis do not point up the potentially significant benefits that would occur in the urban environment for situations where there is a high volume of buses (e.g., bus malls).

The RCI* values in Table 6-21 are illustrative of the benefits from the bus noise emission regulation to be realized in any specific future year. These RCI* values start at 0.00 for the no regulation baseline option, and then increase to 1.5 percent for Option 4 in the year 2010. This value shows that for this regulatory option a benefit of 1.5 percent reduction in overall traffic noise impact will be realized.

Note that in Table 6-20, the total U.S. impact is collapsed into a single-value LWP -- for a given year and given regulatory option. In this condensation, the numbers of persons exposed to different noise levels is lost. This population exposure information is presented in Tables F-1 to F-10 in Appendix F. These tables show the number of persons in the United States who live in specific noise exposure areas, in 3-decibel ranges. Measurable reductions in impact are noted in these tables for each of the regulatory options.

Single Event Activity Interference

The purpose of the single event activity interference analysis is to examine the benefits of reducing bus noise in greater detail. Here, potential activity interference is examined separately for (1) sleep disruption, (2) sleep awakening, and (3) speech interference, both indoors and outdoors and pedestrian.

For sleep disruption, Level Weighted Population (LWP) and both types of Relative Change in Impact (RCI and RCI*) appear in Tables 6-22 and 6-23. These tables are organized identically to Tables 6-20 and 6-21 presented previously.

Tables 6-22 and 6-23 show very large benefits in terms of a reduced potential for sleep disruption due to the regulation of bus noise. These benefits represent reductions in that proportion of impact that is attributable to buses alone.

The values of LWP contained in Table 6-22 are composite numbers representing the total number of people exposed to bus passbys, multiplied by the number of bus passby events to which they are exposed, weighted by the degree of anticipated interference. For example, if 32 million people are exposed nightly to bus passby noise, and each is exposed to ten separate passbys, and each passby has an independent probability of disrupting sleep of 25 percent, the total LWP displayed for that situation would be 80 million (32,000,000 X 10 X 0.25). Each cell in Table 6-22 represents such a composite number.

Again, the LWP values are indicators which are used to compare regulatory options, and are not absolute measures of actual benefits. To better quantify the benefits of different regulatory options, the RCI and RCI* values are used.

From Tables 6-22 and 6-23, the results of the analysis may be summarized as follows:

- With no bus regulation (baseline column), the RCI becomes increasingly negative due primarily to increases in bus operations and U.S. population growth. This same trend is apparent for Option 1.

TABLE 6-22

SLEEP DISRUPTION IMPACT - ALL BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	48.64	48.64	48.64	48.64	48.64	48.64	48.64	48.64	48.64	48.64
1985	69.44	66.86	64.58	66.55	64.58	66.60	69.38	64.58	64.58	33.61
1990	83.60	78.87	64.69	65.96	57.70	59.34	63.83	54.90	57.83	12.76
1995	95.49	89.11	64.48	64.53	48.82	49.52	53.07	41.29	49.11	1.49
2000	107.26	99.95	68.99	68.21	47.26	47.31	48.22	36.10	47.66	0.04
2010	133.00	123.55	85.02	83.99	57.57	57.57	57.57	43.03	58.03	0.03

TABLE 6-23

SLEEP DISRUPTION IMPACT - ALL BUSES

YEARS	REGULATORY OPTIONS, RELATIVE CHANGE IN IMPACT (RCI)																			
	Baseline		Option 1		Option 2		Option 2A		Option 3		Option 3A		Option 3B		Option 4		Option 5		Option Q	
	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*
1980	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
1985	-42.66	0$00	-37.46	3.63	-32.77	6.92	-36.82	7.08	-32.77	6.92	-36.92	4.01	-42.64	0.00	-32.77	6.92	-32.77	6.92	30.9	51.55
1990	-71.80	0.00	-61.84	5.89	-33.0	22.62	-31.61	21.10	-18.63	30.98	-22.0	29.02	-33.29	22.95	-12.87	34.33	-18.89	30.83	73.77	84.74
1995	-96.24	0.00	-83.20	6.68	-32.57	32.47	-32.67	32.42	-3.70	48.87	-1.81	48.14	-9.11	44.42	15.11	56.76	-0.97	48.57	96.94	98.44
2000	-120.43	0.00	-105.49	6.82	-41.84	35.68	-40.23	36.41	2.84	55.94	2.73	55.89	8.63	55.04	25.78	66.34	2.01	55.57	99.93	79.97
2010	-173.33	0.00	-154.01	7.11	-74.79	36.08	-72.68	36.85	-18.36	56.71	-18.36	56.71	-18.36	56.71	11.53	67.65	-19.31	56.37	99.95	99.9[illegible]

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.
RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

- o For Options 2 and 2A, the RCI holds constant until about 1995. Up to this time, the effects of the increasingly strict regulations are just offset by increases in bus operations and U.S. population. After 1995, the RCI becomes again more negative, in the absence of more stringent noise emission standards.

- o For the remainder of the regulatory options, the situation improves dramatically between 1985 and 2000. Option Q virtually eliminates all impact. Of the remaining options, Option 4 demonstrates the most significant improvement where the extent and severity of potential sleep disruption is estimated to be reduced by 26 percent, relative to 1980 -- even with the anticipated increase in bus operations and U.S. population.

- o Each of the regulatory options shows an RCI around minus 30-to-40 percent for the year 1985. This increase in impact results from significant increases in bus operations between 1980 and 1985. The difference between options show the effects of regulatory lead times (effective dates) on near-term benefits.

As discussed above, the RCI* values pertain only to a single year to avoid confusion of regulatory consequences with anticipated increases in bus operations and U.S. population. These RCI* values show the potential benefits for any given year relative to the impact that would occur in that year with no bus noise reduction.

The trends in RCI* in Table 6-23 are as follows:

- o For the year 1985, (with only the first stage of regulation in effect) the various regulatory options result in benefits up to 7 percent (with the exception of Option Q).
- o For later years, (as the regulatory levels become more stringent) the potential benefits increase to approximately 68 percent except Option Q which shows a virtual elimination of impact.
- o In general, the more stringent regulatory options show greater RCI* benefits, with Option 4 yielding by far the greatest benefits in the later years (with the exception of Option Q).

Tables 6-22 and 6-23 do not distinguish among the three types of buses: transit, intercity, and school buses. Separate LWP results appear in Tables F-11 through F-13 in Appendix F. Similarly, RCI and RCI* results appear separately by bus type in Tables F-14 through F-16. A comparison of Tables F-11 through F-16 indicates that transit buses dominate sleep disruption, followed by intercity buses and then school buses.

The second type of activity interference is sleep awakening. The probability of sleep awakening is less than for sleep disruption, since it takes more noise, generally of longer duration, to awaken a sleeper than it does to change the depth of sleep state.

For sleep awakening, LWP and both RCI and RCI* appear in Tables 6-24 and 6-25. These tables are organized identically to Tables 6-22 and 6-23. Again, in Table 6-24, the LWP values represent a composite number of the people exposed, the number of passby events, and the probability of an interference occurring.

TABLE 6-24

SLEEP AWAKENING IMPACTS - ALL BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	25.64	25.64	25.64	25.64	25.64	25.64	25.64	25.64	25.64	25.64
1985	36.67	35.34	34.12	35.15	34.12	35.18	36.67	34.12	33.59	17.73
1990	44.22	41.67	33.98	34.63	30.23	31.07	34.03	28.75	30.30	6.73
1995	50.52	47.13	33.64	33.67	25.21	25.58	27.50	21.23	25.36	0.79
2000	56.70	52.78	35.86	35.46	23.93	24.20	24.69	18.29	24.37	0.01
2010	70.18	65.10	44.18	43.65	29.38	29.38	29.38	21.78	29.62	0.01

TABLE 6-25

SLEEP AWAKENING IMPACTS - ALL BUSES

YEARS	REGULATORY OPTIONS, RELATIVE CHANGE IN IMPACT (RCI)																			
	Baseline		Option 1		Option 2		Option 2A		Option 3		Option 3A		Option 3B		Option 4		Option 5		Option Q	
	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*
1980	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
1985	-43.02	0.00	-37.83	3.63	-33.07	6.95	-32.09	4.15	-33.07	6.95	-37.21	4.06	-43.02	0.00	-33.07	6.95	-31.01	8.40	30.85	51.65
1990	-72.46	0.00	-62.52	5.77	-32.53	23.16	-35.06	21.69	-17.90	31.64	-21.18	29.74	-32.72	23.04	-12.13	34.98	-18.06	31.48	73.75	84.78
1995	-97.04	0.00	-83.81	6.71	-31.20	33.41	-31.32	33.35	1.68	50.10	0.23	49.37	-7.25	45.57	17.20	57.98	1.09	49.80	96.92	98.44
2000	-121.14	0.00	-105.85	6.91	-39.86	36.75	-38.30	37.46	6.67	57.80	5.61	57.32	3.71	56.46	28.67	67.74	4.95	57.02	99.96	99.98
2010	-173.71	0.00	-153.90	7.24	-72.31	37.05	-70.24	37.80	-14.59	58.14	-14.59	58.14	-14.59	58.14	15.05	68.97	-15.52	57.79	99.96	99.99

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.
RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

These tables show a very large reduction in potential sleep awakenings due to the regulation of bus noise. The trends in RCI and RCI* for sleep awakening are nearly identical to the trends evidenced in Tables 6-22 and 6-23 for sleep disruption. For example, Options Q and 4 show the most benefits, with a virtual elimination of impact under Option Q, and reductions in RCI and RCI* of nearly 15 and 68 percent, respectively for Option 4 in the year 2010.

Separate results for each of the three types of buses appear in Tables F-17 and F-22 in Appendix F. A comparison of these tables indicates the same trends as discussed above for sleep disruption. Again, transit buses dominate over intercity buses and school buses.

The third type of activity interference examined is speech interference. Discussed first is total speech interference -- indoors at home, outdoors at home, and for pedestrians near bus routes. Then these three types of speech interference are separately tabulated and discussed.

For total speech interference, LWP, RCI and RCI* appear in Tables 6-26 and 6-27. Again, these tables are organized identically to the previous tables. The RCI and RCI* values in Table 6-27 summarize the LWP trends in Table 6-26.

These tables show very large benefits in terms of reduced speech interference due to the regulation of bus noise. The trends in RCI are as follows:

- o With no bus regulation (baseline column), the RCI becomes increasingly negative -- as the increase in bus operations and U.S. population cause increased exposure to the (unregulated) buses. This same trend is apparent for Option 1.

TABLE 6-26

TOTAL SPEECH INTERFERENCE - All Buses

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33
1985	10.55	10.42	10.11	10.21	10.11	10.32	10.55	10.11	10.11	5.26
1990	12.72	12.45	10.49	10.56	9.50	9.59	10.26	9.09	9.55	2.23
1995	14.52	14.15	10.72	10.66	8.87	8.51	9.78	7.24	8.99	0.60
2000	16.27	15.86	11.54	11.34	8.42	8.42	8.54	6.77	8.57	0.42
2010	20.11	19.57	14.23	13.43	10.33	10.33	10.33	8.04	10.47	0.95

TABLE 6-27

TOTAL SPEECH INTERFERENCE - ALL BUSES

YEARS	REGULATORY OPTIONS, RELATIVE CHANGE IN IMPACT (RCI)																			
	Baseline		Option 1		Option 2		Option 2A		Option 3		Option 3A		Option 3B		Option 4		Option 5		Option Q	
	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*
1980	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
1985	-43.92	0.00	-42.08	1.28	-37.83	4.23	-39.25	3.24	-37.83	4.23	-40.68	2.25	-43.88	0.03	-37.83	4.23	-37.83	4.23	28.27	50.16
1990	-73.47	0.00	-69.79	2.12	-43.11	17.50	-44.00	16.99	-29.54	25.32	-30.78	24.61	-39.98	19.31	-23.96	28.54	-30.31	24.88	69.57	82.46
1995	-97.94	0.00	-93.02	2.49	-46.17	26.16	-45.39	26.55	-20.95	38.90	-16.03	41.38	-33.20	32.71	1.27	50.12	-22.57	38.08	91.83	95.87
2000	-121.96	0.00	-116.33	2.54	-57.38	29.10	-54.64	30.33	-14.84	48.26	-14.87	48.25	-16.45	47.54	7.69	54.41	-16.91	47.33	94.24	97.41
2010	-174.33	0.00	-166.95	2.69	-94.14	29.23	-83.18	33.23	-40.93	48.63	-40.93	48.63	-40.93	48.63	-9.68	60.02	-42.79	47.95	87.11	95.30

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

- For Options 2 and 2A, the RCI also increases negatively between 1980 and 2000, but much more slowly. For these regulatory options, the bus noise regulations more completely offset the increased impact due to increased bus operations and U.S. population.

- For the remainder of the regulatory options, the situation improves between 1985 and the year 2000. Again, Option Q virtually eliminates all impacts. Of the remaining options, the improvement is a maximum for Option 4, where the RCI is approximately 8 percent for the year 2000. For this year, the bus regulations have reduced the incidence and magnitude of speech interference by 8 percent, relative to 1980 -- even in light of the increase in bus operations and U.S. population.

- Each of the regulatory options shows an RCI of about minus 35-to-45 percent for the year 1985. This increase in impact results from anticipated increases in bus operations between 1980 and 1985, before noise regulations become influential.

The RCI* values, on the other hand, pertain only to a single year, and thereby avoid confusion of regulatory consequences with consequences of increased bus operations and U.S. population.

The RCI* trends in Table 6-27 are as follows:

- For the year 1985, the various regulatory options generally result in benefits up to 4 percent (except Option Q). This indicates the benefits of regulating buses just to the first regulatory level.

- For later years (and as more stringent regulatory levels are imposed), the benefits increase to a maximum approaching 60 percent.

- o In general, the more stringent regulatory options show greater RCI* benefits. Within this trend, Option 4 is more beneficial than the others.

Speech interference impact has been calculated separately for persons at home indoors, persons at home outdoors, and for pedestrians. Corresponding results for these three portions of speech interference appear in Tables 6-28 through 6-33.

The trends in these tables are nearly identical to the trends for total speech interference. The differences are as follows:

- o For indoor speech interference (Tables 6-28 and 6-29), the RCI values level out for Options 2 and 2A, rather than deteriorating between 1985 and 1995. For the remainder of the regulatory options, the benefits improve dramatically between 1985 and the year 2000. The initial deterioration prior to 1985 would be completely offset by the regulations. Other than Option Q, Option 4 yields greater benefits than the others.

- o Also for indoor speech interference, the RCI* for 1985 (with only the first level of regulation in effect) ranges from 4 to 6 percent. The differences between Options are more apparent in later years, with benefits rising to above 70 percent for Option 4. Although these RCI* benefits are greater for indoor speech interference than for total speech interference, the lower baseline population means fewer people benefited.

- o For outdoor speech interference (Tables 6-30 and 6-31), the Baseline and Option 1 RCI's shows a progressively worsening situation with time.

TABLE 6-28

INDOOR SPEECH INTERFERENCE - ALL BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
1985	3.09	3.05	2.92	2.95	2.92	2.95	3.09	2.92	2.92	1.50
1990	3.71	3.62	2.82	2.84	2.49	2.52	2.80	2.39	2.51	0.58
1995	4.23	4.11	2.70	2.70	1.96	1.97	2.97	1.57	1.99	0.08
2000	4.73	4.60	2.83	2.82	1.79	1.79	1.84	1.38	1.84	0.01
2010	5.83	5.65	3.47	3.45	2.16	2.16	2.16	1.52	2.22	0.01

TABLE 6-29

INDOOR SPEECH INTERFERENCE - ALL BUSES

YEARS	REGULATORY OPTIONS RELATIVE CHANGE IN IMPACT (RCI)																			
	Baseline		Option 1		Option 2		Option 2A		Option 3		Option 3A		Option 3B		Option 4		Option 5		Option Q	
	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*
1990	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
1985	-43.67	0.00	-41.67	1.39	-35.67	5.57	-37.30	4.44	-35.63	5.60	-37.35	4.40	-43.67	0.00	-35.63	5.60	-35.63	5.60	30.19	51.41
1990	-72.70	0.00	-68.42	2.48	-31.26	24.00	-32.28	23.40	-15.86	32.91	-17.35	32.05	-30.00	24.72	-11.02	35.71	-16.65	32.45	73.16	84.46
1995	-96.70	0.00	-91.02	2.88	-25.63	36.13	-25.63	36.13	9.07	53.77	8.42	53.44	-37.95	29.86	26.88	62.83	7.40	52.92	96.33	98.13
2000	-120.09	0.00	-113.72	2.90	-31.49	40.26	-31.16	40.25	16.60	62.11	16.56	62.09	14.42	61.12	36.05	70.94	14.42	61.12	99.49	99.77
2010	-171.16	0.00	-162.84	3.07	-61.30	40.51	-60.28	40.89	-0.60	62.90	-0.60	62.90	-0.60	62.90	29.16	73.88	-3.12	61.97	99.44	99.79

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

TABLE 6-30

OUTDOOR SPEECH INTERFERENCE - ALL BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35
1985	1.95	1.92	1.85	1.80	1.85	1.87	1.95	1.85	1.85	1.00
1990	2.36	2.30	1.86	1.81	1.65	1.67	1.82	1.58	1.66	0.45
1995	2.69	2.63	1.84	1.81	1.37	1.38	1.48	1.19	1.39	0.13
2000	3.02	2.95	1.96	1.95	1.31	1.31	1.34	1.04	1.32	0.09
2010	3.74	3.64	2.42	2.42	1.64	1.64	1.64	1.24	1.62	0.11

TABLE 6-31

OUTDOOR SPEECH INTERFERENCE - ALL BUSES

YEARS	REGULATORY OPTIONS, RELATIVE CHANGE IN IMPACT (RCI)																			
	Baseline		Option 1		Option 2		Option 2A		Option 3		Option 3A		Option 3B		Option 4		Option 5		Option Q	
	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*
1980	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
1985	-44.44	0.00	-42.22	1.54	-37.03	5.13	-33.33	7.69	-37.03	5.13	-38.52	4.10	-44.44	0.00	-37.03	5.13	-37.03	5.13	25.92	48.72
1990	-74.81	0.00	-70.37	2.54	-37.77	21.19	-34.07	23.30	-22.00	30.08	-23.70	29.24	-34.81	22.88	-17.03	33.05	-22.96	29.66	66.66	80.93
1995	-99.35	0.00	-94.81	2.23	-36.29	31.60	-34.07	32.71	-1.48	49.07	-2.22	48.69	-9.62	44.98	11.85	55.76	-2.96	48.32	90.37	95.16
2000	-123.70	0.00	-118.51	2.32	-45.18	35.09	-44.44	35.43	2.96	56.62	2.96	56.62	0.74	56.62	22.96	65.56	2.22	56.29	93.33	97.01
2010	-177.03	0.00	-169.62	2.67	-79.25	35.24	-79.25	35.29	-21.48	56.14	-21.48	56.14	-21.48	56.14	8.14	66.84	-20.00	56.68	91.85	97.05

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.
RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

TABLE 6-32

PEDESTRIAN SPEECH INTERFERENCE - ALL BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)								
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	3.83	3.83	3.83	3.83	3.83	3.83	3.83	3.83	3.83	3.83
1985	5.51	5.45	5.34	5.39	5.34	5.39	5.51	5.34	5.34	2.80
1990	6.65	6.52	5.82	5.85	5.36	5.40	5.65	5.12	5.39	1.26
1995	7.59	7.42	6.18	6.14	5.54	5.16	5.32	4.48	5.61	0.43
2000	8.52	8.32	6.76	6.69	5.32	5.32	5.36	4.36	5.41	0.35
2010	10.55	10.29	8.35	7.58	6.53	6.53	6.53	5.28	6.63	0.44

TABLE 6-33

PEDESTRIAN SPEECH INTERFERENCE - ALL BUSES

YEARS	REGULATORY OPTIONS RELATIVE CHANGE IN IMPACT (RCI)																			
	Baseline		Option 1		Option 2		Option 2A		Option 3		Option 3A		Option 3B		Option 4		Option 5		Option Q	
	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*	RCI	RCI*
1980	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
1985	-43.87	0.00	-42.20	1.16	-39.35	3.14	-40.53	2.23	-39.35	3.14	-40.63	2.25	-43.79	0.05	-39.35	3.14	-39.35	3.14	27.06	49.30
1990	-73.54	0.00	-70.25	1.89	-51.80	12.53	-52.58	12.08	-39.87	19.40	-40.92	18.80	-47.42	15.05	-33.66	22.98	-40.68	18.93	67.25	81.13
1995	-98.09	0.00	-93.63	2.25	-61.22	18.61	-60.28	19.09	-44.62	26.99	-34.66	32.02	-38.88	29.89	-16.91	40.98	-46.40	26.10	83.86	94.37
2000	-122.36	0.00	-117.15	2.35	-76.30	20.71	-74.58	21.49	-38.80	37.58	-38.83	37.57	-39.95	37.06	-13.65	48.89	-41.18	36.51	90.81	95.87
2010	-175.23	0.00	-168.42	2.47	-117.88	20.84	-97.83	28.12	-70.33	38.11	-70.33	38.11	-70.33	38.11	-37.66	49.99	-73.12	37.10	88.57	95.35

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

Options 2 and 2A level out beginning about 1985 as in the case of indoor speech interference. For the remainder of the regulatory options, the situation improves between 1985 and 2000, though not as dramatically as for indoor speech interference. With the exception of Option Q, Option 4 results in greater benefit than the others.

- Also for outdoor speech interference, the RCI* benefits rise towards 70 percent for Option 4, though again the lower baseline population for outdoor speech interference means fewer people benefited.

- For pedestrian speech interference (Tables 6-32 and 6-33), the RCI trends match the total trends more closely, since the baseline pedestrian population is more than half the total. The RCI does not become positive for any of the options considered, except for Option Q.

- Also for pedestrian speech interference, the RCI* trends also match the total trends closely. For later years, the benefits increase to a maximum of 50 percent. Except for Option Q, Option 4 is more beneficial than the others.

Tables 6-28 through 6-33 do not distinguish among the three types of buses: transit, intercity, and school buses. Separate LWP results appear in Tables F-23 through F-31 in Appendix F -- and also separately for indoor, outdoor, and pedestrian speech interference. Similarly, separate RCI and RCI* results appear in Tables F-32 through F-40. These latter tables contain only selected years, and also repeat some of the LWP information from Tables F-23 through F-31.

Interior Impact

Interior noise impacts have been assessed with respect to both passengers and drivers of the buses.

Two types of interior impact are considered: hearing damage risk and speech interference. Hearing damage risk is assessed in terms of the twenty-four hour equivalent sound level, $L_{eq(24)}$. Speech interference is evaluated in terms of the equivalent sound level, $L_{eq(T)}$, during the duration of exposure (brief for passengers and essentially the full work day for bus operators). These noise metrics are discussed in the subsection entitled "Noise Metrics."

Potential hearing damage risk and speech interference impacts are tabu-ated (1) for passengers and (2) for operators. These results, presented in ables 6-34 to 6-61, consist of LWP, RCI, and RCI* values in the same format s in the exterior noise tables presented previously. The results presented n these Tables pertain to all buses. Separate tabulations for transit, ntercity, and school buses which highlight the differences by bus type, are resented in Tables D-41 to D-120 in Appendix D.

Risk of hearing damage results from long-term exposure to noise, from all ources. For this reason it is assessed using the twenty-four hour measure $_{eq(24)}$. Bus noise makes up only a portion of this twenty-four hour noise xposure, both for passengers and operators (see Table 6-16). Therefore, he adverse effect of the bus noise on hearing depends, in part, upon each erson's total noise exposure for that portion of each twenty-four hour period hen the person is not on the bus. That is, risk of noise-induced hearing ill vary depending upon daily noise exposures received by passengers and drivers at times when they are not riding on the bus. Because of the wide variation in individual life styles and activities, it is difficult to determine precisely these patterns of non-bus noise exposure. Therefore, for this analysis, three values of non-bus "background" noise exposure have been assumed: 60 dB, 70 dB, and 80 dB. Separate tables containing the results for each of these three background noise possibilities are presented.

In all, for examining potential hearing damage risk, upon passengers and drivers the following tabulations were carried out with results in terms of LWP, RCI and RCI*:

- o Passengers and drivers
  - o All buses combined
    - o LWP for 60 dB non-bus noise exposure
    - o RCI for 60 dB non-bus noise exposure
    - o RCI* for 60 dB non-bus noise exposure
    - o These same three tables for 70 dB background
    - o These same three tables for 80 dB background

The results of the analysis of potential hearing damage risk to passengers for all bus type appear in Tables 6-34 through 6-42. Tables 6-34 through 6-36 show the LWP, RCI and RCI* values assuming a non-bus noise exposure level of 60 dB. The LWP_H values contained in these tables are composite numbers representing the total number of bus riders over a variety of exposure times and levels. For example, Table 6-34 shows that in 1990 for Option 3 there is predicted to be a Level Weighted Population of 71,200. From Tables 6-35 and 6-36, the corresponding RCI and RCI* values are 76.46 and 84.7 percent, respectively. In other words, Option 3 shows that in 1990 there would be 76 percent reduction in risk of hearing damage from that occurring in 1980, and almost an 85 percent reduction from that which would occur in 1990.

TABLE 6-34

HEARING LOSS IMPACT: PASSENGERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 60 - LWPH (thousands)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	302.5	302.5	302.5	302.5	302.5	302.5	302.5	302.5	302.5
1985	410.2	198.3	198.3	323.0	198.3	366.4	410.2	198.3	198.3
1990	464.6	71.2	71.2	161.4	71.2	199.0	282.2	71.2	71.2
1995	500.9	7.8	7.8	40.2	7.8	59.0	110.0	7.8	7.8
2000	531.5	0.1	0.1	1.4	0.1	3.9	16.4	0.1	0.1
2008	582.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 6-35

HEARING LOSS IMPACT: PASSENGERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 60 - RCI

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-35.60	34.45	34.45	- 6.78	34.45	-21.12	-35.60	34.45	34.45
1990	-53.59	76.46	76.46	46.64	76.46	34.21	6.71	76.46	76.50
1995	-65.59	97.42	97.42	86.71	97.42	80.50	63.64	97.42	97.42
2000	-75.70	99.97	99.97	99.54	99.97	98.71	94.58	99.97	100.0
2008	-92.46	100	100	100	100	100	100	100	100.0

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

TABLE 6-36

HEARING LOSS IMPACT: PASSENGERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 60 - RCI*

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	51.7	51.7	21.3	51.7	10.7	0.0	51.7	51.7
1990	0.0	84.7	84.7	65.3	84.7	57.2	39.3	84.7	84.7
1995	0.0	98.4	98.4	92.0	98.4	88.2	78. 0	98.4	98.4
2000	0.0	100.0	100.0	99.7	100.0	99.3	96.9	100.0	100.0
2008	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

TABLE 6-37

HEARING LOSS IMPACT: PASSENGERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	3083.1	3083.1	3083.1	3083.1	3083.1	3083.1	3083.1	3083.1	3083.1
1985	4044.7	2532.7	2448.1	3255.6	2448.1	3648.4	4044.7	2448.1	2448.1
1990	4457.4	1685.6	1180.0	1748.9	1090.3	1997.3	2742.8	1081.3	1115.7
1995	4701.4	1280.6	452.3	644.2	262.3	621.8	1075.6	239.1	314.5
2000	4930.5	1283.8	305.7	310.2	57.2	84.2	194.7	24.7	123.9
2008	5321.1	1384.1	322.4	322.4	45.0	45.0	45.0	7.8	116.7

TABLE 6-38

HEARING LOSS IMPACT: PASSENGERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-31.19	17.85	20.60	-5.60	20.60	-18.34	-31.19	20.60	20.60
1990	-44.58	45.33	61.73	43.27	64.64	35.22	11.04	64.93	63.81
1995	-52.49	58.46	85.33	79.11	91.49	79.83	65.11	92.24	89.80
2000	-54.92	58.36	90.08	89.94	98.14	97.27	93.68	99.20	95.98
2008	-72.59	55.11	89.54	89.54	98.54	98.54	98.54	99.75	96.21

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

TABLE 6-39

HEARING LOSS IMPACT: PASSENGERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	37.4	39.5	19.5	39.5	9.8	0.0	39.5	39.47
1990	0.0	62.2	73.5	60.8	75.5	55.2	38.5	75.7	74.97
1995	0.0	72.8	90.4	86.3	94.4	86.8	77.1	94.9	93.31
2000	0.0	74.0	93.8	93.7	98.8	98.3	96.1	99.5	97.49
2008	0.0	74.0	93.9	93.9	99.2	99.2	99.2	99.9	97.81

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

TABLE 6-40

HEARING LOSS IMPACT: PASSENGERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - LWPH (thousands)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	210989.5	210989.5	210989.5	210989.5	210989.5	210989.5	210989.5	210989.5	210989.5
1985	298342.6	296909.9	296761.3	297459.3	296761.3	297899.1	298342.6	296761.3	296761.4
1990	364950.1	362336.1	361449.6	361929.1	361108.9	361966.6	362799.2	361005.4	361239.3
1995	430206.3	426999.2	425546.8	425698.3	424824.6	425163.4	425669.0	424555.2	425092.0
2000	502784.5	499380.7	497663.1	497663.3	496715.4	496740.8	496863.9	496333.4	497057.1
2008	637404.5	633750.9	631880.5	631880.5	630816.1	630816.1	630816.1	630367.0	631783.4

TABLE 6-41

HEARING LOSS IMPACT: PASSENGERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-41.40	-40.72	-40.65	-40.98	-40.65	-41.19	-41.40	-40.65	-40.65
1990	-72.97	-71.73	-71.31	-71.54	-71.15	-71.56	-71.95	-71.10	-71.21
1995	-103.90	-102.38	-101.69	-101.76	-101.35	-101.51	-101.75	-101.22	-101.48
2000	-138.30	-136.69	-135.87	-135.87	-135.42	-135.43	-135.49	-135.24	-135.58
2008	-202.10	-200.37	-199.48	-199.48	-198.98	-198.98	-198.98	-198.77	-199.44

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

TABLE 6-42

HEARING LOSS IMPACT: PASSENGERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI*

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.5	0.5	0.3	0.5	0.1	0.0	0.5	0.53
1990	0.0	0.7	1.0	0.8	1.1	0.8	0.6	1.1	1.02
1995	0.0	0.7	1.1	1.0	1.3	1.2	1.1	1.3	1.9
2000	0.0	0.7	1.0	1.0	1.2	1.2	1.2	1.3	1.14
2008	0.0	0.6	0.9	0.9	1.0	1.0	1.0	1.1	0.88

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

In Table 6-34, two trends are apparent in the LWP_H. First, the LWP_H decrease with time as ever more stringent regulations are imposed. This decrease in impact shows that the projected benefits from reducing bus noise emissions predominate over the concurrent increases in the number of bus passengers.

The second trend apparent in Table 6-34 is the pattern across regulatory options. During 1980, no decrease in LWP_H occurs, since no regulations exist. For later years, all regulatory options show a decrease in LWP_H, some reducing it to near zero. Towards the turn of the century, the decrease in LWP is dramatic for all the regulatory options, although several of the options show significantly higher LWP_H (and therefore less benefits).

Corresponding to Table 6-34, the RCI values in Table 6-35 are 100 percent for all options in the year 2008. This value means that all of the risk of potential hearing damage (due to bus noise only) will be eliminated by reducing interior bus noise assuming a non-bus noise exposure level of 60 dB. That is, none of these persons will be subject to hearing damage risk due to non-bus and bus noise combined.

For the intermediate years, Table 6-35 indicates that progress towards 100 percent reduction is most rapid for Options 1, 2, 3, 4, and 5, with the others trailing only slightly before the year 2000. For all options, however, the year 2008 reduction of 100 percent results in a benefit to the full 1980 LWP_H of 302,500.

The RCI* values in Table 6-36 also shows that by the year 2008 all potential risk of hearing loss impact (due to bus noise only and assuming a 60 dB non-bus noise background) is eliminated by reducing interior bus noise. For 1985, these RCI* values show zero percent for the no regulation baseline, and increase to 51.7 percent for Options 1, 2, 3, 4, and 5. For these options over half the predicted impact is eliminated, even this early in the regulatory time stream. By the year 2008, all regulatory options have eliminated the hearing damage risk due to buses (as combined with a 60 dB non-bus background exposure). This elimination of impact occurs even with the anticipated increase in bus ridership.

Tables 6-37 through 6-39 present the LWP_H, RCI and RCI* values assuming a non-bus noise exposure level of 70 dB. Table 6-37 shows a 1980 baseline LWP_H of 3,083,100 for the case of a 70 dB non-bus noise exposure compared to an LWP_H of 302,500 with a 60 dB non-bus exposure. This increase in LWP_H is due to both the increased non-bus noise exposure and the high interior bus noise levels. This is because hearing damage risk is not a simple function of bus noise combined with background noise. Near the hearing damage risk threshold of 70 dB, the LWP_H will increase dramatically with an increase in background noise providing that the interior bus noise levels are relatively high. On the other hand, were either of these two components to be significantly lower (as in the 60 dB non-bus background case), this sensitivity would be far less.

The RCI values in Table 6-38 show that 90 percent of the impact is eliminated for most of the regulatory options by the year 2008. Typically, Options 3, 3A, and 3B result in a benefit of 98.54 percent. This translates to a reduction in LWP of 3,038,100. Note that this is far more benefit than is achieved for the 60 dB non-bus exposure case.

The RCI* values in Table 6-39 show the benefits of the bus regulation excluding increases in bus ridership. For the year 2008, the values in the table show nearly 100 percent benefit for all of the options except Option 1. For intermediate years, Options 2, 3, 4, and 5 are superior to the others.

Table 6-40 through 6-42 are similar to the previously presented tables, but for a non-bus exposure level of 80 dB. Table 6-40 shows for 1980 an LWP of 210,989,500 compared to the 3,083,100 value with the 70 dB non-bus exposure. This increase is due mostly to the non-bus background noise. Although the bus may contribute to a risk of hearing damage, it would contribute much less than other community and/or workplace noises that make up the remaining daily exposure for the 80 dB non-bus case. This is not true for the other cases examined.

Tables 6-41 and 6-42 show essentially no benefit from the regulation of bus noise assuming an 80 dB non-bus noise exposure. Bus noise exposure would be minimal compared to community and/or workplace noises that make up the remaining daily exposure.

Benefits in terms of reduced risk of noise-induced hearing damage will vary depending upon daily noise exposures received by passengers and drivers at times when they are not riding on the bus. For example, passengers who experience a 60 dB non-bus exposure would incur only little additional risk from interior bus noise, and therefore would not receive large benefits from interior noise reduction. For passengers who may experience an 80 dB non-bus exposure, the regulation would reduce their total risk of incurring hearing loss by only around 1 percent (RCI*). For passengers who would experience a non-bus daily noise exposure of about 70 dB, which is a very typical exposure encountered by a large percentage of the nation's population, the regulation of bus noise would be effective and virtually eliminate any risk of hearing impairment. Obviously, for non-bus exposures within the extremes discussed here, benefits would vary accordingly.

The results of the analysis for potential driver hearing damage risk for all buses is presented in Tables 6-43 through 6-49 -- for non-bus background noise exposures of 60 dB, 70 dB, and 80 dB.

The baseline LWP_H for the 60 dB non-bus background in Table 6-43 shows that the hearing damage risk is minimal in this case. During the year 2008, with no bus regulation, 200,000 drivers may be adversely affected. The potential impact upon drivers is essentially eliminated by all regulatory options except Option 1. With such small numbers of impacts, the trends are obvious; so the corresponding tables for RCI and RCI* are not included here.

With a non-bus background exposure of 70 dB, Table 6-44 shows higher driver LWP_H, though not nearly so high as for passengers. In essence, the difference follows directly because the number of drivers is far smaller than the number of passengers.

The corresponding RCI and RCI* tables (Tables 6-45 and 6-46) show that nearly all potential impact is eliminated by Options 3, 4, and 5.

With a non-bus background of 80 dB, Table 6-47 shows even higher operator LWP_H. As with passengers, these driver LWP_H are due nearly completely to non-bus noise exposure. As Tables 6-48 and 6-49 show, the potential benefits from bus interior noise regulations is small when the population is exposed to such high non-bus noise levels. Benefits are, by far, more significant for drivers who may incur non-bus exposures on the order of 65-75 dB.

For transit buses only, the results of the analysis for hearing damage risk appear in Tables F-41 through F-56. These tables parallel those already

TABLE 6-43

HEARING LOSS IMPACT: DRIVERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 60 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1985	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1990	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1995	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 6-44

HEARING LOSS IMPACT: DRIVERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	29.7	29.7	29.7	29.7	29.7	29.7	29.7	29.7	29.9
1985	38.6	26.2	25.3	31.7	25.3	35.1	38.6	25.3	25.2
1990	42.3	19.4	14.0	18.6	12.6	20.2	26.7	12.2	12.7
1995	44.6	16.4	7.3	8.8	4.3	7.3	11.4	3.3	4.4
2000	46.7	17.0	6.1	6.1	2.0	2.3	3.3	0.7	2.4
2008	50.2	18.6	6.7	6.7	2.1	2.1	2.1	0.5	2.5

TABLE 6-45

HEARING LOSS IMPACT: DRIVERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-29.97	11.78	14.81	-6.73	14.81	-18.18	-29.97	14.81	15.15
1990	-42.42	34.68	52.86	37.37	57.58	31.99	10.10	58.92	57.24
1995	-50.17	44.78	75.42	70.37	85.52	75.42	61.61	88.89	85.19
2000	-57.24	42.76	79.46	79.46	93.27	92.26	88.89	97.64	91.92
2008	-69.02	37.37	77.44	77.44	92.93	92.93	92.93	98.32	91.58

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

TABLE 6-46

HEARING LOSS IMPACT: DRIVERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	32.1	34.5	17.7	34.5	8.9	0.0	34.5	34.7
1990	0.0	54.0	66.9	56.0	70.3	52.3	36.8	71.1	70.0
1995	0.0	63.2	83.6	80.2	90.5	83.6	74.5	92.5	90.1
2000	0.0	63.7	87.0	87.0	95.6	95.1	93.0	98.5	94.9
2008	0.0	62.8	86.7	86.7	95.8	95.8	95.8	99.0	95.0

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

TABLE 6-47

HEARING LOSS IMPACT: DRIVERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	1487.2	1487.2	1487.2	1487.2	1487.2	1487.2	1487.2	1487.2	1487.2
1985	1927.9	1911.6	1910.6	1918.0	1910.0	1922.9	1927.9	1910.0	1910.0
1990	2114.9	2084.9	2074.9	2080.6	2070.3	2080.3	2089.3	2068.6	2074.9
1995	2230.0	2192.9	2176.4	2178.3	2166.6	2170.6	2176.5	2162.5	2176.4
2000	2338.6	2299.4	2297.8	2279.8	2266.8	2267.1	2268.5	2260.5	2279.8
2008	2513.3	2471.8	2450.3	2450.3	2435.8	2435.8	2435.8	2428.4	2450.4

TABLE 6-48

HEARING LOSS IMPACT: DRIVERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-29.63	-28.54	-28.43	-28.97	-28.43	-29.30	-29.63	-28.43	-28.43
1990	-42.21	-40.19	-39.52	-32.90	-39.21	-39.88	-40.52	-39.09	-39.52
1995	-49.95	-47.45	-46.34	-46.47	-45.68	-45.95	-46.35	-45.38	-46.34
2000	-57.25	-54.61	-53.29	-52.29	-52.42	-52.44	-52.53	-52.00	-53.29
2008	-64.00	-66.20	-64.76	-64.76	-63.78	-63.78	-63.78	-63.29	-64.77

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

TABLE 6-49

HEARING LOSS IMPACT: DRIVERS FOR ALL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.8	0.9	0.5	0.9	0.3	0.0	0.9	0.9
1990	0.0	1.4	1.9	1.6	2.1	1.6	1.2	2.2	1.9
1995	0.0	1.7	2.4	2.3	2.8	2.7	2.4	3.0	2.4
2000	0.0	1.7	2.5	2.5	3.1	3.1	3.0	3.3	2.5
2008	0.0	1.7	2.5	2.5	3.1	3.1	3.1	3.4	2.5

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

discussed, and show the same general trends. For all regulatory options, with 60 dB background, the year 2008 reduction in RCI of 100 percent results in a benefit reduction in LWP_H of 302,300. The LWP_H hearing damage risk due to transit buses is nearly equal to the total for all buses for the case of a 60 dB non-bus noise exposure.

With a 70 dB noise bus exposure, (Tables F-44 through F-46), the trends for transit buses are the same as for all buses combined. Then 80 dB background case (Tables F-47 through F-49), again shows minimal potential benefits.

The corresponding results for transit bus drivers is again similar to that for the totality of bus drivers (Tables F-50 to Table F-56). The impact is quite minimal, and the resulting benefits are therefore minimal.

For intercity buses and school buses (separately), the results of the analysis for potential hearing damage risk are presented in Tables F-57 through F-84. RCI and RCI* tables have been omitted, where the LWP_H trends are obvious.

The trends for intercity and school buses are approximately the same as for all buses combined, except for the following:

- o For a 60 dB non-bus exposure, the LWP_H is often zero, even for no regulation (Tables F-57, F-64, F-71, and F-78).
- o For intercity passengers with a 70 dB non-bus exposure, Option 4 yields greater benefits than the others (Tables F-58 to F-60).
- o For intercity passengers with 80 dB non-bus exposure, no benefit (RCI* equals zero) accrues from bus interior noise regulation (Tables F-61 to F-63).

- For intercity drivers with 70 and 80 dB non-bus exposure, Option 4 is superior to the others, though the benefit in terms of a reduction in LWP_H is only 1,200 for 70 dB background, and 1,800 for 80 dB background (Tables F-65 to F-70).

It is apparent from Tables F-41 to F-54 that transit buses dominate the adverse impact for a 60 dB non-bus noise exposure. For such an exposure, the impact and benefits are moderate. For a 70 dB non-bus exposure, school buses are comparable to transit buses. It is for this non-bus exposure that the impact and benefits are most sensitive to bus noise regulations. For an 80 dB non-bus exposure, school and intercity buses dominate, though the regulation of interior noise will have essentially no effect upon reducing this impact.

Tables 6-50 through 6-55 have been prepared as a summary of potential hearing damage risk to bus passengers and drivers. The data presented in these tables are expressed in terms of the number of persons potentially affected.

Across the top of each of these tables are listed the regulatory options. Down the left side are percentage ranges, from zero percent to greater-than-100 percent. These percentages represent the yearly allowable noise exposure. Tabulated separately are a selection of years between 1980 and 2008.

For example, Table 6-50 shows that for the year 1980, under Option 2, 17,838,000 people will use or consume 25-50 percent of their total allowable year noise dosage from bus when riding on buses. This would leave 70-75 percent of their allowable dosage left for noise sources other than interior

TABLE 6-50

YEAR: 1980
ALL BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	16550	16550	16550	16550	16550	16550	16550	16550	16550
25-50	17850	17850	17850	17850	17850	17850	17850	17850	17850
50-80	6844	6844	6844	6844	6844	6844	6844	6844	6844
80-100	4772	4772	4772	4772	4772	4772	3381	3381	4970
>100	3108	3108	3108	3108	3108	3108	3108	3108	3108

TABLE 6-51

YEAR: 1985
ALL BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	21618	32366	33776	28819	33776	25235	21618	33776	33776
25-50	24693	18783	17933	19283	17933	20877	22481	17933	17933
50-80	8741	6639	6180	6968	6180	7853	8741	6180	6180
80-100	6355	3577	3480	5022	3480	5686	6355	3480	4380
>100	4213	2045	2043	3318	2043	3763	4213	2043	2043

TABLE 6-52

YEAR: 1990
ALL BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	24053	43377	51798	52073	54536	48143	41398	54542	51661
25-50	27645	17482	12408	13221	9640	11843	14804	9666	11073
50-80	9412	5660	2900	3390	2894	4141	5803	2893	2598
80-100	7093	1977	1391	2487	1391	3055	4326	1391	2250
>100	4767	744	735	1657	735	2043	2897	755	1649

TABLE 6-53

YEAR: 1995
ALL BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	25694	48965	62701	61752	67276	66089	62019	68616	66393
25-50	24448	17046	8790	7793	2973	3801	5569	2950	3857
50-80	9736	5262	714	828	702	1188	2192	700	702
80-100	7559	1209	234	612	234	1026	1671	234	234
>100	5137	97	82	412	82	609	1129	82	82

TABLE 6-54

YEAR: 2000
ALL BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	27497	51853	56870	68157	75790	75605	74615	75825	74361
25-50	25508	17726	8010	7982	377	393	865	346	1507
50-80	10099	5449	65	52	48	83	328	44	48
80-100	7971	1173	9	1	9	59	247	9	9
>100	5450	18	1	14	1	40	168	1	1

TABLE 6-55

YEAR: 2008
ALL BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	30740	56377	74057	74057	82640	82640	82640	82679	81427
25-50	26597	19121	8631	8631	65	65	65	30	1279
50-80	10744	5911	25	25	6	6	6	2	6
80-100	8663	1285	0	0	0	0	0	0	0
>100	5968	19	0	0	0	0	0	0	0

bus noise. Similarly, under a no regulation condition, nearly 4,774,000 riders will use up from 80 to 100 percent of their yearly allowable exposure on buses, leaving little room for exposure to other sources.

Also, as shown in Table 6-50, under most of the regulatory options, approximately 3,100,000 riders may incur more than 100 percent of their total allowable yearly noise dosage just from buses alone. These people would then run some degree of risk of permanent hearing damage from interior bus noise alone, ignoring all other sources of noise in their lives.

Tables 6-51 through 6-55 present the percent noise dosage for later years. Note that bus interior noise regulations will generally shift people from higher percentage dosage brackets into lower ones at the top of the table. Therefore, an increase in percent dosage at the top of the table is indirectly a benefit. However, potential benefit is best represented by decreases in the bottom two lines of the tables.

Table 6-51 indicates that regulations begin to have a beneficial effect by the year 1985, especially Options 1, 3, 3A, 4, and 5. In 1990, (Table 6-52), the benefits are even more pronounced. For these more stringent regulatory options, the number of people above 100 percent exposure has been reduced from 4,200,000 to under 800,000. Most other percentages show significant reduction, also, compared to the baseline at the left. Generally, only those exposed between 0 and 25 percent has increased, as people are brought down from the higher percentage brackets.

For later years (Tables 6-52 through 6-55), the benefit is very large. By the year 2008 (Table 6-55), all options except Option 1 would result in a reduction of the top-most bracket to zero people and the 80-100 percent bracket to 4,000 people. Option 1 is significantly less effective, with

Options 2 and 2A intermediate. Even under Option 1, however, 10,206,000 people are removed from the top-most percentage bracket by the year 2008. Option 3A is slower to produce these potential benefits.

The summary tables are paralleled for the separate types of buses, in Tables F-85 through F-102 in Appendix F. The trends are the same, independent of bus type. Those people affected most severely by bus noise are those in the two top percentage brackets in these tables. At present (1980), approximately 3,100,000 and 4,800,000 people are in these top two brackets. Of particular note, almost 1,000,000 of these people are school children in school buses, as shown in Table F-97. Of these children, all would potentially benefit from bus interior noise regulations. The number of children in the top two brackets is reduced to zero by 2008, even though the increase in school bus ridership is anticipated. All regulatory options bring about this decrease in impact, though Options 1, 2, 3, 4, and 5 bring it about sooner.

Speech interference is the second interior noise impact assessed here. Its metric is the equivalent noise level over the time of exposure, the $L_{eq(T)}$. The LWP, RCI, and RCI* have been computed using this metric, for the interior noise exposure of both passengers and bus drivers.

The results of these analyses for all buses combined are prescribed in Tables 6-56 through 6-61.

Passenger RCI's (Table 6-57) show the trends of a given regulatory option as time increases. All options except Option 1 result in a net benefit by 1995. Options 3 and those more stringent show the most benefit. For all regulatory options, the benefits due to reduce noise emissions outweigh the increased bus ridership.

TABLE 6-56

SPEECH INTERFERENCE: PASSENGERS FOR ALL BUSES LWP (THOUSANDS)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	15895.2	15895.2	15895.2	15895.2	15895.2	15895.2	15895.2	15895.2	15895.2
1985	21259.9	16513.0	16035.0	18362.7	16035.0	19805.6	21259.9	16035.0	16035.0
1990	24266.6	15637.5	12687.4	14272.4	11936.9	14773.8	17526.9	11485.1	12171.5
1995	26717.3	11169.3	1169.3	11662.3	9481.7	10599.5	12285.9	8179.1	19963.2
2000	29393.2	18245.9	12092.8	12092.2	9742.2	9825.9	10240.4	7711.1	10357.7
2008	34288.8	22379.5	15246.9	15246.9	12338.5	12338.5	12338.5	9586.5	13000.2

TABLE 6-57

SPEECH INTERFERENCE: PASSENGERS FOR ALL BUSES RCI

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-33.75	-3.89	-.88	-15.52	-.88	-24.60	-33.75	-.88	-.88
1990	-52.67	1.62	20.18	10.21	24.90	7.05	10.27	27.74	23.43
1995	-68.08	-1.79	29.73	26.63	40.35	33.32	22.71	48.54	25.59
2000	-84.92	-14.79	23.92	23.93	38.71	38.18	35.58	51.49	34.84
2008	-115.72	-40.79	40.79	40.79	22.38	22.38	22.38	39.69	18.21

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

TABLE 6-58

SPEECH INTERFERENCE: PASSENGERS FOR ALL BUSES RCI*

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	22.3	24.6	13.6	24.6	6.8	0.0	24.6	24.6
1990	0.0	35.6	47.7	41.2	50.8	39.1	27.8	52.7	49.8
1995	0.0	39.4	58.2	56.3	64.5	60.3	54.0	69.4	62.7
2000	0.0	37.9	58.9	58.9	66.9	66.6	65.2	73.8	64.8
2008	0.0	34.7	55.5	55.5	64.0	64.0	64.0	72.0	69.8

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

TABLE 6-59

SPEECH INTERFERENCE: DRIVERS FOR ALL BUSES LWP (THOUSANDS)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	147.2	147.2	147.2	147.2	147.2	147.2	147.2	147.2	147.2
1985	188.7	125.3	123.4	159.0	123.4	173.8	188.7	123.4	123.4
1990	204.6	87.8	76.1	102.0	71.7	110.5	139.0	69.6	74.4
1995	213.9	69.8	50.5	59.6	41.0	56.6	74.2	35.6	47.3
2000	222.9	70.6	47.8	48.1	35.3	36.5	40.8	27.7	43.7
2008	237.3	76.0	51.4	51.4	37.5	37.5	37.5	28.8	46.7

TABLE 6-60

SPEECH INTERFERENCE: DRIVERS FOR ALL BUSES RCI

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-28.19	14.88	16.17	-8.02	16.17	-18.07	-28.19	16.17	16.17
1990	-38.99	40.35	48.30	30.71	51.29	24.93	5.57	52.72	49.46
1995	-45.31	52.58	65.69	59.51	72.15	61.55	49.59	75.82	67.87
2000	-51.43	52.04	67.53	67.32	76.02	75.20	72.28	81.18	70.31
2008	-61.21	48.37	65.08	65.08	74.52	74.52	74.52	80.43	68.27

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

TABLE 6-61

SPEECH INTERFERENCE: DRIVERS FOR ALL BUSES RCI*

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	33.6	34.6	15.7	34.6	7.9	0.0	34.6	34.61
1990	0.0	57.1	62.8	50.2	65.0	46.0	32.1	66.0	63.64
1995	0.0	67.4	76.4	72.1	80.8	73.5	65.3	83.4	77.89
2000	0.0	68.3	78.5	78.4	84.1	83.6	81.7	87.6	80.39
2008	0.0	68.0	78.3	78.3	84.2	84.2	84.2	87.8	80.32

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Passenger RCI*'s (Table 6-58) show that all regulatory options would produce relatively large benefits over the unregulated baseline conditions. By the year 1985, these benefits could amount to more than 20 percent for several of the regulatory options. By the year 2008, benefits ranging from 35-72 percent depending upon options, could be realized.

Driver speech interference estimates appear in Tables 6-59 through 6-61. These trends are similar to the trends for passengers, though less difference is apparent among the various regulatory options.

Without regulation, passengers account for approximately one hundred times the impact as do bus drivers. With the most beneficial regulatory option, in the year 2008, this ratio increases to over 300. In percentages, therefore, drivers may benefit more than passengers. In absolute numbers, however, approximately 120,000 drivers could benefit, compared to over 6,000,000 passengers.

Speech interference results are presented separately for transit, intercity and school buses in Tables F-103 through F-120 in Appendix F. In general, these show the same trends as for all buses combined, except for the following:

- Transit bus drivers receive less benefit, relatively. Options 1, 2, and 2A do not succeed in overriding the increased impact due to increased bus operations (Table F-107). Only Option 4 significantly reduces speech interference, relative to its estimated impact in 1980.

- Transit bus drivers receive very minimal benefit from Option 1 (Table F-108).

- For passengers and drivers on intercity buses, none of the regulatory options override increases due to increased bus operations (Table F-110 - F-113). Passengers do benefit, however, when compared on a year-by-year basis to the baseline case with no regulation (Table F-111). Option 4 appears to be the most effective option, and Option 1 the least effective. Drivers of these buses derive minimal benefit from any of the regulatory options except Option 4 (Table F-114).

- Percentage benefits to school bus passengers exceed those for the other two types of buses (Tables F-116 and F-117). These percentage benefits are estimated to exceed 70 percent for all options except Option 1, and approach 90 percent for the higher-numbered options.

REFERENCES

SECTION 6

1. U.S. EPA, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety." EPA Report 550/9-74-004, March, 1974.

2. "An Assessment of the Technology for Bus Noise Abatement," Booz/Allen Applied Research, Draft final report submitted to U.S. Environmental Protection Agency, Office of Noise Abatement and Control, EPA Contract NO. 68-01-3509, June 22, 1976.

3. U.S. Environmental Protection Agency, "Passenger Noise Environments of Enclosed Transportation Systems," Report Number 550/9-75-025, June 1975.

4. Booz/Allen Applied Research, memo to Wyle Research, March 12, 1976.

5. Welch, B.L. and A.S. Welch (Editors), "Physiological Effects of Noise." New York, Plenum Press, 1970.

6. Bolt Beranek and Newman, Inc., "A Survey of Annoyance from Motor Vehicle Noise." Report No. 2112, June 1971.

7. "Noise-Final Report," Cmnd. 2056, Her Majesty's Stationary Office, London, July, 1963.

8. Warnix, J.L. and B.H. Sharp, "Cost-Effectiveness Study of Major Sources of Noise. Vol. IV - Buses," Wyle Research Report WR 73-10, April 1974.

9. "Guidelines for Preparing Environmental Impact Statements on Noise," Report of Working Group 69, Committee on Hearing, Bioacoustics and Biomechanics, the National Research Council, Washington, D.C., 1977.

10. Sutherland, L., M. Braden, and R. Colman, "A Program for the Measurement of Environmental Noise in the Community and its Associated Human Response, Volume 1," Wyle Research Report WR-73-8 for the U.S. Department of Transportation, December 1973.

11. U.S. Environmental Protection Agency, "Public Health and Welfare Criteria for Noise." EPA Report 550/9-73-002, July 1973.

12. Gunn, W., T. Shighehisa, and W. Shepherd, "Relative Effectiveness of Several Simulated Jet Engine Noise Spectral Treatments in Reducing Annoyance in a TV-Viewing Situation." NASA Langley Research Center, Draft Report, 1976.

13. Lukas, J., "Measures of Noise Level: Their Relative Accuracy in Predicting Objective and Subjective Responses to Noise During Sleep," U.S. Environmental Protection Agency, EPA-600/1-77-010, February 1977.

14. Lukas, J., "Noise and Sleep: A Literature Review and a Proposed Criteria for Assessing Effect," The Journal of the Acoustical Society of America, Vol. 58 (6), pp. 1232-1242, 1975.

15. "Noise Levels of New MCI Buses," Booz-Allen Applied Research, a report submitted to the U.S. Environmental Protection Agency's Office of Noise Abatement and Control, EPA Contract No. 68-01-3509, October 7, 1976.

16. U.S. Environmental Protection Agency Noise Enforcement Facility, "Lima School Bus Test Report," Sandusky, Ohio, June, 1976.

17. Wilbur Smith and Associates, "Transportation and Parking for Tomorrow's Cities," New Haven, Conn., 1966.

18. Russ Kevala, Booz-Allen Applied Research, Personal Communication, September 23, 1976.

19. "Noise Levels of New Eagle Buses," Booz-Allen Applied Research, a report submitted to the U.S. Environmental Protection Agency's Office of Noise Abatement and Control, EPA Contract No. 68-01-3509, November 16, 1976.

20. Grandjean, E., P. Graf, A. Lauber, H.P. Meier, and R. Muller, A Survey of Aircraft Noise in Switzerland, Proceedings of the International Congress on Noise as a Public Health Problem, Dubrovnik, Yugoslavia, May 13-18, 1973, pp. 645-659.

21. Sorenson, S., K. Berglund, and R. Rylander, "Reaction Patterns in Annoyance Response to Aircraft Noise," Proceedings of the International Congress on Noise as a Public Health Problem, Dubrovnik, Yugoslavia, May 13-18, 1973, pp. 669-677.

22. Szalai, A., The Use of Time, Mouton & Co., Paris, 1972.

23. Intercity Domestic Transportation System for Passengers and Freight, Committee on Commerce, Science, and Transportation, 95th Congress 1st Session, 1977, Wash., D.C.

24. "Constitution of the World Health Organization," WHO Office of Public Information, Geneva, Switzerland, 1948.

25. Schultz, Theodore J., "Synthesis of Social Surveys on Noise Annoyance," The Journal of the Acoustical Society of America, 64(2), 377-405, 1978.

26. Goldstein, Jeffrey, "Assessing the Impact of Transportation Noise: Human Response Measures", In Proceedings of the 1977 National Conference on Noise Control Engineering, G.C. Maling (Ed.), Noise Control Foundation, Poughkeepsie, N.Y., pp. 79-98, 1977.

27. Fidell, Sanford, "The Urban Noise Survey," EPA Report No. 550/9-77-100, August 1977, and "Nationwide Urban Noise Survey", The Journal of the Acoustical Society of America, 64(17), 198-206, 1978.

28. Borsky, Paul N., "The Use of Social Surveys for Measuring Responses to Noise Environments," Transportation Noises: A Symposium on Acceptabilty Criteria, J.D. Chalupnik (Ed.), University of Washington Press, Seattle, 1970, pp. 209-227.

29. Gunn, Walter J., "A General Discussion of 'Reactions to Aircraft Noises'," in Reaction to Aircraft Noises: A Symposium Report, E.A. Allvis (Ed.), Journal of Auditory Research, 15, Supplement 5, pp. 214-217, 1975.

30. Hall, F.L., S.M. Taytor, and S.F. Birnie, "Community Response to Road Traffic Noise", McMaster University, Hamilton, Ontario, Canada, December 1977.

31. McKennel, A.C., "Aircraft Noise Annoyance Around London (Heathrow) Airport", U.K. Government Social Survey Report SS.337, 1963.

32. Pearsons, K.S. and R.L. Bennett, "Effects of Interior Aircraft Noise on Speech Intelligibility and Annoyance," National Aeronautics and Space Administration Report NASA CR-145203, August 1977.

33. Swing, John W., "A Case for Single-Event Intrusion Criteria in Achieving Noise-Compatible Land Use," Noise Control Engineering, 11(3), 98, 1978.

34. Allen, J.D., L.L. Faulkner, F.G. Ren, and A.M. White, "The Automobile As a Component of Community Noise," Phase 1 Final Report, Battelle Columbia Laboratories, June 1978.

35. Plomp, R. and A. M. Mimpen, "Speech Reception Threshold for Sentences as a Function of Age and Noise Level," The Journal of the Acoustical Society of America, 66(5), 1333-1342, 1979.

36. Stephens, D.G., "Developments in Ride Quality Criteria," Noise Control Engineering, 12(1), 6-14, 1979.

37. U.S. Environmental Protection Agency, "Transportation Noise and Noise from Equipment Powered by Internal Combustion Engines, EPA Report No. NTID 300.13, December 1971.

38. U.S. Environmental Protection Agency, "Community Noise," EPA Report No. NTID 300.3, December 1971.

39. National Association of Motor Bus Owners, "Bus Facts" (39th Edition), 1972.

40. Transit Fact Book, 76-77 Edition, ISSN 0082-5913, American Public Transit Association, Washington, D.C.

41. Rudder, F.F., Jr., C.N. Pow, B.A. Hutcheson, and D.L. Lam, "National Roadway Traffic Noise Exposure Model, Part I; General Adverse Response Model," U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Report No. EPA 550/9-79-xxx, March 1979.

42. Rudder, F.F., L. Ronk, and B.A. Hutcheson, "National Roadway Traffic Noise Exposure Model," Report prepared for the U.S. Environmental Protection Agency by Science Applications, Inc., 1979.

43. Ma, Y.Y., and F.F. Rudder, "Statistical Analysis of FHWA Traffic Noise Data", U.S. Department of Transportation, Federal Highway Administration, Report FHW-RD-78-64, July 1978.

44. "National Functional System Mileage and Travel Summary", U.S. Department of Transportation, Federal Highway Adminstration, Office of Planning, June 1977.

45. "National Highway Inventory and Performance Study Manual, 1976", U.S. Department of Transportation, Federal Highway Administration, July 1975.

46. "The Status of the Nation's Highways: Conditions and Performance", Report of the Secretary of Transportation to the United States Congress, 95th Congress, 1st Session, (45-29) U.S. Government Printing Office, September 1977.

47. "1970 Census of Population, Number of Inhabitants, United States Summary", U.S. Department of Commerce, Bureau of Census, December 1971.

48. Sutherland, L.C., "Indoor Noise Environments Due to Outdoor Noise Sources," Noise Control Engineering, 11(3), 124-137, 1978.

49. Johnson, D.R., "A Note on the Relationship Between Noise Exposure and Noise Probability Distribution," National Physical Laboratory, NPL Aero Report Ac 40, May 1969.

50. U.S. Environmental Protection Agency, "Background Document for Medium and Heavy Truck Noise Emission Regulations", EPA Report 500/9-76-008, March, 1976.

51. U.S. Environmental Protection Agency, "Proposed Motorcycle Noise Emission Regulations, EPA Report 550/9-77-203, November, 1977.

52. Gray, R. F.: "A Survey of Light Vehicle Operations", Engineering Publication 6313, General Motors Proving Ground, Milford, Michigan, July 1975.

53. Sakagami, J.: "Consideration of Noise Emission of Road Vehicles on Urban Streets in Japan", Proceedings Inter-Noise 75, Tokyo University Sendai 980, Japan, 1975, pp. 21-28.

54. Plotkin, Kenneth J., "Average Noise Levels for Highway Vehicles," Wyle Research Technical Note 79-2, September 1979.

55. "1975 Automobile Facts & Figures", Motor Vehicle Manufacturers Association, Detroit, Michigan 48202.

56. "American Trucking Trends 1975", American Trucking Association, Inc., Washington, D.C. 20036, 1976.

57. Plotkin, K.J., "Average Noise Levels for Highway Vehicles," Wyle Research Technical Note 79-2, Prepared for U.S. Environmental Protection Agency, Office of Noise Abatement and Control, September 1979.

58. Kent, P. and M. Branes: "1975 National Truck Characteristic Report", U.S. Department of Transportation, Federal Highway Administration, April 1978.

59. Galloway, W.J., K. Eldred, and M.A. Simpson, "Population Distribution of the United States as a Function of Outdoor Noise Level," U.S. Environmental Protection Agency Report No. 550/9-74-009A, June 1974.

60. Wyvill, C. (Ed.), "Discussion of Sound Propagation," Technical Meeting, U.S. Environmental Protection Agency, Office of Noise Abatement and Control, held at Crystal City, 14 October 1977.

SECTION 7

ECONOMIC IMPACT OF BUS NOISE CONTROL

I. OVERVIEW OF ECONOMIC IMPACT ANALYSIS

This overview outlines EPA's approach to the economic impact analysis of bus noise regulation. Figure 7-1 is a flow diagram, describing the conceptual format of the analysis, and the discussion that follows is essentially an elaboration of that diagram.

ECONOMIC IMPACT ANALYSIS METHODOLOGY

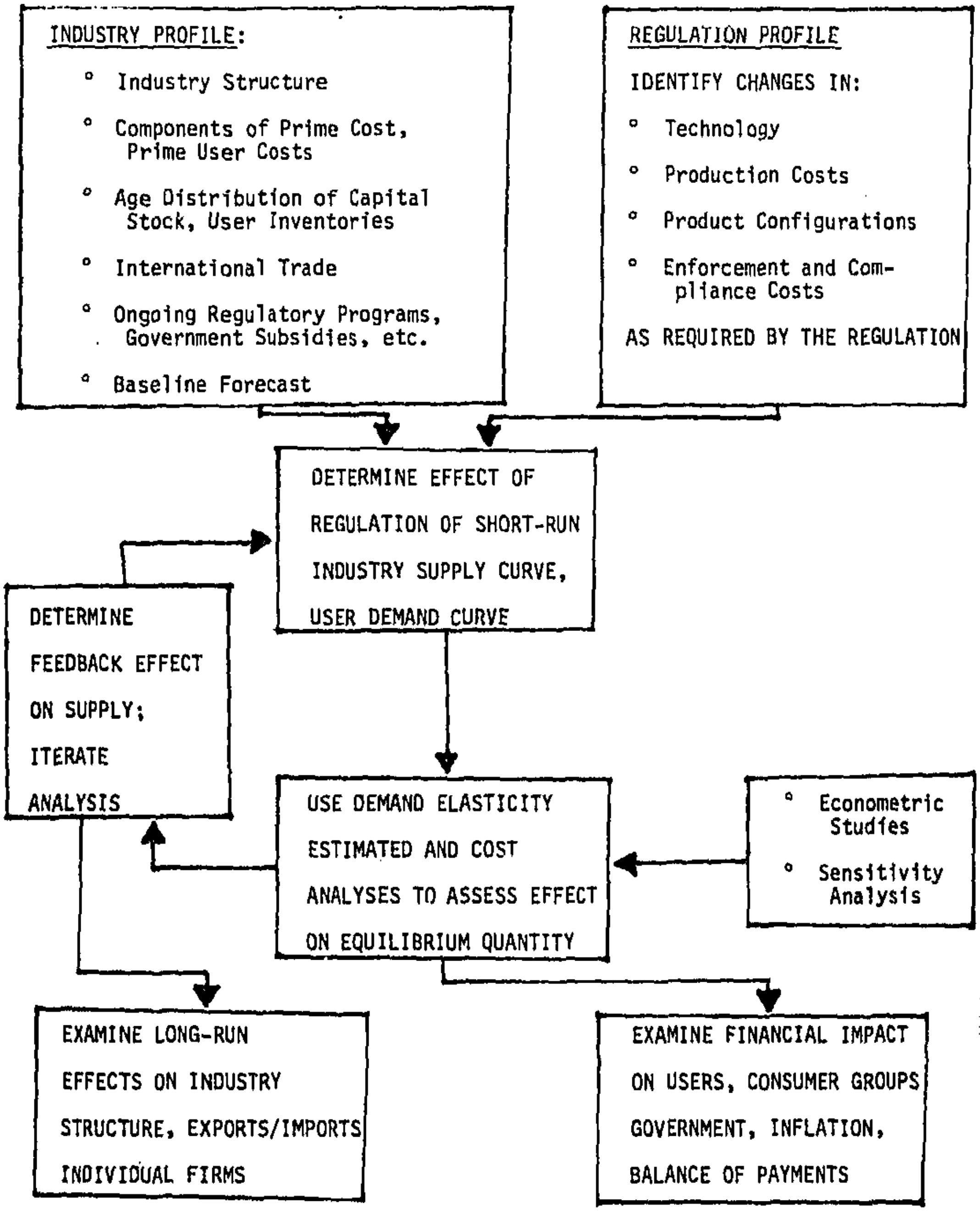
This part describes the basic supply/demand model underlying the analysis. For each of the major areas of bus noise abatement -- intercity buses, urban transit buses, and school buses -- two separate but highly related markets are analyzed.

1. The market for fully equipped, finished buses, purchased by transportation services and viewed as durable capital goods.
2. The market for bus transportation, from the viewpoint of final consumers of bus services.

Bus transit firms, whether intercity carriers, urban transit authorities, or public school districts, act as intermediaries, operating in both of these markets. However, it should be noted that the market for school bus services differs from the market for other bus transportation in that it is dictated more by the need to transport pupils and associated policy and legal considerations than by individual consumer choice.

The demand for buses as a capital good is a "derived" demand for a factor input, that is, derived from the demand for final consumption of bus services by eventual end users. A large portion of the economic analysis is devoted

FIGURE 7-1. ECONOMIC IMPACT ANALYSIS OF NOISE REGULATION



to describing the relationship between factors that can be ascertained about final demand and the conditions under which the final demand translates into a demand for buses as capital inputs.

The mix of regulatory and managerial incentives observed in the various bus transportation markets implies a variety of potential responses to the regulation. A separation of the parallel analyses of the three major categories (transit, intercity, and school buses) is maintained throughout the Economic Impact Analysis.

SUPPLY AND DEMAND AT THE CONSUMER LEVEL

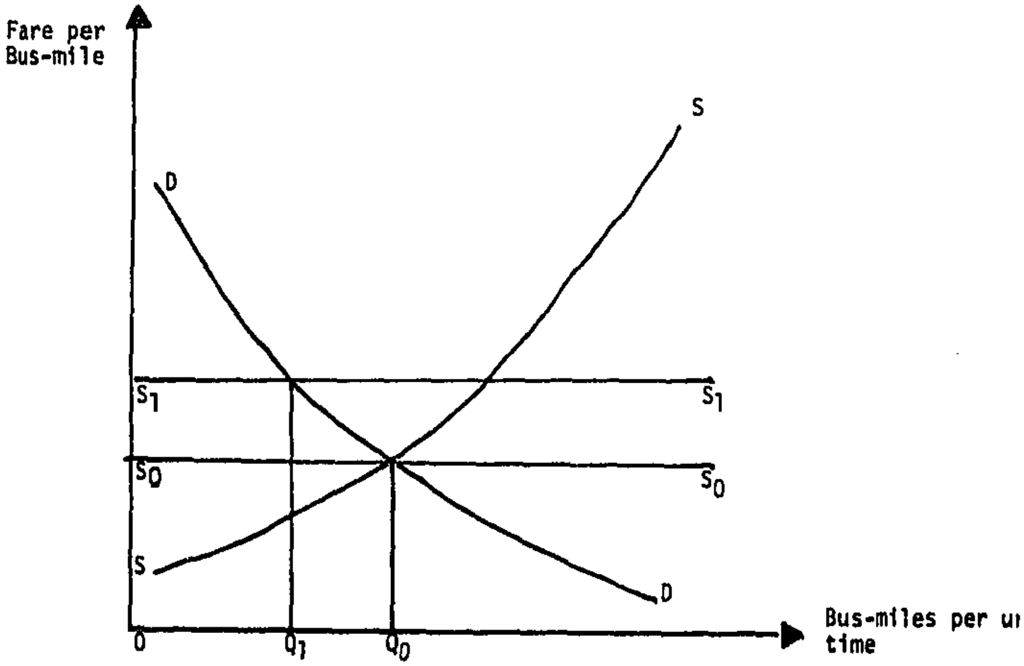
(a) Urban and Intercity Transportation Services

Figure 7-2 portrays a standard supply and demand model for urban and intercity transportation services at the consumer level. Ideally, both the supply and demand schedules could be estimated econometrically, and the analysis conducted in precise, empirical terms. Realistically, however, little is known about either the supply or the demand curve, particularly the former, and it is necessary to proceed in terms of heuristic arguments combined with sensitivity tests of specific parametric assumptions.

The supply and demand curves of Figure 7-2 apply to the relevant market or submarket in which the transit firm operates. For example, the relevant market for an urban transit system is the appropriate urbanized area, while the market for intercity bus carriers is nationwide.

Consider the effect of a rise in the cost of transportation equipment. Assume, to begin with, that the increased cost of equipment results in an increase in the marginal cost of operating a bus transit firm, represented

FIGURE 7-2. SUPPLY AND DEMAND AT THE CONSUMER LEVEL



by a shift of the supply curve facing bus passengers. The assumption can be verified subsequently in an analysis of transit firms.

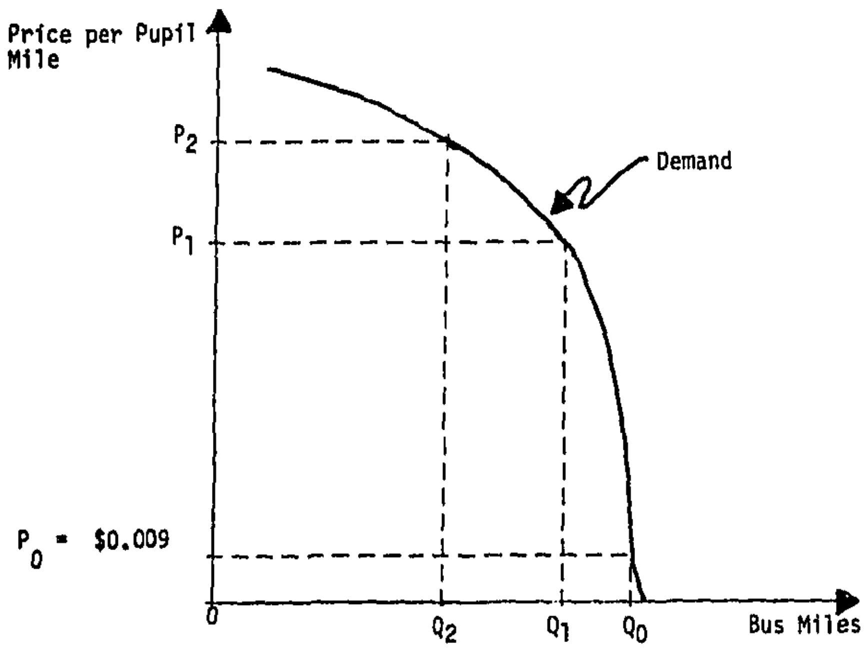
Since the exact shape of the curve SS is not known in advance, a horizontal supply curve S_0S_0 is taken as a first approximation. This shape is consistent with a long-run supply of an industry that does not experience economies or diseconomies of scale (Reference 1) in its bus operations, so the initial analysis also has implication for long-term impacts.

(b) School Bus
Transportation Services

The demand for school transportation services is viewed as being significantly different from that of urban and intercity transportation services. Figure 7-3 is an approximation of the demand for school bus transportation.

FIGURE 7-3

TOTAL MARKET DEMAND FOR
SCHOOL BUS TRANSPORTATION



Present total revenue conditions are approximated by the price-quantity relationship of $Q_0 \times P_0$ where P_0 = \$0.009 represents an approximation[1] of the present taxpayer burden per pupil mile for school bus transportation (calculated in terms of number of students transported at public expense).

As the price per pupil mile for school bus transportation moves between P_0 and P_1 it would be unlikely for parents to choose to transport their children on a personal basis due to the following conditions:

1. The tax burden for pupil transportation is shared by nearly all taxpayers in an area.

2. If large numbers of publicly transported pupils choose alternative forms of transportation, the public costs would remain essentially unchanged in the short term with an additional burden being borne by the individual transporting families.

If the individuals were the only interested parties, the demand curve between P_0 and P_1 might be perfectly inelastic (i.e. vertical) and no reduction in school bus usage would be realized from price/cost increases. However, State and local transportation coordinators and legislators have feasible options available to them such as reducing the volume of service offered. Such policy considerations might be in the following areas:

1. reduction in the quantity and/or length of field trips
2. elimination of free transportation to sporting events

[1]For 1973-74, 267,704 school buses transported 21,347,039 pupils at an average cost of \$0.72 per bus mile. [267,704 x \$.72/21,347,039 = \$0.009] (National Center for Education Statistics, Statistics of State School Systems, 1973-74, Table 41).

3. changing physical conditions which presently preclude walking (such as installing sidewalks and traffic lights where necessary for safe walking.)

Nevertheless, the section of the demand curve between P_0 and P_1 is considered inelastic.

As prices move above level P_1, the likelihood of eliminating school transportation services becomes much more viable, and we would view the curve as becoming more elastic. In this area it might be cost effective to eliminate school transportation services entirely, with school districts possibly offering transportation payment vouchers to differentially impacted families.

INCREMENTAL COST ANALYSIS

An estimate of the effect of the noise regulations on the supply curve SS (see Figure 7-2) can be made by examining the expense statement of a typical transit firm (or of U.S. transit firms in the aggregate). From economic theory, it is known that the supply curve of an industry is the horizontal sum of individual firm supply curves, and individual firm supply curves are the "marginal" or "incremental" cost schedules for operating transit fleets.

The transit firm's expense statement is a sum of contributing expense accounts, including labor (not including maintenance labor) (L), maintenance (M), fuel (F), capital expense (X), stations (S), and other expenses (O):

$$\text{Expense} = L + M + F + X + S + O$$

Imposition of noise control technology as a first approximation, affects only a subset of these expenses. (For the costs of bus noise technology, refer to Appendix G). Since only incremental impact is relevant to movements in the supply curve, consideration of many expense categories can be eliminated.

Specifically, we determine (from Appendix G) the incremental effect on E of imposition of regulatory level R:

$$dE/dR = dM/dR + dF/dR + dX/dR.$$

The derivatives (d) with respect to other expense categories vanish, since as a first approximation the technology has no effect on these items. As will be seen later, this assumption does not hold in the case of lower noise study levels where some additional expense may be incurred due to reduced seating capacity.

Note, however, that the full response to the regulation may change all expense categories as different forms of bus and fleet management technology are applied. The "first-round" approximation is an approach that provides an upper bound to the predicted economic cost impact.

Analysis of incremental capital cost dX/dR deserves special attention. If the firm's capital stock of buses is "K" dollars, then the relevant annual carrying cost is X - (r + i) K dollars, where "r" is the rate of depreciation per year and "i" is the rate of interest. Incremental capital cost therefore is:

$$dX/dR = (r + i)\ dK/dR,$$

where dK/dR represents the additional cost of noise reduction equipment installed on a newly-equipped bus.

(a) Effect on Quantity Demanded

A shift of the supply curve to S_1 S_1 (see Figure 7-2) implies a reduction in equilibrium quantity from Q_0 to Q_1. The econometric formula for estimating this relationship is given by the fare elasticity of transit demand, E_{BF}:

$$E_{BF} = \frac{\text{\% Change in Quantity Demanded (B)}}{\text{\% Change in Fare (F)}}$$

Appendix H reviews estimates of the fare elasticity of demand for the urban bus transit market and the intercity bus transportation market; adequate data for a similar estimate of the school bus market is unavailable due to difficulties associated with defining the concept of a "fare" in that market.

It is important to bear in mind certain cross-effects vis-a-vis other modes of transportation. Empirical work in this area suggests that such "cross elasticities" are indeed present to some extent; hence, a differential rise in the price of bus services compared with fares (or user costs, in the case of private automobiles) of competing modes may have a significant impact on demand for the mode in question. A relevant consideration in this regard is the possibility that simultaneous promulgation of noise regulations on all modes of transit may have similar effects on fares in all markets. To the extent that this phenomenon is true, the effect of cross elasticities of demand is diminished.

(b) Equilibrium
Quantity Impact

As a first approximation, assuming a constant ratio of input factors, the reduction of output to Q_1 translates into a reduced long-run demand for bus capital as input to providing bus services by the ratio $(1- Q_1/Q_0)$. To examine this impact further, we consider the market for finished buses. In doing so, it is hoped that some knowledge may be gained concerning the shape of the supply curve SS.

Analysis of the market for finished buses draws on the industry profile section (Section 3). The aspects of the analysis can be distinguished as one which is long-run and somewhat theoretical, and the other as short-run and descriptive.

LONG RUN ANALYSIS

The long-run analysis considers the effect of a long-run reduction in output of buses by the ratio $(1 - Q_1/Q_0)$, superimposed on the natural long-term growth rate of the industry. Inasmuch as reduction in bus service is predicted by movements along the demand curves in Figures 7-2 and 7-3, reduction in long-run bus output would be forthcoming. (This assumption is supported by an observed constant share of bus capital costs in the expense accounts of bus fleet operators.)

The bus industry profile (Section 3) provides information concerning the size distribution and profitability of bus manufacturers, the history and growth of the industry, foreign trade in buses, life-cycle characteristics of buses, and technical data concerning the manufacture and design technology of buses. This information is examined to assess the likelihood that reduced output levels result in a lower marginal cost of newly produced buses (hence that the supply curve SS in Figure 7-2 is upward-sloping) and whether there are marginal firms in the industry, including importers, who would be forced to cease operations due to the potential reduction in equilibrium output. Note that this latter consideration properly belongs to the normative phase of the overall impact analysis.

If so indicated, a rising supply schedule for bus production would imply a rising supply curve SS in Figure 7-2, and a revision in the quantitative estimate of the impact Q_1/Q_0. An iterative procedure (Figure 7-1) then leads to a determination of the long-run equilibrium.

SHORT-RUN ANALYSIS

Although the long-run analysis is a reliable indicator on which to base the overall impacts, some relevant short-run elements are worth considering, particularly in assessing the possible costs of disruptions following promulgation of the regulation.

One such effect is the so-called "pre-buying" phenomenon, where bus fleet operators invest heavily in pre-regulation bus capital to avoid the higher costs associated with the post-regulation equipment. In contrast to the effect on buyers of buses, the disruptive impact on bus manufacturers is reduced by providing adequate lead times for the development and introduction of noise abatement technology. Based on conversations with manufacturers and the fact that most buses are built on an "order-placed" basis it is doubtful that "pre-buying" will occur.

A second short-run phenomenon is the degree to which higher equipment costs are passed through to consumers and end-users by manufacturers and bus fleet firms. Since most bus fleets (except tourist, some charter and private, non-revenue fleets) are regulated or publicly owned, immediate pass-through of operating cost increases may not occur, particularly in the short-run. Factors working against immediate operating cost pass-through include:

-- government funding of bus capital expenditures

-- political decision-making processes of regulatory bodies

-- regulations relating to routes and service requirements

-- costs of record-keeping and financial control.

Since these factors also serve to reduce or forestall the pass-through of long-run incremental cost increases, the long-run analysis serves as an "upper-bound" on the overall impact estimates.

SENSITIVITY ANALYSIS

In complex numerical computations, the term "sensitivity analysis" refers to tests concerning estimated values of certain key parameters by varying their magnitude and by performing the calculations under alternative assumptions, to detect any significant variations in final results.

A second use of sensitivity analysis is in examining the effect of certain heuristic assumptions about demand elasticities, public funding levels, and product costs. These tests are made routinely in the development of the overall analysis.

FINANCIAL IMPACT
ANALYSIS

The positive economic analysis of post-regulatory impacts has implications for financial impacts on various special interest groups. Since these normative aspects of the regulations may affect the decision-makers, pertinent information is supplied.

Specific areas covered are the effects on exports and imports, impacts on marginal producers, differential impacts on municipalities and consumer groups, costs to government in the form of increased subsidies to transit firms, inflationary impacts, and possible balance of payments repercussions.

The industry profile section (Section 3) presents projections for industry output during the period 1976-90. These projections are extended to the year 2010 and combined with the various technology cost estimates (Appendix G) and the assumptions about the current capital stock of buses to produce a simulation of the financial cost impact of the regulations. The simulation permits the assessment of alternative regulatory actions on the basis of an annualized resource cost to the economy as a whole.

Because the intent of these projections is to obtain estimates of the total resource cost, and not to predict economic behavior, incremental capital cost is handled somewhat differently here than in the above economic analysis. Here the objective is to measure the actual incremental capital expenditures, as opposed to the effect of a change in marginal capital costs on pricing decisions of bus fleet operators.

Actual incremental capital expenditures in any given year are estimated by multiplying the sum of depreciation and interest (r + i) by the value of the stock of additional outstanding equipment (net of reserves for depreciation) that has been committed for the purpose of noise abatement. If, for example, k_t additional equipment is installed in year "t" for noise abatement, then the capital cost related to that investment in year t + s is given by:

$$(r + i)\ (1 - r)^s\ k_t,$$

where the term $(1 - r)^s$ reflects depreciation at annual rate "r" for "s" years.

Alternatively, if straight line depreciation is employed, this cost is estimated by:

$$k_t/n + i\ (1 - s/n)^s\ k_t,$$

where "n" is the depreciable life of the equipment installed.

Regulatory Options

Several alternative regulatory options are considered for each bus type. These options differ by noise level and effective date. Table 6-1, presented in Section 6, details these options. Each of the following sections of this chapter contains estimates of the equipment, operating, and maintenance expenditures attendant with each regulatory option, and estimates of annualized cost and expected price increases for each bus type. After all of the regulatory options have been evaluated, a concluding section of this chapter presents cost estimates and price increases for the regulatory rule. The rule requires all school buses (conventional and integral) to meet an 83 dB exterior noise level in 1981 and 80 dB in 1985. Transit and intercity buses must meet a similar rule, but must also meet 77 dB in 1987. Concurrent with the exterior regulatory schedule, the interior noise level of the buses must not exceed 86 dB, 83 dB and 80 dB respectively.

II. ECONOMIC IMPACT OF NOISE REGULATIONS ON USERS AND MANUFACTURERS

INTRODUCTION

This part of the analysis deals with the economic impact of the promulgation of noise abatement regulations on bus manufacturers, industry suppliers, end-users and other affected groups as have been identified. The industry has been divided into three separate product groups -- intercity, transit, and school buses -- due to the following considerations.

1. The products are dissimilar with respect to their end-use characteristics.
2. Operating entities in each category are structured and regulated differently.

The three economic impact assessments appear in the following order:

A. Economic Impact of Noise Regulations on Intercity Motor Bus Carriers and Manufacturers

B. Economic Impact of Noise Regulations on Urban Transit Motor Bus Carriers and Manufacturers

C. Economic Impact of Noise Regulations on Advanced Design Buses and Manufacturers

D. Economic Impact of Noise Regulations on School Bus Carriers and Manufacturers

E. An Economic Analysis for All Bus Types for the Final Regulatory Rule

A. ECONOMIC IMPACT OF NOISE REGULATIONS ON INTERCITY MOTOR BUS CARRIERS AND MANUFACTURERS

Appendix G indicates three major effects of bus noise reduction technology:

- Additional noise-abatement equipment installed on newly-produced buses, including testing and administrative expenses attributed to the addition of abatement equipment
- Increased maintenance costs for new buses
- Fuel efficiency of new buses.

Since the primary impact of these costs is on bus users -- fleet operators, intercity carriers, and ultimately, consumers -- the analysis below concentrates attention initially on the user end of the industry. Induced impacts on manufacturers and financing authorities is studied subsequently.

ANALYSIS OF USER COSTS AND THEIR EFFECTS UPON SUPPLY MARKETS

By way of introduction, Table 7-A-1 summarizes operating expense accounts of the Class 1 intercity motor bus carrier[2] during the years 1939-77. An important tenet of economic theory (Reference 2) states that the smaller the share of an intermediate product in the composition of final product demanded (bus transportation), the less sensitive (elastic) is demand for an intermediate product (like buses) to changes in its own price. For a given elasticity of demand for the final product (bus transportation), the smaller the share of the intermediate input (buses), the smaller will be the percentage impact of a change in bus prices on the total cost and price of the final product. A relatively small change in the price of the final product (transportation), implies a relatively small effect on quantity demanded of both the final product and the intermediate good.

Using this theorem, Table 7-A-1 lends insight into the probable results of the economic impact analysis. Bus capital, the major component of the "Depreciation and Amortization" account in the ICC reporting format, represents a small fraction of total operating expenses, less than five percent. Although the bus manufacturing industry is heavily dependent upon the "derived" demand for new buses, this "derived" demand is unlikely to change significantly as a result of a regulation-induced price change. Because of

[2]Class designations are formed using annual revenue dollars.
Class 1 carriers have revenues of $50,000,000 or more.
Class 2 carriers have revenues of $500,000 or more but less than $1,000,000
Class 3 carriers have revenues less than $500,000.

TABLE 7-A-1
OPERATING EXPENSE (CENTS PER BUS MILE)
CLASS I MOTOR BUS CARRIERS, 1939-77

Expense Category	1939	1959	1960	1970	1973	1974	1975	1976	1977p
Total	19.90	32.77	48.08	67.50	86.82	96.96	105.22	113.62	122.05
Operation and Maintenance - Total	14.72	26.53	39.59	57.52	74.09	83.29	92.21	99.05	107.55
Equipment Maintenance and Garage	3.44	6.67	8.01	10.33	12.27	13.32	14.57	15.49	16.10
Transportation	5.93	10.98	17.33	23.97	30.67	35.72	38.84	41.73	45.04
Station	1.85	3.69	6.49	11.62	15.01	16.45	17.62	19.52	21.35
Traffic, Solicitation, and Advertising	0.94	1.13	1.72	2.22	2.86	3.20	3.83	4.39	4.71
Insurance and Safety	1.06	1.45	1.99	2.41	3.49	4.03	4.19	4.49	5.38
Administrative and General	1.49	2.62	4.08	7.43	9.79	10.57	12.16	13.42	14.97
Depreciation and Amortization	2.06	2.82	3.47	3.52	3.82	4.32	4.55	4.42	3.98
Operating Taxes and Licenses	2.40	2.98	4.31	5.19	6.93	7.15	7.57	8.03	8.58
Operating Rents, Net	0.72	0.43	0.71	1.28	1.98	2.20	1.88	2.12	1.94

Source: American Bus Association, One-half Century of Service to America, Tables 3 and 4, and 1978 annual report. p: preliminary.

the minor role played by capital expenditures in the total operating expense account of intercity transit carriers, the bus manufacturing industry should be able to pass on the additional (equipment and testing) costs without severely reducing their sales.

Conversely, the large supply of fuel and mechanic labor is not very dependent upon the small demand of the bus industry's operating expense account. The potential for adverse economic impacts upon the suppliers of these inputs is negligible.

COST ESTIMATES
FROM APPENDIX G

Table 7-A-2 summarizes the pertinent estimates of equipment and operating costs associated with noise level regulation from Appendix G. Expense estimates are in 1978 dollars. Equipment cost per bus was converted from 1976 dollars, as stated in Appendix G, to 1978 dollars by applying the percentage increase in the Producer Price Index (buses) from 1976 to 1978 (197.1/168.5 = 1.170). Maintenance costs were converted to 1978 dollars by applying the percentage increase in the Producer Price Index (transportation) from 1976 to 1978 (173.4/151.5 = 1.145). All costs were rounded to the nearest $5.00. It should be noted that the various technology levels are costed independently of one another.

The estimates in Table 7-A-2 are "incremental" expenses, that is, additional expenses over and above the costs of purchasing and operating a typical bus that has no noise abatement equipment installed. Incremental fuel costs are computed on the basis of midpoint mileage estimates, as described in the footnote to the table.

For Technology Level 4, an additional consideration not reflected in Table 7-A-2 is the fact that noise abatement equipment required to attain

TABLE 7-A-2

INCREMENTAL EQUIPMENT AND OPERATING EXPENSES ASSOCIATED WITH PROPOSED LEVELS OF NOISE ABATEMENT TECHNOLOGY, DIESEL POWERED INTEGRAL INTERCITY BUSES (1978 dollars)

Technology Level	Exterior dB	Interior dB	EPA Estimated Equipment Cost Per Bus[1]	Fuel Cost Per Bus Year[2]	Maintenance Cost Per Bus Year[3]
1	83	86	$ 819	$ 315	$160
2	80	83	1544	340	349
3	77	80	3767	610	595
4	75	78	4946	845	950

1. Adjusted to 1978 dollars using the Producer Price Index for Buses. Includes testing and administrative expenses attributed to the addition of abatement equipment.

2. Fuel cost per bus-year is estimated by multiplying incremental gallons per mile (Appendix G) times 60 cents per gallon times 250,000 vehicle miles per bus-year. From industry sources, EPA has determined that intercity buses are driven very intensively during the initial two years of operation. Thus, 250,000 miles per year estimate is used for this part of the economic impact analysis. The 55,858 miles per year estimate, an overall average, (Appendix G) is incorporated into Table 7-A-8 and used in determining the annualized cost of this regulatory option.

3. Adjusted to 1978 dollars using the Producer Price Index for Transportation.

Source: Appendix G.

the 75 dB exterior level and the 78 dB interior level also entails a reduction in seating capacity by two seats (four passengers) from the standard 43-seat bus. Reduced seating capacity clearly imposes costs on the intercity carriers, but the magnitude of these costs is difficult to assess. The average passenger load on intercity trips is 20 passengers, or less than one fourth full, so a large proportion of current service would be unaffected by the loss of these seats, except to the extent that increase crowding of remaining capacity adversely affects customer demand.

Industry sources[3] have indicated to EPA that the price differential for similarly-equipped 41 and 49 passenger-rated buses was $12,000 (or 4 seats; 2 passengers per seat) in 1976. If an assumption is made that demand for bus service approaches individual bus capacity, a "worst case" estimate, the cost of losing two seats (four passengers) due to noise regulation is $6,000. This seat loss cost in 1978 dollars can be estimated by applying the percentage increase in the Producer Price Index (buses) from 1976 to 1978:

$$(197.1/168.5) \times \$6,000 = \$7,000$$

No measurable difference is indicated in operating and maintenance costs due to this reduced seating capacity.

The only adjustment called for in Table 7-A-2 is the addition of $7,000 to the equipment cost for Technology Level 4. This adjustment is included in all subsequent calculations of the economic impact analysis.

The $7,000 estimate is substantiated by some evidence collected in 1973 by Greyhound Lines, Inc., in connection with their discussion at that time to make the 43-seat bus standard equipment in preference to the 38-seat bus. Greyhound's study involved a survey of departure loads for twelve different

[3]Housman Bus Sales; Chicago, Illinois (a major distributor)

U.S. locations. For a sample of 2,179 scheduled bus departures, 45, or 2.07 percent, had passenger loads of 39 to 43 passengers. Since Greyhound has a legal obligation to provide service for all paying customers, the implication is that a reduction in bus seating capacity from 43 to 38 seats would raise total operating costs by roughly two percent.

ESTIMATE OF INCREMENTAL CAPITAL COSTS

The formula for estimating incremental capital costs is

$$dX/dR = (r + i)\ dK/dR,$$

where "dX/dR" is the incremental capital cost associated with regulatory level "R", "dK/dR" is the dollar value of noise abatement equipment installed on new buses, "r" is the rate of depreciation, and "i" is the rate of interest. Three alternatives for estimating "r" are discussed: estimates based on observations of prices of used equipment, life cycle estimates, and analysis of carriers' accounting statements. Each of these methods are examined in turn.

(a) Estimates Based on Observed Used Equipment Prices

In this case the lack of meaningful data on which to base estimates is evident. The difference in quality and design of used buses versus newly produced buses makes price comparisons difficult. The used market itself is not well organized, thus pure quotations are not easily obtained or necessarily representative.

One major dealer did provide EPA with a pair of prices of standard intercity buses for the years 1976 and 1964. The price for the 1964 bus includes expenses incurred by the dealer for equipment overhaul and refurbishing. True "depreciation" is not certain:

1976 new intercity bus	$85,000-$95,000
1964 good condition used intercity bus	$31,000-$32,000

The implied rate of depreciation over the 12-year period is estimated as follows:

$$\frac{1 - (31,500/90,000)}{12} = 8.4\%$$

(b) Estimates Based on Life Cycle Assumptions

Table 7-A-3 and 7-A-4 demonstrate that the total U.S. population of intercity buses has remained relatively constant during the past two decades, and that new bus production has amounted to five-to-ten percent of total stocks. The difference between the two tables in the ratio of new bus production to total stocks is explained by the fact that Table 7-A-4 records only Class I bus inventories, whereas Table 7-A-3 gives estimates of Class I, II and III inventories.

A large portion of the supply of buses to Class II and Class III fleet operators is in the form of second-hand, used buses from Class I operators, and only a small part of this supply is in the form of newly-produced buses. Hence, the total supply of new buses, around 1,200 per year, more properly represents replacement service to the entire population of carriers and not just to Class I Carriers.

On the assumption that the age distribution and technology of buses is roughly uniform over time, the figures in Table 7-A-3 indicate a lower bound on the rate of depreciation of five percent per year. The fact that total bus stocks are slowly declining indicates that some buses may be going out of service earlier than necessary. Therefore, the depreciation may be even less than this low estimate.

(c) Estimates Based on Carriers' Financial Statements

An upper bound on the rate of depreciation may be obtained by examining the pertinent accounting statements from Interstate Commerce Commission (ICC)

TABLE 7-A-3

INTERCITY BUS FLEET VEHICLE INVENTORY AND PRODUCTION
1970-77

Calendar Year	Bus Inventory[a]	Bus Shipments	Shipments as Percent of Existing Stock
1970	22,000	1,064	4.84%
1971	21,900	977	4.46
1972	21,400	1,353	6.32
1973	20,800	1,276	6.13
1974	20,600	1,350	6.55
1975	20,500	NA	–
1976	20,100	NA	–
1977p	20,100	1,455	7.24

Source: National Association of Motor Bus Owners (NAMBO)
American Bus Association (ABA).

Note: [a]Bus inventory refers to estimated inventories of all operating companies, including Class I, Class II and Class III Carriers, from One-half Century of Service to America, Table 1, and 1978 annual report. p: preliminary.

NA: not available.

TABLE 7-A-4

SELECTED BALANCE SHEET AND OPERATING STATISTICS, CLASS I INTERCITY MOTOR BUS CARRIERS, 1941-74

Calendar Year	Total Revenue Passenger Equipment	Net Revenue Passenger Equipment[a]	Depreciation of Revenue Equipment	Equipment Acquired During Year	Equipment Owned At Year-End
	(millions)	(millions)	(millions)	(buses)	(buses)
1941	$ 75.0	$ 42.4	$12.1	1,358	7,891
1950	214.2	88.7	24.4	697	13,200
1955	264.7	112.1	25.0	1,344	11,547
1960	319.8	119.4	27.6	1,639	11,093
1961	332.1	127.8	26.7	1,057	11,036
1962	402.2	178.5	32.6	1,329	13,873
1963	408.3	184.3	32.0	1,102	13,608
1964	428.0	205.1	37.7	1,543	14,274
1965	376.0	171.8	34.8	1,084	11,295
1966	394.7	186.1	37.4	1,376	11,749
1967	424.1	199.0	38.9	1,411	12,307
1968	450.0	194.3	40.7	1,205	12,257
1969	415.9	250.2	34.3	743	10,063
1970	418.7	256.6	32.8	1,042	10,158
1971	439.5	255.9	32.9	893	9,900
1972	454.0	249.5	31.3	972	9,711
1973	464.2	226.3	34.9	1,000	9,300
1974	482.1	300.0	38.2	1,031	9,885

Source: Interstate Commerce Commission, Transport Statistics in the United States (annual).

Note: [a]Net of Revenue for Depreciation. Coverage varies from year to year according to ICC definition of Class I carriers.

Class I annual reports. These statistics are provided in Table 7-A-4 for the period 1941 through 1974.

ICC accounting rules permit a variety of depreciation formulas for reporting purposes, including depreciation by number of miles driven, but the industry norm is eight-year, straight-line depreciation. The ICC Class I motor bus statistics are dominated by the major carriers (Greyhound, Continental Trailways, etc.) and the numbers in Table 7-A-4 undoubtedly reflect this method of accounting.

The eight-year figure is well below the true economic life of intercity buses: actual service life is at least fifteen and potentially thirty years or more. But due to the significantly greater intensity with which new intercity buses are driven during the initial two years of operation (250,000 miles per year as compared with an average annual mileage of 55,858 miles per year), the official depreciation life of eight years represents a compromise between straight-line method and true economic loss-of-value.

The question remains whether to use the "total revenue" or "net revenue" accounts as the basis for estimating the rate of annual depreciation. Use of the "total" definition (Column 2 of Table 7-A-4) results in an understatement of depreciation, since it includes equipment still owned but older than eight years and therefore no longer depreciated. Net revenue passenger equipment, on the other hand, results in an overstatement of depreciation because the eight-years, straight-line formula results in an understatement of the total capital stock.

Note, however, that estimates of the rate of depreciation based on these accounting summaries are not biased due to price inflation: both the numerator (stated depreciation) and the denominator (total or net assets) are increased each year by equally inflated increments.

Using the net equipment definition of depreciable assets, an upper bound for the annual rate of depreciation "r" is estimated from the years 1964 through 1973 to be 16.65% per year.

(d) Summary of Rate Depreciation Estimates

Intercity buses have potentially long service lives, and the concept of a "rate of depreciation" is not necessarily well-defined or applicable. Depreciation is itself an economic variable, subject to variation according to the maintenance and route decisions of the fleet operator.

Historically, however, the size of the total U.S. fleet and production of new equipment have maintained relatively constant levels through the past two decades. On the assumption that this record is representative of the type of depreciation that buses do in fact experience, EPA estimates an annual rate of depreciation of five to fifteen percent, with a best midrange estimate of ten percent per annum.

ESTIMATES OF INCREMENTAL PRIME COST

The technology cost estimates from Table 7-A-2 for incremental equipment, fuel, and maintenance costs can be combined into single estimates of incremental cost per vehicle mile. This is accomplished by converting equipment cost increments from Table 7-A-2 into per annum capital costs (depreciation plus interest), and then by dividing the sum of annual capital, fuel, and maintenance cost by 250,000 miles per year.

The relatively high figure of 250,000 vehicle miles per year is used rather than the average 55,858 miles per year, because the purpose of the analysis is to estimate the effect of marginal prime cost. The results of using the alternative 55,858 miles per year figure are indicated in Table 7-A-8.

Tables 7-A-5 and 7-A-6 provide results of the calculation for assumptions of 5% and 15% annual rate of depreciation. It is clear that the calculated numbers are relatively insensitive to both the assumption about the annual rate of depreciation and the incremental capital cost from Table 7-A-2. In the following analysis, only the midrange estimate of these numbers (i.e., 10% depreciation and the estimate of incremental capital costs) is considered.

IMPACT ON QUANTITY OF BUS SERVICE DEMANDED

On the assumption that increments to prime cost are passed through fully, to consumers, results of the sort provided in Tables 7-A-5 and 7-A-6 can be combined with average revenue statistics to estimate the potential increase in average fare per mile that results from the various levels of noise abatement technology.

Statistics on average revenues per vehicle mile are provided in Table 7-A-7. Comparison of these numbers with expenses per revenue mile, Table 7-A-1, indicates that profit margins in this regulated industry are moderate and relatively constant, although declining, over time. The average revenue in 1978 dollars is estimated by applying the percentage increase in the Consumer Price Index (transportation)[4] for 1977 to June 1978:

$$(185.5/177.2) \times 103.13 = 107.96 \text{ cents per vehicle mile.}$$

Midrange calculations for the estimated percentage increase in average revenues are given in Table 7-A-8. These numbers are multiplied by the demand elasticity estimate of -0.5 from Appendix H to compute the expected change in quantity of service demanded.

[4]Department of Labor, Bureau of Labor Statistics.

TABLE 7-A-5

INCREMENTAL PRIME COST PER BUS-MILE OF SERVICE ASSOCIATED WITH LEVELS OF NOISE ABATEMENT TECHNOLOGY, DIESEL POWERED INTEGRAL INTERCITY BUSES

Technology Level	Exterior dB	Interior dB	EPA Estimates Incremental Costs Cents Per Vehicle Mile[a]
1	83	86	.239¢
2	80	83	.368¢
3	77	80	.708¢
4	75	78	1.435[b]¢

Source: Table 7-A-2. Interest and depreciation are calculated as 15% of incremental capital cost (5% depreciation from Table 7-A-3 plus 10% interest). Estimates reflect an assumption of 250,000 vehicle-miles per bus year. (See Source note to Table 7-A-2.)

Note: [a]1978 dollars.

[b]Includes adjustment for reduced seating capacity.

TABLE 7-A-6

INCREMENTAL PRIME COST PER BUS-MILE OF SERVICE ASSOCIATED WITH LEVELS OF NOISE ABATEMENT TECHNOLOGY, DIESEL POWERED INTEGRAL INTERCITY BUSES

Technology Level	Exterior dB	Interior dB	EPA Estimates Incremental Costs Cents Per Vehicle Mile[a]
1	83	86	.234 ¢
2	80	83	.430 ¢
3	77	80	.859 ¢
4	75	78	1.913[b] ¢

Source: Same as Table 7-A-5 but with interest and depreciation computed as 25% of incremental capital cost (i.e., 15% depreciation plus 10% interest).

Note: [a]1978 dollars.

[b]Includes adjustment for reduced seating capacity.

TABLE 7-A-7

OPERATING REVENUE PER PASSENGER AND PER VEHICLE MILE, 1939-77, U.S. CLASS I INTERCITY BUS OPERATIONS

Calendar Year	Passenger Revenue (millions)	Operating Revenue per Passenger	Operating Revenue per Vehicle Mile
1939	$113.9	$0.83	22.35¢
1950	321.4	0.97	34.32
1960	354.8	2.12	48.68
1965	453.2	2.73	55.36
1968	463.7	3.18	60.93
1969	483.2	3.55	65.25
1970	510.9	3.81	68.84
1971	540.1	4.19	74.32
1972	540.3	4.25	76.45
1973	462.4	4.73	79.91
1974	647.9	5.13	89.35
1975	641.9	5.46	93.16
1976	646.2	5.76	96.10
1977	650.1	6.48	103.13

Source: American Bus Association, One Half Century of Service to America, Tables 3 and 4: Regular route intercity service and 1978 Annual Report.

IMPACT ON EQUILIBRIUM BUS PRODUCTION

The foregoing analysis, and Table 7-A-8, indicates that for all technology levels, the impact on equilibrium bus service demanded is quite small, and in most cases virtually imperceptible. Since it is unlikely that the technology of bus fleet management permits substantial substitution between buses and other inputs in the production of bus service, it is probable that reduced patronage of one or two percent resulting from noise abatement technology will translate into an equivalent reduction in long-run demand for new buses.[5]

A long run perspective on total costs to be incurred by the industry (both producer and user) can be obtained by calculating the annualized cost attendant to each regulatory option. The annualized cost calculation considers the equipment, testing, and administrative costs per bus, the price increase and reduced bus demand resulting from the price increase, and projects a revised baseline of sales over the relevant forecast period. With the revised sales forecast, equipment, testing, and administrative expenses to be incurred by the manufacturer, the annual operating and maintenance expenditures for each regulatory option are calculated. The analysis covers the time period 1980-2010. These costs are discounted back to 1980 using a 10 percent rate of discount and an annuity is determined. The annuity is the constant annual payment needed to cover the discounted future expenses of each bus over its life. Table 7-A-9 presents the annualized cost calculations for each regulatory option, along with expected price increases.

[5] Passengers per bus (average load) have remained remarkably constant on intercity bus service. 1950: 18.2 passengers per bus; 1960: 18.0; 1965: 19.2; 1970: 19.1; 1975: 19.3. (Source: ABA, One-half Century of Service to America.)

TABLE 7-A-8

ESTIMATED PERCENTAGE INCREASE IN AVERAGE FARE PER MILE, AND EFFECT ON QUANTITY DEMANDED, ASSOCIATED WITH LEVELS OF NOISE ABATEMENT TECHNOLOGY, DIESEL POWERED INTEGRAL INTERCITY BUSES

Technology Level	Exterior dB	Interior dB	Assumption A Fare Increase	Assumption A Change in Demand	Assumption B Fare Increase	Assumption B Change in Demand
1	83	86	.237%	-0.118%	1.059%	-0.530%
2	80	83	.370	-0.185	1.075	-0.827
3	77	80	.726	-0.363	2.109	-1.624
4	75	78	1.550	-0.775[a]	6.939[a]	-3.469[a]

Source: Tables 7-A-2 and 7-A-7. Operating revenues per mile in 1978 dollars are estimated at 107.96.

Note: Calculations assume 10 percent per annum depreciation, 10 percent per annum rate of interest and EPA estimates of costs. Calculations under Assumption A assume 250,000 vehicle miles per bus-year, whereas calculations under Assumption B assume 55,858 vehicle miles per bus-year.

[a]Includes adjustment for reduced seating capacity.

TABLE 7-A-9

INTERCITY BUSES

ANNUALIZED COST AND VEHICLE PRICE INCREASE

Regulatory Option	Annualized Cost (millions)	Percentag Price Increase
1	$ 5.26	0.7
2	8.97	1.4
2a	6.84	1.4
3	15.43	3.4
3a	12.71	3.4
3b	11.13	3.4
4	21.26	4.5
5	15.43	3.4

Assuming employment impacts follow the general trend of demand, reduced employment over the range of technology levels is 0.35 to 2.25 percent, considered insignificant since those unemployed will have skills similar to those producing substitute modes of transportation. Also, there may be modest increases in the personnel needed to design, build, install noise control components and conduct the necessary noise testing.

Fluctuations in annual bus output of one or two percent are well below the normal variation experienced from year to year by the bus industry as a whole (Table 7-A-3). Any attempt to refine the analysis further along the lines of an aggregate demand model would prove fruitless. The remainder of Subsection 7-A addresses secondary financial impacts and the baseline projections.

FINANCIAL IMPACTS
ON USERS

The regulation may have adverse economic impacts not recorded above in the "long-run" analysis if it causes short-run financial disruptions or has adverse distributional effects. Consider first the impact on the consumer and fleet operators.

Since motor bus intercity travel is typically somewhat slower and less convenient than travel by alternative modes (especially airplane and automobile), a larger portion of intercity bus patronage is from lower income groups than for other modes. Increases in the costs of intercity bus transportation will, therefore, affect lower income groups more adversely than others. The magnitude of this distributional effect is likely to be quite small, however. An increase in fare revenues by 6.939 percent (Table 7-A-8) and a resulting predicted loss in demand of 3.469 would increase the total revenue of all U.S. carriers by about 19.9 million (in 1978).

Fleet operators might be disadvantaged by the noise abatement technology if the increased equipment costs could not be met without incurring substantial additional financing. The relatively small share of equipment replacement costs (Table 7-A-1) in total operating expenditures makes this an unlikely possibility, however. Moreover, the increased responsiveness of regulatory bodies to permitting cost-justified fare increases will help firms to maintain satisfactory profit margins.

FINANCIAL IMPACTS ON PRODUCERS, INCLUDING EXPORTERS AND IMPORTERS

As indicated in the above economic analysis, the long-run impact on equilibrium industry output is likely to be small in percentage terms, so that given the current growth rate of industry output no actual reductions in output are projected from one year to the next as a result of reduced demand for bus services. There remains, however, the possibility of adverse impact on specific supplies if their product or technology differs significantly from the industry norm.

For U.S. producers of intercity buses, Table 3-15 (Section 3) indicates that the market is dominated by two large producers: Motor Coach Industries (Greyhound), and Eagle International, who together account for almost all 100 percent of U.S. production. The production of these busmakers is highly standardized (Table 3-5), and no differential impact on producers is envisaged.

Most of the U.S. international trade of intercity buses is conducted with Canada. Canadian production, trade, and regulation of buses are so completely integrated with U.S. production (under the Automotive Pact Trade Agreement) that virtually no differential impacts vis-a-vis Canadian imports is expected.

B. ECONOMIC IMPACT OF NOISE REGULATIONS ON URBAN TRANSIT MOTOR BUS CARRIERS AND MANUFACTURERS

Appendix G indicates three major effects of bus noise reduction technology, as applied to the standard diesel powered integral urban transit bus:

- o Additional noise-abatement equipment installed on newly-equipped buses
- o Increased maintenance costs for new buses
- o Reduced fuel efficiency of new Advanced Design Buses (ADB's)

The primary impact of these costs is on bus users - fleet operators, transit authorities, and consumers. The analysis below concentrates attention initially on the user end of the industry. Subsequently, induced impacts on manufacturers and financing authorities are studied.

ANALYSIS OF USER COSTS

Tables 7-B-1 and 7-B-2 summarize operating expense accounts of a sample of urban bus transit systems which are also members of the American Public Transit Association. The tables demonstrate that bus capital, the major component of the "Depreciation and Amortization" account, represent less than seven percent of total operating expense.

An important tenet of economic theory (reference 2) states that the smaller the share of an intermediate product in the composition of final product demand (bus transportation), the less sensitive (elastic) is demand for an intermediate product (like buses) to changes in its own price. For a given elasticity of demand for the final product, (transportation), the smaller the share of the intermediate input, (buses), the smaller will be the percentage impact of a change in bus prices on the total cost and price of the

TABLE 7-B-1

PERCENTAGE DISTRIBUTION OF EXPENSES BY EXPENSE CATEGORY, APTA BUS TRANSIT SYSTEM RESPONDENTS, 1960 AND 1969

Expense Category	Percentage of Total	
	1960	1969
Total Operating Expenses	100.00	100.00
Operation and Maintenance - Total	85.56	86.72
Equipment Maintenance and Garage	19.26	16.37
Transportation	49.42	52.68
Station	0.60	1.04
Traffic, Solicitation, and Advertising	0.90	1.29
Insurance and Safety	5.31	4.41
Administrative and General	10.07	10.93
Depreciation and Amortization	6.06	6.98
Operating Taxes and Licenses	7.92	5.81
Operating Rents, Net	0.46	0.46

Note: Numbers are compiles from American Public Transit Association, Transit Operating Report, 1960 and 1969, as aggregates of respondent-firm data. The sample contains 107 firms in 1960 and 76 firms in 1969.

Source: John D. Wells, et. al., Economic Characteristics of the Public Transportation Industry. Table 3.5 Washington, D.C.: U.S. Government Printing Office, 1972.

TABLE 7-B-2

EXPENSES PER BUS-MILE BY EXPENSE CATEGORY
AGGREGATE FOR 48 BUS TRANSIT SYSTEMS,
AND PERCENTAGE DISTRIBUTION, 1974

EXPENSE CATEGORY	CENTS PER BUS-MILE	PERCENT OF TOTAL
Total Operating Expense	116.65	100.00
Operation and Maintenance and Garage	106.18	91.02
Equipment Maintenance and Garage	20.68	17.73
Transportation	63.31	54.27
Station	0.25	0.21
Traffic, Solicitation, and Advertising	1.93	1.65
Insurance and Safety	4.65	3.99
Administrative and General	15.36	13.17
Depreciation and Amortization	5.27	4.52
Depreciation of Revenue Equipment	4.60	3.94
Operating Taxes and Licenses	5.20	4.46

Source: American Public Transit Association, Transit Operating Report for Calendar/Fiscal Year 1974, Section D. The sample consists of all APTA respondent systems in locations where buses are the sole public transit mode and for which either ICC or APTA format of accounts are provided.

final product. A relatively small change in the price of the final product, (transportation), implies a relatively small effect on quantity demanded of both the final product and the intermediate good.

Using this theorem, Tables 7-B-1 and 7-B-2 lend insight into the probable results of the economic impact analysis. Since bus capital has a small share in total factor cost, a given regulation-induced change in the price of new buses has only a small effect on the "derived" demand for new buses. The ability of the bus manufacturing industry to pass through the additional equipment costs without severely reducing sales is thereby enhanced.

Expenses for fuel and maintenance are relatively important components of the operating expense accounts, but here the potential for adverse economic impacts on the suppliers of these inputs - the petroleum industry and the supply of skilled mechanic labor, respectively, - is negligible due to the overwhelming size of these markets relative to the bus service industry.

COST ESTIMATES
FROM APPENDIX G

Table 7-B-3 summarizes the pertinent estimates of technology cost from Appendix G. Expense estimates include equipment and testing costs and an administrative expense equal to five percent of the sum of equipment and testing costs. These costs, hereafter referred to simply as equipment costs, are in 1978 dollars. Equipment cost per bus was converted from 1976 dollars as stated in Appendix G to 1978 dollars by applying the percentage increase in the Producer Price Index (buses) from 1976 to 1978 (197.1/168.5 = 1.170). Maintenance cost per bus-year was converted to 1978 dollars by applying the percentage increase in the Producer Price Index (transportation) from 1976 to 1978 (173.4/151.5 = 1.145). All costs were rounded to the nearest $5.00. It

TABLE 7-B-3

INCREMENTAL EQUIPMENT AND OPERATING EXPENSES ASSOCIATED WITH LEVELS OF NOISE ABATEMENT TECHNOLOGY DIESEL POWERED INTEGRAL URBAN TRANSIT BUSES

(1978 dollars)[1]

Technology Level	Exterior dB	Interior dB	EPA Estimated Equipment Cost Per Bus	Fuel Cost Per Bus Year[2]	Maintenance Cost Per Bus Year[3]
1	83	86	$ 544	$ 40	$ 160
2	80	83	1275	35	349
3	77	80	2686	70	595
4	75	78	4922	110	950

Source: Appendix G.

1. Adjusted to 1978 dollars using prices by the Producer Price Index for buses.
2. Fuel cost per bus-year is estimated by multiplying incremental gallons per mile (Appendix G) times 60 cents per gallon times 37,608 vehicle miles per bus-year.
3. Adjusted to 1978 dollars using the Producer Price Index for transportation.

should be noted that the various technology levels are costed independently of one another.

The estimates in Table 7-B-3 are "incremental" expenses, that is, additional expenses over and above the costs of purchasing and operating a typical bus that has no noise abatement equipment installed. Incremental fuel costs are computed on the basis of midpoint mileage estimates, as described in the footnote to the table.

For Technology Level 4, an additional consideration not reflected in Table 7-B-3 is the fact that noise abatement equipment required to attain the 75 dB exterior level and the 78 dB interior level also entails a reduction in seating capacity by two seats (four passengers) from the standard 45 or 53 passenger bus. Reduced seating capacity clearly imposes costs on the transit firm, but the magnitude of these costs is difficult to assess in the absence of accurate information on capacity utilization of existing buses.

An indirect estimate of the cost of reduced seating capacity is available by comparing the costs of constructing and operating buses of different sizes. Two sizes of urban transit buses are produced, with passenger ratings and specification as follows:

Passenger Rating	Standard Wheelbase (Inches)	Length (Feet)	Weight (1,000 lbs.)	Engine Make and Model
45	225	35	17.6 - 22.7	Det D 6V-71N - or -
53	285	40	19.3 - 23.8	Det D 8V-71N

Industry sources have indicated to EPA that the two bus types had prices in 1976:

35 foot	$58,000 - $68,000
40 foot	$64,000 - $75,000

A comparison of midpoint price estimates indicates a price differential of \$6,500 for eight passengers, hence an implied differential of \$3,250 for four passengers. The cost of seat loss in 1978 dollars can be estimated by applying the percentage increase in the Producer Price Index (buses) from 1976 to 1978:

$$(197.1/168.5) \times \$3250 = \$3,800.$$

Bus industry sources have also indicated to EPA that there is no measurable difference in operating and maintenance costs between the two buses. Hence, the only adjustment called for in Table 7-B-3 is the addition of \$3,800 to the equipment cost for Technology Level 4. <u>This adjustment is included in all subsequent calculations of the economic impact analysis.</u>

ESTIMATES OF INCREMENTAL CAPITAL COSTS

The formula for estimating incremental capital costs is:

$$dX/dR = (r + i)\, dK/dR,$$

where "dX/dR" is the incremental capital (equipment) cost associated with regulatory level "R", "dK/dR" is the dollar value of noise abatement equipment installed on new buses, "r" is the rate of depreciation, and "i" is the rate of interest. Accurate estimates of the rate of depreciation "r" are difficult to obtain.

In the absence of satisfactory price information on used urban transit buses, two alternatives for estimating "r" are discussed: (1) estimates based on life cycle assumptions, and (2) analysis of fleet operators' accounting statements.

(a) Estimates Based on Life-Cycle Assumptions

Table 7-B-4 shows that the total U.S. population of transit buses has remained virtually constant at roughly 50,000 units during the post World War

TABLE 7-B-4

URBAN BUS TRANSIT VEHICLE INVENTORY AND PRODUCTION, 1940-77

Calender Year	Motor Bus Inventory	New Passenger Buses Delivered	Deliveries as Percent of Existing Stock
1940	35,000	3,984	11.38%
1945	49,670	4,441	8.94
1950	56,820	2,668	4.70
1955	52,400	2,098	4.00
1960	49,600	2,806	5.66
1961	49,000	2,415	4.93
1962	48,800	2,000	4.10
1963	49,400	3,200	6.48
1964	49,200	2,500	5.08
1965	49,600	3,000	6.05
1966	50,130	3,100	6.18
1967	50,180	2,500	4.98
1968	50,000	2,228	4.46
1969	49,600	2,230	4.50
1970	49,700	1,442	2.90
1971	49,150	2,514	5.11
1972	49,075	2,904	5.92
1973	48,286	3,200	6.63
1974	48,700	4,818	9.89
1975	50,811	5,261	10.35
1976	52,382	4,745	9.06
1977p	51,968	2,437	4.69

Source: American Public Transit Association, Transit Fact Book ('77-'78), Tables 14 and 15. p: preliminary.

II period. New production has averaged roughly six percent of total inventories during this period.

On the assumption that the age distribution and technology of buses is roughly uniform over time, these numbers indicate a lower bound on the rate of depreciation of six percent per year. Some caution should be exercised, however, in accepting this figure as an unbiased estimate of depreciation, because of the likely possibility that inventory figures represent an increasing proportion of relatively inactive buses. Such buses serve as capital reserves to meet contingencies and periods of peak demand. The accretion of such reserves during the post-war period implies a downward bias in the above estimate of the annual rate of depreciation.

A comparable estimate of the rate of depreciation based on life cycle data was recently made using fleet inventory characteristics collected by the American Public Transit Association (Reference 3). Using survivor curve techniques applied to the age distribution of current bus fleet inventories, the study concluded that transit buses have an average life of 19 years, implying a depreciation rate of roughly six percent per annum. As with the above estimate, however, the 19-year age may be biased (upwards) due to the existence of significant stocks of old, low-use buses.

(b) Estimates Based on Fleet
Operators' Financial Statements

An upper bound on the rate of depreciation may be obtained by examining the pertinent accounting statements from ICC annual reports for Class I carriers engaged primarily in local or suburban service.

ICC accounting rules permit a variety of depreciation formulas for reporting purposes, but the industry norm (and the rule of the Internal

Revenue Service) is an eight year, straight-line depreciation. Eight years is well below the true economic life of urban transit buses; actual service life can extend from fifteen to twenty years or longer. Table 7-B-5 presents the pertinent statistics from the ICC Annual Statistics. A question remains about whether to use the "total revenue" or "net revenue" accounts as the basis for estimating the rate of annual depreciation. Use of the "total" definition (Column 2 in Table 7-B-5) results in an understatement of depreciation, since it includes equipment still owned but older than eight years and therefore no longer depreciated. New equipment (Column 3 in Table 7-B-5), on the other hand, overstates depreciation because the eight year formula understates the total capital stock.

Note, however, that estimates of the rate of depreciation based on these accounting summaries are not biased due to price inflation; both the numerator (stated depreciation) and the denominator (total or net assets) are increased each year by equally inflated increments.

Using the net equipment definition of depreciable assets, an upper bound on the annual rate of depreciation "r" is estimated for the years 1960-73 as 14.3% annum.

(c) Summary of Rate of Depreciation Estimates

Urban transit buses have potentially long service lives, and the concept of a single "rate" of depreciation is not obviously well-defined or applicable. Depreciation is itself an economic variable, subject to variation according to the maintenance and route decisions of the fleet operator.

Historically, however, the size of the total U.S. fleet and production of new urban transit buses have maintained relatively constant levels. On the assumption that this record is representative of the type of depreciation

TABLE 7-B-5

SELECTED BALANCE SHEET AND OPERATING STATISTICS, CLASS I MOTOR BUS CARRIERS ENGAGED IN LOCAL OR SUBURBAN SERVICE, 1941-74

Calendar Year	Total Revenue Passenger Equipment (millions)	Net Revenue Passenger Equipment[a] (millions)	Depreciation of Revenue Equipment (millions)	Equipment Acquired During Year (Buses)	Equipment Owned at Year-End (Buses)
1941	$ 23.6	$ 9.1	$ 2.34	335	3,167
1950	259.7	25.7	5.26	247	5,146
1955	292.3	31.2	7.05	510	6,547
1960	390.9	37.3	6.08	578	5,938
1961	100.1	40.7	6.83	424	5,755
1962	43.1	17.8	3.38	414	3,311
1963	47.3	16.5	3.29	281	3,135
1964	55.3	21.0	3.55	439	3,357
1965	139.0	81.6	9.99	709	6,603
1966	141.2	87.6	10.46	622	6,953
1967	149.7	60.1	11.05	533	7,342
1968	152.2	97.2	11.09	635	7,344
1969	131.0	84.6	8.52	331	4,912
1970	132.0	88.5	8.24	213	4,837
1971	117.1	79.5	6.59	150	4,054
1972	134.6	89.1	7.44	127	4,518
1973	92.0	22.1	4.71	79	3,001
1974	105.4	41.7	5.74	241	3,378

Source: Interstate Commerce Commission, Transportation Statistics in the United States (annual).

Note: [a]Net of Reserves for Depreciation. Coverage varies from year to year according to ICC definition of Class I carriers.

that buses do, in fact, experience, EPA estimates an annual rate of depreciation of six to fourteen percent, with a best midrange estimate of ten percent per annum.

ESTIMATES OF INCREMENTAL PRIME COST

The technology cost estimates from Table 7-B-3 for incremental equipment, fuel, and maintenance cost can be combined into single estimates of incremental cost per vehicle mile. This is done by converting equipment cost increments from Table 7-B-3 into per annum capital costs (depreciation plus interest), and then dividing the sum of annual capital, fuel, and maintenance cost by 37,608 vehicle miles per year. These costs are presented in Table 7-B-6.

EFFECT OF UMTA SUBSIDIES FOR EQUIPMENT PURCHASES

Qualified urban transit authorities receive a subsidy of up to 80% of the cost of new equipment purchases from the Urban Mass Transportation Administration (UMTA). Since the urban transit firm has no incentive to pass on costs borne by the Federal Government to its customers, the effect of UMTA subsidies is to reduce the effective capital cost by 80%. Table 7-B-7 reproduces the calculations of Table 7-B-6 on the assumption that incremental equipment costs have an annual value equal to 20% that assumed in Table 7-B-6.

The calculations also constitute a sensitivity analysis with respect to the assumption about the rate of depreciation. In effect, Table 7-B-7 assumes an annual rate of depreciation of 2.0% in place of 10% in Table 7-B-6. The difference in the resulting numbers is not substantial, and one may conclude that the economic impact analysis is relatively insensitive to the assumption about the annual rate of depreciation.

TABLE 7-B-6

INCREMENTAL PRIME COST PER BUS-MILE OF SERVICE ASSOCIATED WITH LEVELS OF NOISE ABATEMENT TECHNOLOGY DIESEL POWERED INTEGRAL URBAN TRANSIT BUSES

Technology Level	Exterior dB	Interior dB	EPA Estimated Incremental Costs Cents Per Vehicle Mile[a]
1	83	86	0.821 ¢
2	80	83	1.700 ¢
3	77	80	3.200 ¢
4	75	78	7.457[b] ¢

Source: Tables 7-B-3 and 7-B-4. Interest and depreciation are calculated as 20% of incremental capital cost (10% depreciation plus 10% interest). Estimates reflect an assumption of 37,608 vehicle-miles per bus-year.

[a] 1978 dollars
[b] Includes adjustment for reduced seating capacity.

TABLE 7-B-7

INCREMENTAL PRIME COST PER BUS-MILE OF SERVICE ASSOCIATED WITH LEVELS OF NOISE ABATEMENT TECHNOLOGY

Technology Level	Exterior dB	Interior dB	EPA Estimated Incremental Costs Cents Per Vehicle Mile[a]
1	83	86	.590¢
2	80	83	1.157¢
3	77	80	2.054¢
4	75	78	3.480[b]¢

Source: Same as Table 7-B-6, but with interest and depreciation computed as 4.0% of incremental capital cost (i.e., 1/5 x 20%).

[a]1978 dollars
[b]Includes adjustment for reduced seating capacity.

IMPACT ON QUANTITY OF
BUS SERVICE DEMANDED

On the assumption that some portion of the cost increases are passed through to consumers in higher fares, figures provided in Table 7-B-7 can be combined with average revenue statistics to estimate the potential increase in average fare per mile that results from various levels of noise abatement technology.

Statistics on average revenue per vehicle mile are provided in Table 7-B-8. The average fare in 1978 dollars can be estimated by applying the percentage increase in the Consumer Price Index (transportation)[6] from 1977 to June 1978:

$$(185.5/177.2) \times 91.30 = 95.58 \text{ cents per vehicle mile.}$$

Examination of the cost/revenue ratio of U.S. urban mass transit systems (Table 7-B-9) indicates that an assumption of full cost pass-through of incremental expenses is unwarranted. Not only do urban transit systems enjoy significant subsidies in the purchase of new equipment (a relatively small proportion of total operating costs), bus subsidies by Federal (UMTA), state and municipal financing authorities have brought about a condition of costs in excess of revenues by a ratio approaching two-to-one in 1977.

A reasonable assumption is that such subsidization will continue at present levels. The calculations of Table 7-B-10 assume, therefore, that only one-half of regulation induced cost increments are passed on to consumers in the form of higher fares.

Percentage increases in fares as computed in Table 7-B-10 translate into estimates of the corresponding decrease in ridership by applying demand elas-

[6] Department of Labor, Bureau of Labor Statistics.

TABLE 7-B-8

OPERATING REVENUE PER PASSENGER AND PER VEHICLE MILE, 1940-77, U.S. MOTOR BUS TRANSIT SYSTEMS

Calendar Year	Passenger Revenue (millions)	Operating Revenue per Passenger (millions)	Operating Revenue per Vehicle Mile
1940	$248.8	6.87	20.83¢
1945	590.0	7.07	34.26
1950	734.2	9.56	38.74
1955	826.3	14.41	48.32
1960	910.3	17.17	57.75
1961	897.8	18.57	58.69
1962	910.1	19.07	60.06
1963	932.2	19.62	61.20
1964	950.4	20.10	62.20
1965	971.9	20.55	63.59
1966	998.1	21.23	65.59
1967	1037.3	22.39	67.98
1968	1049.7	23.20	69.60
1969	1114.8	25.71	75.41
1970	1193.6	29.41	84.69
1971	1226.8	32.23	89.19
1972	1177.8	33.07	90.05
1973	1183.8	32.40	86.38
1974	1269.6	31.76	88.72
1975	1310.1	31.99	85.85
1976	1366.0	32.77	86.38
1977p	1482.0	34.90	91.30

Source: American Public Transit Association, Transit Fact Book '77-'78.
p: preliminary.

TABLE 7-B-9

TREND OF TRANSIT OPERATIONS, 1940-77

Calendar Year	Operating Revenue (millions)	Operating Expense (millions)	Cost-Revenue Ratio
1940	$ 737.0	$ 660.7	0.896
1945	1,380.4	1,231.7	0.892
1950	1,452.1	1,385.7	0.954
1955	1,426.4	1,370.7	0.961
1960	1,407.2	1,376.5	0.978
1965	1,443.8	1,454.4	1.007
1966	1,478.5	1,515.6	1.025
1967	1,556.0	1,622.6	1.043
1968	1,562.7	1,723.8	1.103
1969	1,625.6	1,846.1	1.136
1970	1,707.4	1,995.6	1.169
1971	1,740.7	2,152.1	1.236
1972	1,728.5	2,241.6	1.297
1973	1,797.6	2,536.1	1.411
1974	1,939.7	3,239.4	1.670
1975	2,002.4	3,705.9	1.851
1976	2,161.1	4,020.9	1.861
1977p	2,280.0	4,304.8	1.888

Source: American Public Transit Association, Transit Fact Book '77-'78, Table 3 and Table 4. p: preliminary.

TABLE 7-B-10

ESTIMATED PERCENTAGE INCREASE IN AVERAGE FARE PER MILE, AND EFFECT ON QUANTITY DEMANDED, ASSOCIATED WITH LEVELS OF NOISE ABATEMENT TECHNOLOGY, DIESEL POWERED INTEGRAL URBAN TRANSIT BUSES

Technology Level	Exterior dB	Interior dB	Fare Increase	Changing Demand
1	83	86	0.308%	-0.154%
2	80	83	0.605	-0.303
3	77	80	1.074	-0.537
4	75	78	1.960	-1.980[a]

Source: Tables 7-B-3 and 7-B-8. Operating revenues per mile in 1978 dollars are estimated at 95.58.

Note: Calculations assume 10 percent per annum depreciation and 10 percent per annum rate of interest, and that 20% of the incremental capital costs are incurred by transit firms (UMTA financing the remaining 80%). Fare increase is computed on the assumption of a fifty percent cost pass-through. Calculations assume 37,608 vehicle miles per bus-year.

[a]Includes adjustment for reduced seating capacity.

ticity estimates from Appendix H. The calculations of regulation-induced reduction in quantity demanded in Table 7-B-10 assume an elasticity of -0.5: actual percentage decreases in quantity may be less than those computed in the table.

IMPACT ON EQUILIBRIUM
BUS PRODUCTION

The foregoing analysis, and Table 7-B-10, indicates that for all technology levels, the impact on equilibrium bus service demanded is quite small, and in most cases virtually imperceptible. Since it is unlikely that the technology of bus fleet management permits substantial substitution between buses and other inputs in the production of bus service, it is probable that reduced patronage of one or two percent resulting from noise abatement technology will translate into an equivalent reduction in long-run demand for new buses.[7]

A long-run perspective on total costs to be incurred by the industry (both producer and user) can be obtained by calculating the annualized cost attendant to each technology level. The annualized cost calculation considers the equipment, testing, and administrative costs per bus; the price increase and reduced bus demand resulting from the price increase; and projects a revised baseline of sales over the relevant forecast period. With the revised sales forecast, equipment, testing and administrative expenses to be incurred by the manufacturer, the annual operating and maintenance expenditures for each regulatory option are calculated. The analysis covers the time period 1980-2010. These costs are discounted back to 1980 using a 10

[7] Motor bus passengers per vehicle have declined steadily since World War II, despite fluctuations in relative operating costs. 1945: 5.74 passengers per vehicle; 1950: 4.74; 1955: 4.24; 1960: 4.08; 1965: 3.80; 1970: 3.57; 1975: 3.32. (Source: APTA Transit Fact Book '75-'76, Tables 6 and 10.)

percent rate of discount and an annuity is determined. The annuity is the constant annual payment needed to cover the discounted future expenses of each bus over its life. Table 7-B-11 presents the annualized cost calculation for each technology level, along with expected price increases.

Assuming employment impacts follow the general trend of demand, reduced employment over the range of technology levels is 0.30% to 2.85 percent. This is considered insignificant since those unemployed will have skills similar to those producing substitute modes of transportation. However, there may be modest increases in the personnel needed to design, build and install noise control components and conduct necessary testing.

Fluctuations in annual bus output of two percent or less are well below the normal variation experienced from year to year by the bus industry as a whole (Table 7-B-4). The remainder of this analysis for transit buses addresses secondary financial impacts and baseline projections.

FINANCIAL IMPACT
ON USERS

The regulation may have adverse economic impacts not recorded above in the "long-run" analysis if it causes short-run financial dislocations or has distributional effects. Consider the impact on consumers and fleet operators.

Since urban transit by motor bus is typically somewhat slower and less convenient than travel by alternate modes, especially auto, a larger portion of urban bus patronage is from lower income groups than for other modes.[8]

---

[8]The Federal Highway Administration's Nationwide Personal Transportation Study, 1973, shows that for 1969-70, ridership on bus and street car transportation is distributed as follows (by annual household income): $0-3,000: 12.7%; $3,000-3,999: 10.8%; $4,000-4,999: 9.2%; $5,000-5,999: 8.8%; $6,000-7,499: 12.3%; $7,500-9,999: 15.4%; $10,000-14,999: 16.3%; 15,000 and over: 7.9%; Not applicable: 6.6%.

TABLE 7-B-11

TRANSIT BUSES

ANNUALIZED COST AND VEHICLE PRICE INCREASE

Regulatory Option	Annualized Cost (million $)	Percentage Price Increase
1	$ 9.86	0.6
2	18.16	1.5
2a	13.73	1.5
3	29.91	3.1
3a	24.16	3.1
3b	20.75	3.1
4	45.53	5.7
5	29.91	3.1

Increases in the costs of urban transit will therefore affect lower income groups more adversely than others. The magnitude of this distributional effect is likely to be quite small, however. A maximum predicted increase in fare revenues of 2.0 percent (Table 7-B-10) and a corresponding decrease in demand of 1.0 percent would increase the total revenue of U.S. bus transit systems by about $11.6 million (in 1978).

Fleet operators would be disadvantaged by the noise abatement technology if the increased equipment costs could not be met without incurring substantial additional financing. The relatively small share of equipment replacement costs (Tables 7-B-1 and 7-B-2) in total operating expenses makes this an unlikely possibility, particularly when considering the UMTA equipment subsidy program.

The annual survey by the American Public Transit Association of urban fleet inventories indicates the likely replacement needs of various municipalities. Table 7-B-12 presents such a summary, broken down by size of city fleet. It is apparent from Table 7-B-12 that larger cities do not differ significantly from smaller cities in terms of median fleet age.

Table 7-B-13 identifies major municipalities with median fleet age in excess of ten years as of June 10, 1975. Municipalities that are especially prone to replacement needs appear to be distributed evenly by geographical region and city type.

FINANCIAL IMPACTS ON PRODUCERS, INCLUDING EXPORTERS AND IMPORTERS

The long-run impact on industry output equilibrium is likely to be small in percentage terms. Thus, given the current growth rate of industry output (in recent years), small actual reductions in output are projected from one

TABLE 7-B-12

MEDIAN AGE OF FLEET BY FLEET SIZE,
U.S. MOTOR BUS TRANSIT SYSTEMS,
AS OF JUNE 30, 1975

Fleet Size (Buses)	Number of Cities	Mean Median Age	Standard Deviation
500 or more	17	9.82 years	4.14
100 to 499	43	8.23	4.48
50 to 99	41	9.54	7.23
3 to 49	104	9.64	6.68

Source: American Public Transit Association, Transit Passenger Vehicle Fleet Inventory as of June 30, 1975.

TABLE 7-B-13

MAJOR BUS TRANSIT SYSTEMS WITH MEDIAN FLEET AGE IN EXCESS OF TEN YEARS AS OF JUNE 30, 1975

City	Fleet Size (Buses)	Median Fleet Age (Years)
Maplewood, New Jersey	1847	12
Boston, Massachusetts	1149	13
Oakland, California	878	12
Seattle, Washington	559	20
Buffalo, New York	556	12
Milwaukee, Wisconsin	523	13
Cincinnati, Ohio	444	11
Houston, Texas	421	13
Norfolk, Virginia	285	18
Richmond, Virginia	233	14
Sacramento, California	204	13
Jacksonville, Florida	193	13
Louisville, Kentucky	179	14
Charlotte, North Carolina	132	14
Hampton, Virginia	106	19
Holyoke, Massachusetts	98	23
Dayton, Ohio	93	27
Des Moines, Iowa	90	17
Des Plaines, Illinois	88	20

Source: American Public Transit Association, Transit Passenger Vehicle Fleet Inventory as of June 30, 1975.

year to the next as a result of reduced demand for bus services. There remains, however, the possibility of adverse impact on specific suppliers if their product or technology differs significantly from the industry norm.

Table 3-16, Section 3, indicates that the market is dominated by two large producers: General Motors and Flxible, who together account for about 90 percent of U.S. production. The production of these bus-makers is highly standardized (Table 3-6) and no differential impact on producers is envisaged.

Since the noise abatement technology involves mostly minor additions and modifications to existing equipment, the potential for impacting U.S. export production to non-regulated countries is minimal. The only importer of consequence of urban transit buses is Mercedes-Benz, whose marketing activities are devoted exclusively to the airport-hotel and municipal "feeder route" markets.

The Mercedes-Benz buses sold in the U.S. are small (passenger rating: 19), limited use vehicles which do not compete with the industry standard U.S. urban transit model. Annual average sales amount to 200 units, with a base price of $26,111. Sales to municipalities are primarily to service "feeder" routes, and some further penetration of this market is anticipated in future years.

Noise levels of the Mercedes bus are currently high (84 dB) at 75% of maximum throttle at 45 mph. Mercedes-Benz has engaged in research to reduce these levels, including the development of optional equipment to reduce exterior noise to 80 dB. Information on their ability or the cost of attaining noise levels below 80 dB is not available at present.

C. ECONOMIC IMPACT OF NOISE REGULATIONS ON ADVANCED DESIGN BUSES AND MANUFACTURERS

The Advanced Design Bus (ADB) is perceived by major transit bus producers as the bus of the future. Currently there are about 3,580 ADB buses being produced by the two major manufacturers, General Motors Corp., Truck and Coach Division and Grumman-Flxible Corp. Abating the noise produced by these ADBs requires somewhat different equipment than for other transit buses. A separate analysis is provided here to evaluate the costs of compliance for the different regulatory levels under study. It is important to note that this analysis is meant to be separate from the analysis of transit buses previously provided. The cost and impacts are not additive because an assumption made here is that over time transit buses will be replaced by the ADBs. For now, however, they are evaluated separately.

Cost Estimates from Appendix G

Table 7-C-1 summarizes the pertinent estimates of technology costs from Appendix G. Expense estimates include equipment and testing costs and an administrative expense equal to 5% of the sum of equipment and testing costs. These costs, referred to as equipment costs, are in 1978 dollars, having been converted from 1976 dollars by applying the percentage increase in the Producer Price Index (buses) from 1976 to 1978 (197.1/168.5=1.170). Maintenance costs per bus year were converted to 1978 dollars by applying the percentage increase in the Producer Price Index (transportation) from 1976 to 1978 (173.4/151.5=1.145). It should be noted that the various technology levels are costed independently of one another and are incremental expenses, that is, additional expenses over and above the costs of purchasing and operating a typical bus that has no noise abatment equipment installed.

Similar to the analysis of urban transit buses, Technology Level 4 for the ADBs entails a reduction in seating capacity by 2 seats from the

TABLE 7-C-1

INCREMENTAL EQUIPMENT AND OPERATING EXPENSES
ASSOCIATED WITH LEVELS OF NOISE ABATEMENT TECHNOLOGY
ADVANCED DESIGN BUSES
(1978 DOLLARS)

Technology Level	Exterior dB	Interior dB	EPA Estimated Equipment Cost[1]	Fuel Cost Per Bus Year[2]	Maintenance Cost Per Bus Year[3]
1	83	86	$ 13	$ 0	$ 0
2	80	83	742	45	292
3	77	80	1806	80	544
4	75	78	2909	125	899

Source: Appendix G

1 Adjusted to 1978 dollars using the Producer Price Index for buses.

2 Fuel cost per bus year is estimated by multiplying incremental gallons per mile (Appendix G) times 60 cents per gallon times 37,608 vehicle miles per bus year.

3 Adjusted to 1978 buses using the Producer Price Index for transportation.

standard 45 or 53 passenger bus. Reduced seating capacity imposes a cost on the transit firm. An indirect estimate of the cost of reduced seating capacity is available by comparing the costs of constructing and operating buses of different sizes. This has already been done in the transit bus analysis where a cost for loss of seating capacity was estimated at $3,800. That cost is used here for the analysis of ADBs for Technology Level 4.

Estimates of Incremental Capital Costs

The analysis for transit buses, estimates rates of depreciation and shows how to apply rates of depreciation to determine incremental capital costs. It is concluded that urban transit buses have potentially long service lives and a single rate of depreciation may not be applicable. Futhermore, depreciation is an economic variable subject to variation according to the maintenance and route decisions of the fleet operator. A best estimate of the annual rate of depreciation is from 6 to 14% with a mid-range estimate of 10% per annum. That rate is used for the analysis of ADBs also.

Estimates of Incremental Prime Costs

The technology cost estimates from Table 7-C-1 for incremental equipment, fuel and maintenance costs can be combined into single estimates of incremental cost per vehicle mile. This is done by converting equipment cost increments from Table 7-C-1 into per annum capital costs (depreciation plus interest), and then dividing the sum of annual capital, fuel, and maintenance cost by 37,608 vehicle miles per year. These costs are presented in Table 7-C-2.

Effect of UMTA Subsidies for Equipment Purchases

Qualified urban transit authorities receive a subsidy of up to 80% of the cost of new equipment purchases from the Urban Mass Transportation Administra-

TABLE 7-C-2

INCREMENTAL PRIME COST PER BUS MILE OF SERVICE ASSOCIATED WITH LEVELS OF NOISE ABATEMENT TECHNOLOGY, ADVANCED DESIGN BUSES

Technology Level	Exterior dB	Interior dB	EPA Estimated Incremental Costs, Cents Per Bus Mile[a]
1	83	86	.007 ¢
2	80	83	1.291 ¢
3	77	80	2.620 ¢
4	75	78	6.291[b] ¢

Source: Table 7-C-1. Interest and depreciation are calculated as 20% of incremental capital cost (10% depreciation plus 10% interest). Estimates reflect an assumption of 37,608 vehicle-miles per bus year.

[a] 1978 dollars

[b] Includes adjustment for reduced seating capacity

tion (UMTA). Since the urban transit firm has no incentive to pass on costs borne by the Federal Government to its customers, the effect of UMTA subsidies is to reduce the effect of capital costs by 80%. Table 7-C-3 reproduces the calculations of Table 7-C-2 on the assumption that incremental equipment costs have an annual value equal to 20% that is assumed in Table 7-C-2. These calculations also constitute a sensitivity analysis with respect to the assumption about the rate of depreciation. In effect, Table 7-C-3 assumes an annual rate of depreciation of 2.0% in place of 10% in Table 7-C-2. The difference in the resulting numbers is not substantial and one may conclude that the economic impact analysis is relatively insensitive to the assumption about the annual rate of depreciation.

Impact on Quantity of Bus Service Demanded

On the assumption that some portion of the cost increases are passed through to consumers in terms of higher fares, the figures provided in Table 7-C-3 can be combined with average revenue statistics to estimate the potential increase in average fare per mile that results from various levels of noise abatement technology. The statistics on average revenue per vehicle mile were provided above in Table 7-B-8. The average fare in 1978 dollars was estimated by applying the percentage increase in Consumer Price Index (transportation) from 1977 to 1978; it is equal to 95.58 cents per vehicle mile.

Examining the cost revenue ratio of U.S. urban mass transit system indicates that an assumption of full cost pass-through of incremental expenses is unwarranted. Not only do urban transit systems enjoy significant subsidies in the purchase of new equipment, but subsidies by Federal, State and municipal financing authorities have brought about a condition of costs in excess of revenues by a ratio approaching 2:1 in 1977. A reasonable assumption is that such subsidization will continue at these present levels.

TABLE 7-C-3

INCREMENTAL PRIME COST PER BUS-MILE OF SERVICE ASSOCIATED WITH LEVELS OF NOISE ABATEMENT TECHNOLOGY ADVANCED DESIGN BUS

Technology Level	Exterior dB	Interior dB	EPA Estimated Incremental Costs Cents per Vehicle Miles[a]
1	83	86	.001 ¢
2	80	83	.975 ¢
3	77	80	1.851 ¢
4	75	78	3.436[b] ¢

Source: Same as Table B, but with interest and depreciation computed as 4.0% of incremental capital cost (i.e., 1/5 x 20%).

[a] 1978 dollars

[b] includes adjustment for reducing seating capacity

Table 7-C-4 which shows percentage increases in fare and corresponding declines in demand for bus service for each regulatory level assumes that only half of regulation induced cost increments are passed on to consumers in the form of higher fares. Percentage fare increases in Table 7-C-4 translate into estimates of the corresponding decrease in ridership by applying demand elasticity estimates from Appendix H. The calculations of regulation induced reduction in quantity demanded in Table 7-C-4 assume an elasticity of -0.5: actual percentage decreases in quantity may be less than those computed in the table.

Impact on Equilibrium Bus Production

The foregoing analysis and Table 7-C-4 indicates that for all technology levels the impact on equilibrium bus service demanded is quite small. Since it is unlikely that the technology of bus fleet management permits substantial substitution between buses and other inputs in the production of bus service, it is probable that reduced patronage of about 1% resulting from noise abatement technology will translate into an equivalent reduction in long-run demand for new buses.

A long-run perspective on total costs to be incurred by the industry (both producer and user) can be obtained by calculating the annualized cost attendant to each technology level. The annualized cost calculation considers the equipment, testing and administrative cost per bus, the price increase and reduced bus demand resulting from the price increase, and projects a revised baseline of sales over the relevant forecast period. With the revised sales forecast, equipment, testing and administrating expenses to be incurred by the manufacturer, the annual operating and maintenance expenditures for each regulatory option are calculated. The analysis covers the time period 1980 through 2010. These costs are discounted back to 1980 using a 10% rate of

TABLE 7-C-4

ESTIMATED PERCENTAGE INCREASE IN AVERAGE
FARE PER MILE, AND EFFECT ON QUANTITY DEMANDED,
ASSOCIATED WITH LEVELS OF NOISE ABATEMENT TECHNOLOGY,
ADVANCED DESIGN BUSES

Technology Level	Exterior dB	Interior dB	Fare Increase	Change in Demand
1	83	86	.001	-0.0005
2	80	83	.510	-0.255
3	77	80	968	-0.484
4	75	78	1.798	-0.899

discount and an annuity as determined. The annuity is the constant annual payment needed to cover the discounted future expenses of each bus over its life.

Most of the data used in calculating annualized costs comes from Appendix G. The baseline forecast of ADB sales comes from Section 3 of this document, and requires some explanation. At the present time the two manufacturers of ADBs are together producing about 3,600 vehicles per year. Both producers are attempting to increase productive capacity.[9] Those experts who follow the motor bus industry believe that at some point in the not-too-distant future, ADBs will completely replace other transit buses. Thus the forecast of transit bus sales given in Section 3 may, in the future, more accurately reflect the sales forecast of ADBs. An assumption is made here that in the year 1985 all transit production is for ADBs. From 1980 to 1985 the average annual growth rate of ADBs is 7.1 percent. From 1985 to 2010, the baseline forcast for ADBs is equal to the forecast for transit buses provided above. Needless to say, this analysis and the analysis of transit buses presented above are mutually exclusive, or at least not directly additive. Table 7-C-5 presents the annualized cost calculation for each technology level, along with expected price increases.

Assuming employment impacts follow the general trend of demand, reduced employment over the range of technology levels is 0.005 to 1.30 percent. This is considered insignificant since those unemployed will have skills similar to those producing substitute modes of transportation. However, there may be modest increases in the personnel needed to design, build, and install noise control components and to conduct the necessary testing.

[9] Telephone conversation between Don DeYoung and Al Newman Department of Transportation, May 5, 1980.

TABLE 7-C-5

ADVANCED DESIGN BUSES
ANNUALIZED COST AND VEHICLE PRICE INCREASE

Regulatory Option	Annualized Cost (million $)	Percentage Price Increase
1	$ 0.07	0.01
2	12.87	0.7
2a	10.73	0.7
3	23.73	1.6
3a	20.40	1.6
3b	17.50	1.6
4	36.64	2.6
5	23.73	1.6

Fluctuations in annual bus output of 1% or less are well below the normal variation experience from year to year by the bus industry as a whole (Table 7-B-4). The remainder of this analysis for ADBs addresses secondary financial impacts and baseline projections.

Financial Impact on Users

The regulation may have adverse economic impacts not recorded above in the "long run" analysis if it causes "short run" financial dislocations or has distributional impacts. Consider the impacts on consumers and fleet operators.

Since travel by ADBs and urban transit buses in general is typically slower and less convenient than travel by alternative modes, especially auto, the larger portion of urban bus patronage is from lower income groups than for other modes. Increases in the costs of ADBs will therefore affect lower income groups more adversely than others. The magnitude of this distributional effect is likely to be quite small, however. A maximum predicted increase in fare revenues of 1.8% (Table 7-C-4) and a corresponding decrease in demand of 0.9% would increase the total revenue of U.S transit bus systems by about $8.1 million (in 1978).

Fleet operations might be disadvantaged by the noise abatement technology if the increase equipment costs in total operating expenses (about 5% to 6%) makes this an unlikely possibility, particularly when considering the UMTA equipment subsidy program.

An annual survey by the American Public Transit Association of urban fleet inventories indicates the likely replacement needs of various municipalities (presented above in Table 7-B-12). It is obvious that larger cities do not differ significantly from smaller cities in terms of median fleet age.

Table 7-B-13, also presented previously, identifies major municipalities with median fleet age in excess of 10 years as of June 10, 1975. Municipalities that are especially prone to replacement needs appear to be distributed evenly by geographic region and city type.

D. ECONOMIC IMPACT OF NOISE REGULATIONS ON SCHOOL BUS CARRIERS AND MANUFACTURERS

INTRODUCTION

The school bus industry is a highly complex entity consisting of several manufacturers producing an almost infinite number of variations to the basic product - a vehicle designed to transport pupils to and from schools. Almost any combination of the following characteristic variables can be specified by the school bus customer:

1. Engine Type - Gasoline or diesel of various horsepower ratings.
2. Construction - Body-on-chassis or integral.
3. Engine placement - Forward, mid-unit, or rear.
4. Make - Chassis (3 primary manufacturers), body (6 primary manufacturers), integral (2 manufacturers).
5. Size (seating capacity) - as many as 97 passengers.
6. Options - Air conditioning, interior quality, transmissions (various speeds; standard or automatic), etc.

Thus school buses are custom-made with different cost and prices associated with each of the variables described above.

Due to the impracticality of assessing the economic impact of noise abatement regulations on all possible variations in the product, the analysis has been limited in the following manner:

- Small buses (under 10,000 pounds gross vehicle weight rating (GVWR)) have been eliminated from consideration.

- Size of buses (in terms of passenger capacity) and optional equipment have been considered only with respect to their contribution to the price range of the final product.

The outgrowth of these limiting factors are the following school bus "product" types:

1. Gasoline powered conventional
2. Gasoline powered forward control
3. Parcel delivery and motor home chassis
4. Diesel powered conventional
5. Diesel powered forward control
6. Diesel powered integral mid-engine
7. Diesel powered integral rear-engine

Consideration has been given to differential noise abatement costs associated with individual manufacturers.

The primary economic areas affected by noise abatement regulations are shown schematically in Figure 7-D-1. Each of the following economic impact areas is evaluated:

1. Manufacturers
2. End users
3. Suppliers

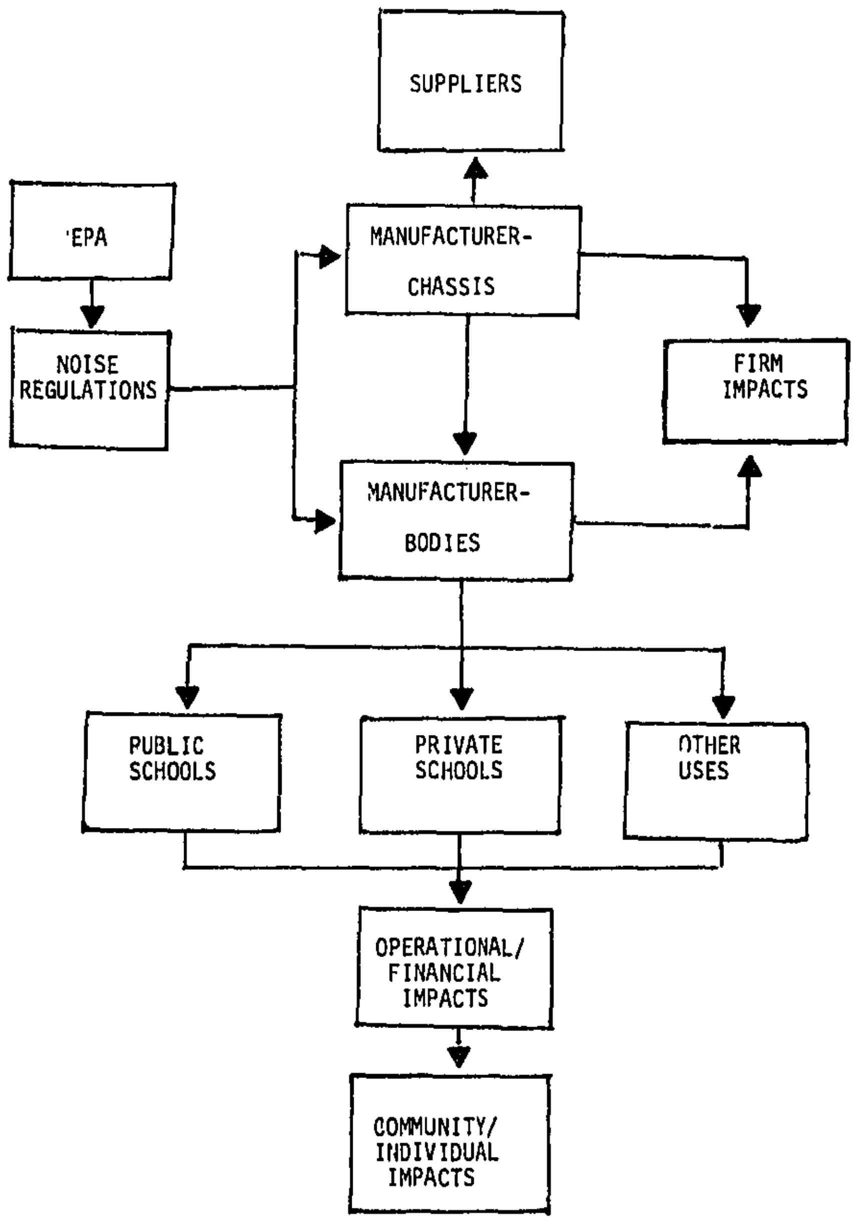
Quantitative estimates are presented where possible. The following topics are presented:

-- Costs of noise abatement
-- Industry considerations
-- Analysis of user costs
-- Estimates of incremental capital costs

FIGURE 7-D-1

ECONOMIC IMPACT FLOW CHART

SCHOOL BUSES



-- Estimates of incremental prime costs

-- Impact on quantity of bus production

-- Annualized costs borne by producers and consumers

-- Final impacts

-- Baseline projections

COSTS OF NOISE
ABATEMENT

After assessing the noise abatement technology presently available to the school bus industry, EPA analyzed the costs associated with applying that technology to the various types of school buses. EPA's estimates of those costs and discussions concerning the required manufacturing processes are included in the text and figures of Appendix G of this report.

In order to properly analyze the costs of quieting school buses, it is necessary to relate the post-regulatory costs of manufacture to the present costs. This cost data is considered by most companies to be proprietary and confidential. Therefore, post-regulatory prices (assuming a full cost pass-through) related to pre-regulatory prices serves as a best availale approximation of estimated cost increases.

(a) Present School
Bus Prices

Due to the variation in model types available to the consumer, there is no one price which is representative of all school buses. However, Table 7-D-1 identifies the range of prices for each type of bus.

Note in Table 7-D-1 the wide range of prices quoted within bus type category and between different categories of bus. The range within categories is due to different specifications demanded by bus purchasers rather than by any discernible differences among manufacturers' production processes. Diesel powered units cost from $2,000 to $4,000 more than comparably

TABLE 7-D-1

MAY, 1979 PRICES FOR
COMPLETED SCHOOL BUSES, BY TYPE OF BUS

Type of Bus	Range of Prices	Average Price
Gasoline Powered:		
Conventional	$13,000-22,000	$19,000
Forward Control	$35,000-42,000	$38,000
Parcel Delivery	$12,000-16,500	$14,500
Diesel Powered:		
Conventional	$17,000-28,000	$23,000
Forward Control	$35,000-43,000	$40,000
Integral Mid-engine	$45,000-100,000	$60,000
Integral Rear-engine	$50,000-70,000	$55,000

Source: Section 3

Note: The average price expressed here is the price given by respondents as closely approximating the mean price paid for units.

equipped gasoline powered units. Also, the nature of construction and special characteristics of the integral units account for the large price difference between all other bus types.

(b) Estimated Cost Increases

The percent cost increase due to the regulatory options is calculated by applying the manufacturing cost increases expressed in Appendix G to the prices of respective units presented in Table 7-D-1.

IMPORTANT INDUSTRY CONSIDERATIONS

Section 3 contains a profile of the school bus industry. Certain major points are detailed here since they are important in analyzing the economic impact of noise emission regulations.

(a) Competitive Nature of the Industry

Due to the complex nature of the distribution channels in the school bus market, it is important to highlight some salient points relative to industry competition.

The market for integrally constructed buses is distinctly different from that of body-on-chassis models both in terms of market interactions and marketability. The principle differences are:

1. The sale of the integrally constructed bus is generally conducted by the manufacturer of the unit, whereas the body-on-chassis bus is normally sold through a distributor representing a particular body builder. The body builder obtains the driveable chassis from the chassis manufacturer (with the chassis make and specifications being indicated in the bid document).

2. The integrally constructed unit contains physical characteristics which make it more appropriate for use in a particular geographic region and for specific functions where the body-on-chassis type is physically unsuitable or economically unjustified. Integral units appear to be particularly well-suited for use in mountainous terrain and on high speed highways. Integral units are also well-suited for such special purposes as transporting athletic teams.

Due to these differences body-on-chassis school buses are not close substitutes for integrally constructed buses. Rather, they more resemble intercity buses, although they are not as heavily constructed nor as costly.

Aside from integrally constructed bus types, a high degree of competition appears to exist within bus categories. For example, different makes of gasoline powered conventional buses compete directly. Any make of bus body can be constructed on any one of the four major chassis designs, and sales are typically determined on the basis of competitive bids by several producers. Domestic market share data for the four major chassis manufacturers (Table 7-D-2) shows that a great deal of brand switching does occur from year-to-year -- further a priori information indicating a high degree of competition.

At the assembly stage of manufacture, diesel and gasoline body-on-chassis school buses are highly substitutable, and the assembler can switch easily from production of one to the other.

(b) Price Movements

No information has been found during the course of this study to describe, quantitatively, how school bus manufacturers have reacted to increased

TABLE 7-D-2

SHARES OF DOMESTIC MARKET
FOR SCHOOL BUS CHASSIS - 1973-1977

Make	1973	1974	1976	1977*
Chevrolet	11.9%	12.8%	15.0%	11.0%
GMC	8.2%	9.2%	8.2%	8.2%
Ford	29.6%	35.0%	22.7%	24.4%
International Harvester	50.3%	43.9%	54.1%	50.5%
	100.0%	100.0%	100.0%	100.0%**

Source: Motor Vehicle Manufacturers Association

* In 1977 Dodge had 1.5% of the market shares but subsequently dropped out of the market place.

** Totals do not add up to 100%.

production costs in the past. However, if the Producer Price Index for all buses is a representative measure of school bus price movements, we find that bus prices have risen about the same as the PPI for all transportation (See Table 7-D-3). Both indices show a significant increase from 1974 to 1975.

Irrespective of manufacturers' response to other associated cost increases, industry sources indicate that cost increases caused by regulatory actions are passed completely through to consumers.

(c) Differential Impacts

Differential impacts on the school bus industry are discussed below in the context of differing costs by firms manufacturing the same product type, and of differing costs associated with quieting different types of buses.

1. Differential costs, by manufacturer, in producing the same product. Technology levels under analysis here will cause no differential cost changes across firms in the industry.

2. Differential costs associated with quieting different product types. Inspection of the price differentials for the various technology levels indicates that little change in the relative competitive positions of competing units will result from the regulatory levels.

Differential impacts on the demand for various construction categories of school buses will be minimal under the regulatory level.[10]

---

[10] Integrally constructed mid-engine and rear-engne buses built by Crown Coach and Gillig Bros. are an exception to this statement, but as mentioned earlier, they are considered specialized products not competing directly with other school bus types.

TABLE 7-D-3

WHOLESALE PRICE COMPARISON
ALL MANUFACTURERS VS. BUSES

(1967=100)

YEAR	PPI - BUSES	PPI - TRANSPORTATION
1967	100.0	-
1968	103.6	100.0
1969	106.9	100.8
1970	111.2	104.6
1971	115.0	110.3
1972	116.8	113.7
1973	117.7	115.1
1974	129.6	125.5
1975	156.4	141.5
1976	168.5	151.5
1977	176.8	161.3
1978	197.1	173.4

Source: U.S. Department of Labor, Bureau of Labor Statistics

Note: The PPI for transportation uses 1968 as the base year so a strict comparison of the two indices is not possible. However, if the PPI for transportation were adjusted to 1967 dollars, the succeeding years would show higher cost and more accurately track the PPI for buses.

For purposes of the overall microeconomic analysis, two principal construction categories, conventional gasoline and conventional diesel school buses, will be analyzed. Table 7-D-4 shows that this simplification sacrifices little accuracy in coverage.

ANALYSIS OF
USER COSTS

To assess the economic impact of noise abatement technology on the overall market for school buses, an examination of user costs similar to Subsections 7-A, 7-B and 7-C is appropriate. However, no "fare" is generally charged to riders of school buses. Instead, pupil transportation expenses are funded out of general school system revenues. Route service decisions are determined in part by local school boards and in part by requirements of State and Federal law to provide adequate transportation for all pupils.

Just under half of the pupils attending schools travel to their destination by means other than school buses,[11] either on foot, by public conveyance, or in private automobiles. Since the allocation of school system revenues is in part at the discretion of local government, service decisions -- and by implication, the demand for transportation equipment -- will respond to changes in the cost of providing transportation service.

Table 7-D-5 demonstrates that during the period 1963-74, expenditures by school systems for replacement and new vehicles was a relatively small percentage of total transportation expenditures. Since total bus inventories were also rising significantly during this period (Table 7-D-6), annual

[11] In 1971 - 1972, 46.1 percent and in 1973 - 1974, 51.5 percent, of average daily attendance was transported at public expense: (National Center for Educational Statistics, Statistics of State School Systems).

TABLE 7-D-4

PERCENT DISTRIBUTION
OF ALL SCHOOL BUS TYPES

Type of Bus	Percent of Total Buses
Gasoline Powered:	
-Conventional	84.8%
-Forward Control	0.7%
-Parcel Delivery and Motor Home Chassis	4.4%
Subtotal Gasoline	89.9%
Diesel Powered:	
-Conventional	4.9%
-Forward Control	3.9%
-Integral Mid-Engine	1.0%
-Integral Rear-Engine	0.3%
Subtotal Diesel	10.1%
TOTAL ALL TYPES	100.0%

Source: Based on market share information from Motor Vehicle Manufacturers Association, School Bus Fleet, industry interviews, and EPA estimates.

Figure 7-D-5

HISTORICAL REVIEW OF EXPENDITURES BY ELEMENTARY AND SECONDARY SCHOOLS BY MAJOR ACCOUNT AND BY TRANSPORTATION RELATED ACCOUNTS

(dollars figures in thousands)

	School Years					
	1963-1964	1965-1966	1967-1968	1969-1970	1971-1972	1973-1974
Total Expenditures(1)	$20,097	$25,600	$32,111	$40,048	$47,655	$56,518
Total Current Expenditures for Elementary and Secondary Schools	17,218	21,053	26,877	34,218	41,818	50,025
Capital Outlays	2,978	3,755	4,256	4,659	4,459	4,979
Interest on School Debt	701	792	978	1,171	1,378	1,514
Total Pupil Transportation Expenditures	723	812	1,021	1,268	1,607	1,955
Capital Outlays for Transportation Vehicles and Equipment	49	25	40	49	99	97
Current Transportation Expenditures	674	787	981	1,219	..508	1,858
Salaries(2)	245	310	348	445	532	625
Replacement of Vehicles(2)	72	77	82	88	104	132
Supplies & Maintenance for(2) Buses and Garages	121	137	143	185	208	271
Other Transportation Expenses(2)(3)	236	263	408	501	664	830
Total Pupil Transportation Expenditures As % of Total Expenditures	3.5%	3.2%	3.2%	3.2%	3.4%	3.5%
Total Pupil Transportation Expenditures As % of Total Current Expenditures	4.2%	3.9%	3.8%	3.7%	3.8%	3.9%
Salaries as % of Total Pupil Transportation Expenditures	33.9%	38.2%	34.1%	35.1%	33.1%	32.0%
Vehicle Replacement & Capital Outlays for Vehicles and Equipment as % of Total Transportation Expenditures	16.7%	12.6%	11.9%	10.8%	12.6%	11.6%
Supplies and Maintenance as % of Total Transportation Expenditures	16.7%	16.9%	14.0%	14.6%	12.9%	13.9%
Other Expenses as % of Total Transportation Expenditures	32.6%	32.4%	40.0%	39.5%	41.3%	42.5%

Notes: (1) Excluding current expenditures for services not related to elementary and secondary education.

(2) Calculated on the basis of expense distribution of states which were consistent in their reporting methodology. The following nine states were inconsistent for most years of the analysis: Alabama, Alaska, Arizona, California, Hawaii, Iowa, Montana, Ohio, and Texas.

(3) Includes contracted services, fares for public transportation, and payments in lieu of transportation.

Sources: Digest of Educational Statistics, 1975 Edition, U.S. Department of Health, Education, and Welfare, Education Division, Table 69.

Statistics of State School Systems, various editions, U.S. Department of Health, Education, and Welfare, National Center for Education Statics, various tables.

TABLE 7-D-6

UNITED STATES SCHOOL BUS
INVENTORY AND SALES
1968-74

Calendar Year	Bus Inventory	Bus Shipments	Shipments as Percent of Existing Stock	Net Shipments[a] as percent of Existing Stock
1968	262,204	29,015	11.07%	6.58%
1969	263,973	28,064	10.24	4.85
1970	288,750	27,408	9.51	3.09
1971	307,285	28,358	9.23	6.26
1972	316,421	30,635	9.68	4.16
1973	333,892	30,039	9.00	2.78
1974	354,634	29,561	8.34	--

Source: Industry Sources.

Note: [a]Net shipments are defined as gross shipments less replacement requirements to keep inventory as a constant level.

capital replacement costs were at most ten percent of total transportation expenditures.

Since bus capital is a small fraction of total factor cost in the production of bus service, a given regulation-induced change in the price of new buses has only a small effect on the total cost of transportation and therefore, on the "derived demand" for new buses. The ability of the bus manufacturing industry to pass through the additional equipment costs without severely reducing sales is thereby enhanced.

COST ESTIMATES
FROM APPENDIX G

Tables 7-D-7 and 7-D-8 summarize the estimates of technology cost from Appendix C. Expense estimates are in 1978 dollars. Maintenance cost per bus-year was converted to 1978 dollars by applying the percentage increase in the Producer Price Index (transportation) from 1976 to 1978 (173.4/151.5 = 1.145). All costs were rounded to the nearest $5.00.

The estimates in the tables are "incremental" expenses, that is, additional expenses over and above the costs in 1978 of purchasing and operating a typical bus that has no noise abatement equipment installed. Incremental fuel costs are computed on the basis of a mid-point mileage estimate as described in the note for Table 7-D-7.

Equipment cost for technology levels 1 and 2 for both gasoline powered and diesel powered conventional school buses are noticeably small. These types of school buses do not require any additional equipment at the levels since any abatement devices needed to comply with 83 and 80 dBA have been made to the bus chassis by chassis manufacturers complying with the medium and heavy truck noise emission regulation issued by EPA in 1976. Only

TABLE 7-D-7

INCREMENTAL EQUIPMENT AND OPERATING EXPENSES ASSOCIATED WITH LEVELS OF NOISE ABATEMENT TECHNOLOGY, GASOLINE POWERED CONVENTIONAL SCHOOL BUSES

(1978 dollars)

Technology Level	Exterior dB	Interior dB	EPA Estimated[1] Equipment Cost Per Bus	Fuel Cost Per Bus Year[2]	Maintenance Cost Per Bus Year[3]
1	83	86	3	0	12
2	80	83	4	0	26
3	77	80	683	10	183
4	75	78	971	30	195

Source: Appendix G.

[1]Adjusted to 1978 dollars using the Producer Price Index for buses.

[2]Assumes 8,939 miles operation per year.

[3]Adjusted to 1978 dollars using the Producer Price Index for transportation.

TABLE 7-D-8

INCREMENTAL EQUIPMENT AND OPERATING EXPENSES ASSOCIATED WITH LEVELS OF NOISE ABATEMENT TECHNOLOGY, DIESEL POWERED CONVENTIONAL SCHOOL BUSES

(1978 dollars)

Technology Level	Exterior dB	Interior dB	EPA Estimated[1] Equipment Cost Per Bus	Fuel Cost Per Bus Year[2]	Maintenance Cost Per Bus Year[3]
1	83	86	2	0	0
2	80	83	4	5	30
3	77	80	1685	30	246
4	75	78	2087	30	515

Source: Appendix G.

[1]Adjusted to 1978 dollars using the Producer Price Index for buses.

[2]Assumes 8,939 miles operation per year.

[3]Adjusted to 1978 dollars using the Producer Price Index for transportation.

testing expense and an administrative charge are further incurred by the bus manufacturer. At technology levels 3 and 4 additional abatement devices are required and are applied by the bus manufacturer.

ESTIMATES OF INCREMENTAL CAPITAL COSTS

The formula for estimating incremental capital costs is:

$$dX/dR = (r + i)\ dK/dR$$

where "dX/dR" is the incremental capital (equipment) cost associated with regulatory level "R", "dK/dR" is the dollar value of noise abatement equipment installed on new buses, "r" is the rate of depreciation, and "i" is the rate of interest.

In the absence of satisfactory data summarizing fleet operators' balance sheets and annual depreciation charges, two alternatives for estimating "r" are discussed: (1) estimates based on life cycle assumptions; (2) estimates based on observed used equipment prices.

(a) Estimates Based on Life Cycle Assumptions

Table 7-D-6 shows that the total population of school buses in the United States has grown dramatically in the last decade. Replacement requirements, shown in the last column of the table, have constituted a relatively modest proportion of the total population, roughly five percent.

This five percent figure is lower than the actual rate of depreciation experienced, however, for two reasons. First, a significant portion of the observed population of school buses consists of relatively inactive, reserve inventories that are used only occasionally during the year for emergency purposes or special events. Such buses, which have outlived their normal lives as useful working capital, do not properly belong in the depreciation estimate. Secondly, since the bus population has grown and production in earlier years was smaller than in recent years, and hence the rate of obsolescene of past years is lower than the rate of depreciation of the total stock.

A somewhat cruder estimate based on life cycle assumptions is the industry estimate of an average useful life of 9-10 years for gasoline-powered conventional school buses (which comprise 85% of the total stock). (See Table 7-D-4.) The implied depreciation rate is 10-11% per year.

(b) Estimates Based on Observed Used Equipment Prices

One major dealer in used school buses provided EPA with a representative pair of prices for good condition conventional gasoline-powered school buses built in the years 1976 and 1970. Both buses are equipped with five-speed transmissions:

1976 new conventional school bus	$14,100
1970 good condition used conventional school buses	$ 5,500

The implied rate of depreciation over the 6-year period is estimated as follows:

$$1 - (5,500/14,100)^{1/6} = 14.52\%$$

(C) Summary of Rate of Depreciation estimates

As with intercity and urban transit buses, conventional school buses have potentially long service lives depending on routes traveled, maintenance, and mileage figures. Estimates based on life cycle assumptions indicate a minimum rate of depreciation of a least six percent per annum.

Observed market prices of old and new buses imply a depreciation rate as high as fifteen percent. EPA's independent estimate for conventional gasoline-powered school buses is twelve percent, somewhat above the ten percent figure for transit and intercity buses. For conventional diesel powered school buses, EPA's estimate is ten percent per annum.

ESTIMATES OF INCREMENTAL PRIME COST

The technology cost estimates from Tables 7-D-7 and 7-D-8 for incremental equipment, fuel, and maintenance can be combined into single estimates of incremental cost per vehicle mile. This is done by converting equipment cost increments into per annum capital costs (depreciation plus interest), and then by dividing the sum of annual capital, fuel, and maintenance cost by 8,939 vehicle miles per year.

Tables 7-D-9 and 7-D-10 provide these calculations for conventional gasoline-powered and conventional diesel-powered school buses, respectively. Sensitivity tests show little change in costs due to alternative assumptions concerning depreciation.

IMPACT ON QUANTITY OF BUS SERVICE DEMANDED

On the premise that increments to prime cost are transmitted to taxpayers, the political decision-making process will respond to increased transportation costs by reducing service, by lengthening pupil riding times, and by increasing the number of pupils riding in each bus. If the decision-making process is efficient, the equilibrium response of ridership, equipment, and routes will be precisely the same as the response that would occur in a market environment where a fare equal to average expense including normal profit was charged to each pupil.

TABLE 7-D-9

INCREMENTAL PRIME COST PER BUS-MILE
OF SERVICE ASSOCIATED WITH PROPOSED LEVELS OF
NOISE ABATEMENT TECHNOLOGY,
GASOLINE-POWERED CONVENTIONAL SCHOOL BUSES

Technology Level	Exterior dB	Interior dB	EPA Estimated Incremental Costs Per Vehicle Mile[a]
1	83	86	.141¢
2	80	83	.300¢
3	77	80	3.687¢
4	75	78	4.690¢

Source: Table 7-D-5. Interest and depreciation are calculated as 20% of incremental capital cost (10% depreciation plus 10% interest). Estimates reflect an assumption of 8,939 vehicle miles per year.

Note: [a]1978 dollars.

TABLE 7-D-10

INCREMENTAL PRIME COST PER BUS-MILE
OF SERVICE ASSOCIATED WITH PROPOSED LEVELS OF
NOISE ABATEMENT TECHNOLOGY,
DIESEL-POWERED CONVENTIONAL SCHOOL BUSES

Technology Level	Exterior dB	Interior dB	EPA Estimated Incremental Costs Per Vehicle Mile[a]
1	83	86	.004 ¢
2	80	83	.400 ¢
3	77	80	6.858 ¢
4	75	78	10.766 ¢

Source: Table 7-D-5. Interest and depreciation are calculated as 20% of incremental capital cost (10% depreciation plus 10% interest). Estimates reflect an assumption of 8,939 vehicle miles per year.

Note: [a]1978 dollars.

The correspondence of market and non-market equilibria enables us to predict the effects of cost increases on equilibrium school bus ridership and the demand for school buses.

Statistics on average expense per vehicle mile for the United States are provided in Table 7-D-11. Average expense for 1974 are adjusted to 1978 dollars by applying the percentage increase in the Consumer Price Index[12] (transportation) for 1974 to June 1978:

$$(185.5/137.7) \times .72 = 96.99 \text{ cents per vehicle mile.}$$

Calculations for the estimated percentage increase in average expense are given in Tables 7-D-12 and 7-D-13. These numbers are multiplied by the demand elasticity estimate of -0.50 to compute the expected change in the quantity of service demanded. This elasticity is the same as that estimated in Appendix H for urban transit. It is probably high in absolute terms due to imperfections in the political process. The fact that pupils' marginal cost of time is relatively low implies lack of sensitivity to service charges.

IMPACT ON QUANTITY OF BUS PRODUCTION

The foregoing analysis, and Tables 7-D-12 and 7-D-13, indicate that the impact on equilibrium bus service is relatively small, particularly compared to the three percent per annum projected growth rate of (baseline) industry production. Although alternative forms of transportation for school children do exist, it is unlikely that the technology of bus fleet management permits substantial substitution between buses and other inputs in the production of bus service. Reduced ridership of three to five per-

[12] Department of Labor, Bureau of Labor Statistics.

TABLE 7-D-11

TRANSPORTATION EXPENDITURE PER PUPIL AND PER BUS MILE, 1963-74, U.S. PUBLIC SCHOOLS

School Year	Average Cost Per Pupil Transported	Average Cost per Bus Mile	Vehicle Replacement and Capital Outlays as % of Transport Expenses
1963-63	$46.53	$0.40	16.7%
1965-66	50.68	0.42	12.6
1967-68	57.27	0.50	11.9
1969-70	66.96	0.54	10.8
1971-72	77.43	0.63	12.6
1973-74	87.04	0.72	11.6

Source: Statistics of State School Systems, various editions. U.S. Department of Health, Education, and Welfare, National Center for Education Statistics, Table 41.

TABLE 7-D-12

ESTIMATED PERCENTAGE INCREASE IN AVERAGE FARE PER MILE, AND EFFECT ON QUANTITY DEMANDED, ASSOCIATED WITH PROPOSED LEVELS OF NOISE ABATEMENT TECHNOLOGY GASOLINE-POWERED CONVENTIONAL SCHOOL BUS

Technology Level	Exterior dB	Interior dB	Fare Increase	Change in Demand
1	83	86	.145%	-0.073%
2	80	83	.309	-0.154
3	77	80	3.802	-1.901
4	75	78	4.835	-2.418

Source: Tables 7-D-8 and 7-D-11. Operating costs per bus mile in 1978 are estimated at 96.99 cents (72 cents from Table D-C-11 times inflation factor derived from Consumer Price Transportation Index change to June 1978). The elasticity of demand is estimated as -0.50.

TABLE 7-D-13

ESTIMATED PERCENTAGE INCREASE IN AVERAGE FARE PER MILE, AND EFFECT ON QUANTITY DEMANDED, ASSOCIATED WITH PROPOSED LEVELS OF NOISE ABATEMENT TECHNOLOGY DIESEL-POWERED CONVENTIONAL SCHOOL BUS

Technology Level	Exterior dB	Interior dB	Fare Increase	Change in Demand
1	83	86	.005%	-0.003%
2	80	83	.413	-0.206
3	77	80	7.070	-3.535
4	75	78	11.100	-5.550

Source: Tables 7-D-8 and 7-D-11. Operating costs per bus mile in 1978 are estimated at 96.99 cents (72 cents from Table 7-D-11 times inflation factor derived from Consumer Price Transportation Index change to June 1978). The elasticity of demand is estimated as -0.50.

cent resulting from noise abatement technology translates into a similar reduction in long-run demand for new buses.

Table 7-D-14 shows that school buses are utilized at near capacity levels. The ability of school bus fleet managers to reduce equipment expenditures for a given level of pupil service is severely limited, and it is doubtful that substantial factor substitution will occur in response to a change in the relative price of bus capital.

A long run perspective on total costs to be incurred by the industry (both producer and user) can be obtained by calculating the annualized cost attendant to each technology level. The annualized cost calculation considers the equipment, testing, and administrative costs per conventional school bus, the price increase and reduced bus demand resulting from the price increase, and projects a revised baseline of sales over the relevant forecast period. With the revised sales forecast, equipment, testing, and administrative expenses to be incurred by the manufacturers, the annual operating and maintenance expenditures for each regulatory option are calculated. The analysis covers the time period 1980-2010. These costs are discounted back to 1980 using a 10 percent rate of discount, and an annuity is determined. The annuity is the constant annual payment needed to cover the discounted future expenses of each bus over its life. Table 7-D-15 presents the annualized cost calculations for each regulatory option, along with expected price increases.

Assuming employment impacts follow the general trend of demand, reduced employment over the range of technology levels in 0.01 to 2.85 percent are considered insignificant since those unemployed will have skills similar to those producing substitute modes of transportation. However, there may be modest increases in the personnel needed to design, build and install noise control components and to conduct necessary testing.

TABLE 7-D-14

AVERAGE RIDERSHIP PER SCHOOL BUS, 1963-74

School Year	Average Daily Attendance Transported/Total Number of Vehicles
1963-64	72.06
1965-66	84.09
1967-68	80.67
1969-70	76.77
1971-72	76.75
1973-74	82.07

Source: National Center for Education Statistics, Statistics of State School Systems, Table 25.

TABLE 7-D-15

CONVENTIONAL SCHOOL BUSES*
ANNUALIZED COST AND VEHICLE PRICE INCREASE

Regulatory Option	Annualized Cost (Million $)	Percentage Price Increase
1	$ 0.39	0.02%
2	0.73	0.02
2a	0.61	0.02
3	37.71	4.0
3a	32.67	4.0
3b	29.49	4.0
4	44.69	5.7

*Note: If the costs attendant to regulating integral school buses are added to costs for conventional school buses, the following cost and price increases result.

Regulatory Option	Annualized Cost (Million $)	Percentage Price Increase
1	$ 2.36	0.06%
2	5.78	0.08
2a	4.38	0.08
3	46.70	4.0
3a	40.12	4.0
3b	36.01	4.0
4	59.52	5.7

FINANCIAL IMPACT ON SCHOOL BUS USERS

The regulations may have adverse economic impacts not recorded above in the "long-run" analysis if they prompt short-run financial dislocations or other distributional effects. Consider first the impact on taxpayers and municipal and state financing authorities.

The preceeding analysis (Tables 7-D-12 and 7-D-13) shows that increases of no more than ten percent (across all school bus types) in pupil transportation expenditures are anticipated even at the most stringent level of proposed noise attenuation. This estimate can be combined with statistics on public school finance to assess the extent of financial impact.

Table 7-D-16 shows that total pupil transportation accounts for only a small percentage of public school system expenditures. This percentage is significantly higher in smaller, non-metropolitan systems. For purposes of estimation, a ten percent increase in total pupil transportation expenditures translates into a 0.24 percent increase in total pupil expenditures in central metropolitan areas, as compared with a 0.58 percent increase in non-metropolitan areas.

Public school system finances are shared by local, state and federal sources as shown in Table 7-D-17. State and local jurisdictions are responsible for about 85 percent of total resources and non-resource receipts.

FINANCIAL IMPACTS ON PRODUCERS INCLUDING EXPORTERS AND IMPORTERS

The economic analysis presented above puts an upper bound on the aggregate percentage reduction in equilibrium demand for school buses at 2.85 percent from base line levels.[13]

[13] These figures are computed as a weighted average from Tables 7-C-10 (85%) and 7-C-11 (15%).

TABLE 7-D-16

PUPIL TRANSPORTATION SERVICES EXPENDITURES BY ENROLLMENT SIZE AND METROPOLITAN STATUS, 1970-71

(Dollar Figures in Millions)

	(1) Total Current Expenditures	(2) Pupil Transportation Expenditures	(3) Pupil Transportation As % of Total Expenditures
All U.S. Public School Systems	$25,827.3	$1,376.7	3.84%
System Enrollment Size:			
5,000 and Over	$23,746.4	$ 707.9	2.98%
Less than 5,000	$12,080.9	$ 668.8	5.54%
Metropolitan Status:			
Central Metropolitan	$10,193.8	$ 249.3	2.45%
Metropolitan, Other	$15,178.3	523.7	3.45%
Non-Metropolitan	$10,455.2	603.8	5.78%

Source: Statistics of Local Public School Systems, Finance, 1970-71. U.S. Department of Health, Education and Welfare, Office of Education.

TABLE 7-D-17

REVENUE AND NONREVENUE RECEIPTS OF LOCAL PUBLIC SCHOOL SYSTEMS BY SOURCE OF FUNDS: UNITED STATES, 1970-71

	(Millions)	(Percent)
Total Receipts	$45,511	100.0%
Revenue Receipts	$42,424	93.2
Local	22,851	50.2
Intermediate	504	1.1
State	15,784	34.7
Federal	3,285	7.2
Nonrevenue Receipts (Bonds)	$ 3,087	6.8%

Source: National Center for Educational Statistics, Statistics of Local Public School Systems, Finance 1970-71, Table A-1.

Figure 3-15, (Section 3) indicates a growth rate in baseline production of 3.0 percent per year through the year 1990. Given proposed lead times for the various noise abatement levels studied, only modest reduction in existing manufacturing capacity will result and producers will incur only minimal financial impacts.

It is important that transit-style integral construction school buses (produced in relatively small numbers by Gillig Bros. and Crown Coach Corporation in California), serve a significantly different market than the conventional school bus market. Integral school buses are long-lived (20-30 years as opposed to 9-10 years), expensive ($55,000-$60,000 as opposed to $19,000-$23,000), and intended primarily for long-route, intensive use typical of the west-coast region in which they are marketed. It is clear that the sensitivity of demand to price increases for these buses, vis-a-vis conventional buses, is very small. Since conventional buses do not compete with these Gillig and Crown Coach models, a price increase would not likely lead to conventional school bus inroads into this market.

Section 3 indicates that the vast majority of school bus chassis and bodies are produced domestically and in Canada (which is virtually equivalent, given the Automotive Pact Trade Agreement). Finished school buses are generally built according to customer specifications, so that producers already possess the necessary flexibility to treat the noise reduction package as an optional item, not included on exports to nonregulated countries.

Since school buses are not imported in significant quantities to the United States, no balance of trade or balance of payments effects are foreseen for the proposed regulation.

E. COST AND ECONOMIC IMPACT OF THE REGULATORY RULE

The regulatory rule requires all school buses to meet an 83 dB noise level in 1981 and an 80 dB level in 1985. Transit and intercity buses must also meet these 83 and 80 dB levels in the same years as school buses, but they must also meet a 77 dB level in 1987.

Table 7-E-1 shows the incremental equipment, testing, and operating expenses for all bus types for the rule. All figures presented are in 1978 dollars. The calculations for school bus costs are determined by taking the weighted average cost for conventional school buses given in Section D of this chapter, and adding to that the weighted average cost increase for integral school buses.

These technology cost estimates presented in 7-E-1 can be combined into single estimates of incremental cost per vehicle mile. This is done by converting each separate equipment cost into per annum capital cost and then by dividing the sum of annual capital, fuel, and maintenance expenditure by the appropriate number of miles travelled per year, per bus type. The results of this calculation are presented in Table 7-E-2 below. Also shown in Table 7-E-2 are the appropriate fare increases attendant with the incremental cost estimates and the decline in demand that would result from the fare increase. Table 7-E-2 shows that only in the case of transit buses is there any impact that might be termed non-negligible; however, the fare increases and demand changes for transit changes are quite low if an assumption is made that 80% of the incremental capital costs is financed through subsidies from UMTA.

The long-run perspective on total costs to be incurred by the industry for all bus types for producers and users can be obtained by calculating

TABLE 7-E-1

INCREMENTAL EQUIPMENT, TESTING, AND OPERATING EXPENSES FOR RULE -- ALL BUSES.
(1978 Dollars)

Bus Type	Equipment Testing Cost	Fuel Cost	Maintenance Cost
Intercity	$3,767	$ 610	$ 595
Transit	2,686	70	595
School*	52	0	46

*Note: Includes all conventional and integral school buses.

Source: Tables 7-A-2, 7-D-3, 7-D-5, 7-D-6, Appendix G.

TABLE 7-E-2

INCREMENTAL PRIME COST PER
BUS MILE OF SERVICE
ASSOCIATED WITH THE RULE,
FOR EACH BUS TYPE

Bus Type	EPA Estimates Incremental Costs, Cents Per Vehicle Mile	Fare Increase (1978 Dollars)	Change in Demand
Intercity	.783	.726	-0.363
Transit	3.200 (2.054)a	3.344 (1.074)a	-1.672 (-0.537)a
School*	0.629	.648	-0.324

*Note: Includes all conventional and integral school buses.

Source: Table 7-A-5, 7-B-3, 7-D-5, 7-D-6, Appendix G Interest and depreciation are calculated as 20% of incremental capital cost (10% depreciation and 10% interest). Estimates reflect an assumption of 250,000 miles per year for intercity buses, 37,608 miles per year for transit buses, and 8,939 miles per year for school buses. Revenue estimates updated to 1978 dollars.

a) Numbers in parantheses are estimated if an assumption of UMTA subsidize 80% of incremental capital cost.

the annualized cost attendant with the regulatory rule. Details of the annualized cost calculation were presented in each of the three preceding sections. Table 7-E-3 presents the annualized cost calculations for the regulatory rule for each bus type, along with expected price increases. The annualized cost for the rule for all bus types is $51.12 million. The weighted average price increase for all bus types for the rule is 0.59%.

TABLE 7-E-3

ANNUALIZED COST AND VEHICLE PRICE INCREASE

Bus Type	Annualized Cost ($ Million)	Percentage Price Increase
Intercity	$ 15.43	3.4
Transit	29.91	3.1
School*	5.78	0.08
Total =	$ 51.12	0.59%

*Note: Includes all conventional and integral school buses

REFERENCES

SECTION 7

1. "An Econometric Model of Urban Bus Operations," Chapter IV of John D. Wells et al, Econometric Characteristics of the Urban Public Transportation Industry (Washington, D.C.: Government Printing Office, 1972).

2. Hicks, John R. The Theory of Wages. London: MacMillan, 1932.

3. Heighchew, Robert E., United States Transit Bus Demand. Highway Users Federation, Washington, D.C.: June, 1975.

4. "A Study to Determine the Economic Impact of Noise Emission Standards in the Bus Manufacturing Industry," Draft Final Report submitted by A.T. Kearney, Inc. under EPA Contract No. 68-01-3512, prepared for the Office of Noise Abatement and Control, September, 1976.

5. "Costs of Noise Abatement to Meet Noise Emission Standards in the Bus Manufacturing Industry," Preliminary Draft Update Report submitted by A.T. Kearney, Inc. under EPA Contract No. 68-01-3512, prepared for the Office of Noise Abatement and Control, September, 1978.

SECTION 8

MEASUREMENT METHODOLOGY

The choice of a procedure for measuring the noise emitted by buses was based on several considerations:

- o Existing bus noise measurement procedures
- o Bus noise characteristics
- o Work cycle of buses
- o Enforcement requirements
  - Repeatability of measurement

1. EXISTING PROCEDURES

A number of existing and proposed noise measurement procedures for buses and trucks were examined for applicability.

For a number of years U.S. industry has been using the SAE J366b measurement procedure (full throttle acceleration) for measuring the exterior sound levels for heavy trucks and buses ISO recommendation, R362, which follows a similar procedure, (Ref. 1) is the basis for noise measurement in some European countries. Table 8-1 compares the main features of these two procedures.

Both procedures require the use of high quality (Type I or "Precision") sound measuring equipment, background noise levels at least 10 dB below the level produced by the test vehicle, and a flat, open space free of reflecting surfaces. The recommended test sites for performing measurements are shown in Figure 8-1.

The ISO recommendation includes a procedure for measurements with stationary vehicles, with the engine operating at governed speed, or at three-quarters of maximum rated speed if the engine is ungoverned.

TABLE 8-1

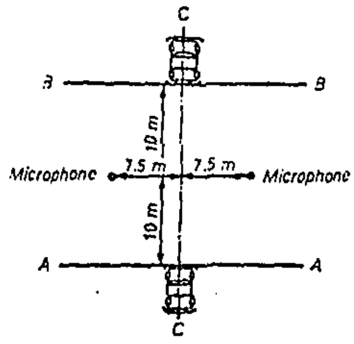
Comparison of Existing Procedures

Procedure	Microphone		Vehicle Condition		Length of Acceleration Lane	Sound Level Reported
	Distance	Height	At Start of Acceleration	At End of Acceleration		
SAE J366b	50 ft. (15.2 m)	4 ft. (1.2 m)	66% of rated or governed engine speed	Maximum rated or governed engine speed, without exceeding 35 mph (56 km/hr)	60 to 100 ft. (18.3 to 30.5 m)	Average of two highest dBA, fast readings within 2 dB of each other
ISO R362	7 m	1.2 m	75% of rated or governed engine speed, or 50 km/hr	Not specified	20 m	All readings—dBA, fast

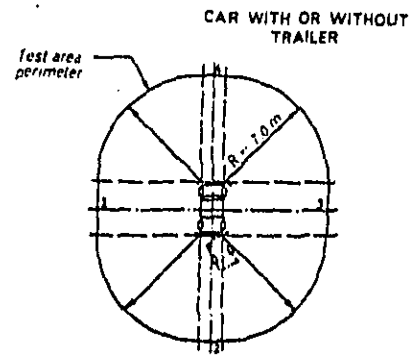
FIGURE 8-1

Recommended Test Sites for
ISO and SAE Procedures

ISO R362 Procedure

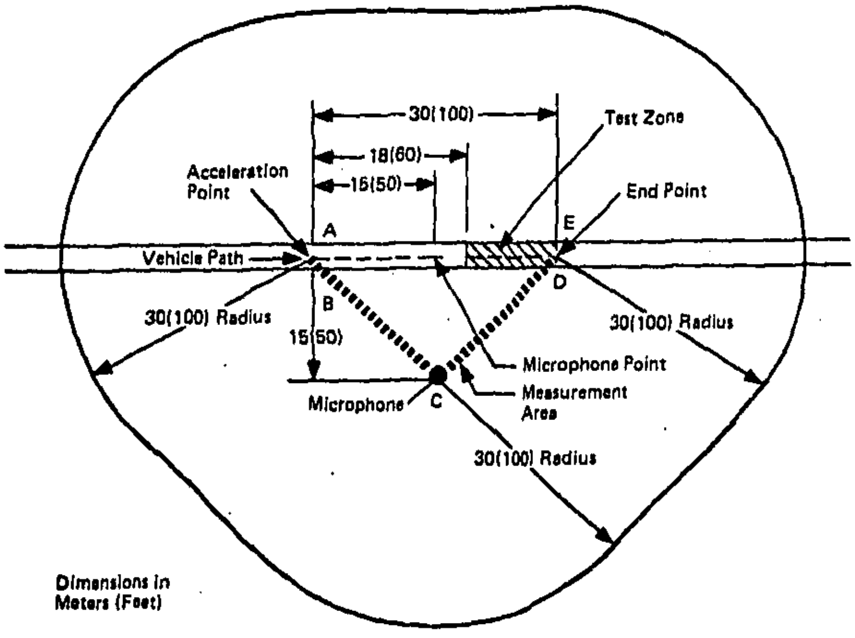


— Measuring positions for measurement with vehicles in motion



— Measuring positions for measurement with stationary vehicles

SAE J366b Procedure

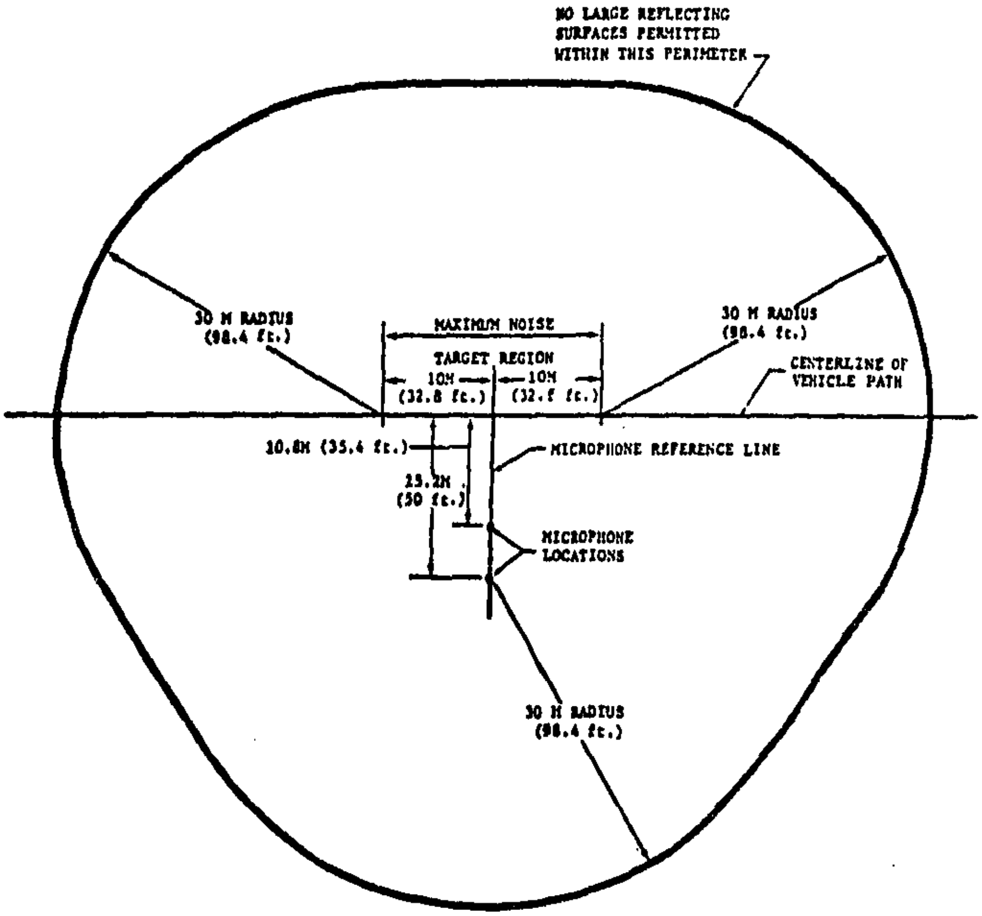


The MITRE Corporation, under contract to the U. S. DOT Urban Mass Transportation Administration, has developed a standard procedure specifically directed at urban transit buses (Ref. 2) For exterior noise, two microphones are required, one at a 15.2 m (50 feet) distance and a 1.2 m (4 feet) height and another at a 10.8 m (35.4 feet) distance and 12.0 m (39.4 feet) height. The latter position corresponds to a slant distance of 15.2 m (50 feet) from the bus lane along a line 45 degrees to the road surface, and is designed to insure controlled noise levels to apartment dwellers. A recommended test site area is shown in Figure 8-2. A stationary starting point ahead of the microphone reference line is selected such that, when the vehicle is accelerated from that point with rapid application at wide open throttle, the chief vehicle noise source of the test coach shall fall within a 32.8 ft. (10 m) region on either side of the microphone reference lines when the vehicle reaches maximum governed speed for manual transmission models or shift point for automatic transmission models. Maximum vehicle speed during the test is limited to 31 mph (50 km/hr). Interior noise levels are measured at the forwardmost passenger seat, the seat nearest the center of the bus, and the rearmost seat.

The Coach Noise Subcommittee of the SAE Vehicle Sound Level Committee has also been preparing recommended procedures for exterior and interior sound levels of motor coaches which include school, transit, and intercity buses. This subcommittee feels that for buses, the "pull-away" or standing start mode of operation normally produces maximum exterior noise levels. They are also considering a shortened test zone where the bus reaches maximum rated or governed speed between tests. Test conditions have also been established for interior noise measurements.

FIGURE 8-2

Minimum Acceptable Test Area for Urban Transit Buses, MITRE Recommendation (Ref. 2)



2. BUS NOISE CHARACTERISTICS

If the noise characteristics are similar while the vehicle is stationary and moving, stationary test procedures are to be preferred because of the resultant ease of testing. Other considerations are the consistency of noise levels between tests and the ease of extrapolation of the measured level to actual noise levels experienced in the community. One of the difficulties with stationary procedures is that if the engine is be precisely controlled. In addition, sudden acceleration of gasoline engines without load is considered damaging since excessively high engine speeds would result. The stationary procedure does offer the advantage of removing one of the unwanted sound sources, namely tires, from the overall sound measured.

Existing bus noise level data (Section 4) include stationary and acceleration noise levels. The SAE Vehicle Sound Level Committee has collected and analyzed noise data on various vehicle types using stationary and acceleration procedures. The data indicate that while each of the procedures gives repeatable measurements for a given vehicle, and about equal spread in levels between different vehicles, the correlation between the two procedures is poor. In other words, vehicles may or may not emit higher levels during acceleration tests as opposed to stationary tests. Thus, there does not appear to be a simple method to predict which of the two levels would be higher for a given vehicle. Because of this problem, most bus manufacturers have adopted the J366b procedure as the standard procedure.

Interior noise has not received much attention from bus manufacturers, except for intercity bus manufacturers. They have discovered mainly that the noisiest section of the bus is generally around the seat nearest the engine.

3. WORK CYCLES

Buses are used for a wide variety of applications under different road and traffic conditions. The proportions of operating time spent under acceleration, deceleration, cruise, and idle conditions vary accordingly. The work or duty cycles of buses are important considerations in the development of a noise measurement procedure because the measured level should be representative of one or more of the prominent modes . operation of the bus.

The school bus generally operates in a suburban environment as opposed to the urban environment of the transit bus. Metropolitan transit buses generally operate in an urban environment picking up and discharging passengers frequently along their daily runs. As a result work cycles consist mainly of accelerations and decelerations with minimum cruise time at constant speeds. The work cycle of an intercity bus is comprised mainly of cruise time at high speed with stops occurring only near bus terminal locations.

A representative work cycle for school buses was estimated from data obtained from the Radnor School District near Philadelphia, Pennsylvania. (Ref. 6)

Number of Routes	25
Number of Stops	541
Total Time	1263 min.
Total Distance Covered	129 miles

Assuming an average cruise speed of 27 mph and acceleration/deceleration rate of 3.22 ft/sec/sec, the percentage of time under different conditions was obtained:

9% of time under acceleration
9% of time under deceleration
21% of time at cruise
61% of time at engine idle

A representative work cycle for urban transit buses was estimated from data furnished by the EPA Mobile Source Air Pollution Laboratory, Ann Arbor, and from the report on the California Steam Bus Project (Ref. 3). Urban drive cycles vary widely. An average work cycle for buses making seven to ten stops per mile would be as follows:

20% of time under acceleration
20% of time under deceleration
26% of time at cruise
34% of time at engine idle

Eagle International Inc., has furnished the following data for intercity buses:

Average cruise speed of intercity buses - 60 mph

Average acceleration and deceleration rates - 1.5 to 3.0 mph/sec

Average cruise distances - 50 miles

Average number of stops and starts per year - 5,000

Typical drive cycles: Acceleration - 5%
Deceleration - 5%
Cruise - 85%
Idle - 5%

4. MEASUREMENT DISTANCE

The location of the receptors of bus noise vary widely. Pedestrians are possibly subjected to the loudest noise levels from buses because of their close proximity to the bus. GMC has reported the existance of data showing that transit buses contribute measurably to the background noise levels in downtown Detroit. They argue that urban transit bus noise should, therefore, be measured at a distance of 15 to 25 feet from the curbside of the bus. (Ref. 4) Extrapolation to 50 ft. measurements from closer distances than 50 ft., however, using the standard 6 dB loss per doubling of distance would suggest levels lower than those actually existing at 50 ft. In addition, because buses can be up to 40 ft. long, measurement distances shorter than 50 ft. place the microphone in a closer proximity to the acoustic nearfield of the bus, an undesirable position for repeatable results.

5. ENFORCEMENT REQUIREMENTS

All available bus noise level data are in A-weighted decibel units. All standard and recommended test procedures also recommend that measurements be made in A-weighted decibel units. Available equipment for measurement of sound directly in these units is reliable and readily available. Since sound levels measured in these units also approximate human subjective response to noise, the A-weighted decibel unit is recommended for any test procedure.

The procedure should be such that repeatable test conditions can be easily obtained. Repeatability can be ensured by specifying engine speeds, engine rpm, test site surface and surrounding conditions.

6. TEST MEASUREMENTS

Noise measurements from 65 school, transit and intercity buses were taken under various test procedures. Exterior as well as interior noise levels were measured during each test.

The SAE J366b standard procedure was used for measuring exterior and interior noise for all buses with manual transmissions and for those buses with automatic transmissions which could be manually held in gear. In addition, stationary noise measurement procedures were also employed for all buses tested.

A modified J366b procedure was used in the case of buses with automatic transmission which could not be manually held in gear. The modified J366b procedure consisted of the bus accelerated under wide open throttle from a predetermined stationary position. The starting position was selected to assure that the bus reached maximum governed speed (i.e., upshift) in the end zone defined by the SAE J366b procedure.

A full throttle pull-away procedure was also examined for all bus types with microphones in line with the front and rear bumpers of the bus. This test is not suitable for vehicles with manual transmissions because of the non-repeatablity of the bus pull-aways.

It should be noted that all interior bus noise measurements were taken with all bus windows and doors closed and all interior fan accessories (including air conditioner fans and/or heating fans) operating. Windscreens were utilized during all the interior measurements to assure that no variation in sound level due to the movement of air throughout the bus would occur. In addition, in order to assure that the interior microphone did not receive acoustic standing wave sound propagation from any bus wall (i.e., the ceiling), the microphone was tilted towards the front of the bus at a 20-30 degree angle from the vertical for all interior bus measurements made.

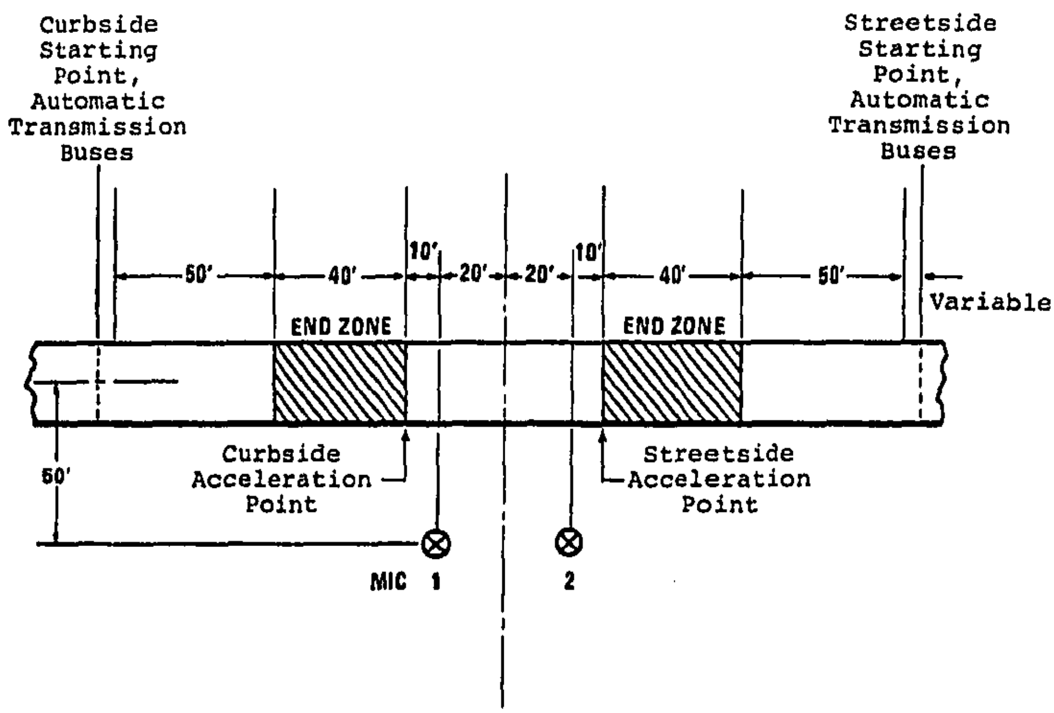
SCHOOL BUSES

The principal noise sources on conventional school buses, the cooling fan, the engine, and the exhaust outlet, are separated by the length of the bus. Thus, two microphones, separated by the length of the bus, were used simultaneously on one side of the bus as shown in Figure 8-3.

Two stationary test procedures were examined for school buses. The IMI (Idle-Max. Governed Speed-Idle) procedure requires the engine throttle to be opened at a rapid rate from idling condition to its maximum governed speed and then closed to return it to idle speed. The maximum governed speed test requires the maximum governed speed to be maintained for approximately ten seconds. This test is not recommended for ungoverned engines as engine damage might result.

FIGURE 8-3

Bidirectional Test Site For
School Bus Noise Measurement



Measured noise levels for 29 new and in-use conventional gasoline school buses under the stationary, pull-away and acceleration procedures may be found in Section 4. Maximum interior noise levels were obtained during the J366b procedure at the seat (driver) nearest the engine.

Since microphones were used to record maximum noise exterior levels with the front and the rear of the school bus as reference points, the tests revealed which of the two ends of each bus was noisier. Figure 8-4 shows that on the average, the front of the bus is louder by 3 decibels on the curbside. Both ends of the bus are about equally loud on the streetside.

TRANSIT BUSES

Exterior and interior noise levels for 24 diesel powered transit buses are summarized in Section 4. During the testing, difficulty was encountered in maintaining uniformity of procedure when performing maximum acceleration (modified J366b) and pull-away testing. In the case of the maximum acceleration procedure the buses would not always shift at the same point in the end zone. In the case of the pull-away procedure, although the buses were accelerated at wide-open throttle the run-up of the engines to the maximum governed rpm was not always consistent. Most of the variation in the bus operations was felt to be due to the age of the buses tested.

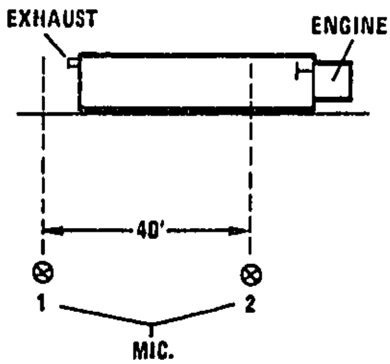
It is interesting to note that in correcting for the variability in the bus operation, it was found that it was easier to correct for the variation in the shift point location by changing the starting point location than for the variation in the engine run-up.

INTERCITY BUSES

Section 4 also displays summaries of exterior and interior noise level data measured from 12 newly manufactured intercity buses. Data was recorded

FIGURE 8-4

Differences in Sound Levels of
Conventional School Buses with
the Front and Rear
Used for Reference



TEST NO.	L(2) - L(1) CURBSIDE	L(2) - L(1) DRIVERSIDE
1	2 dB	0.75 dB
2	3	0.25
3	3.25	-1.25
4	3.67	0
5	3.5	-0.25
6	3.0	-0.33
10	3.0	-1.0
AVERAGE	3.06 dB	-0.167 dB

using a modified J366b sound measurement procedure (both acceleration and deceleration modes were tested), a pull-away procedure (for automatic transmission vehicles) and a stationary IMI procedure. Interior noise level data was taken using all procedures.

7. SUMMARY

Exterior Procedures

The standard SAE J366b procedure was found acceptable for school buses and intercity buses with standard transmissions and automatic transmissions that can be manually locked in gear to prevent upshifting above desired gears.

For transit buses with automatic transmissions which cannot be manually locked in gear, the modified J366b procedure was found acceptable for exterior sound measurement testing.

Interior Procedure

The selection of an interior measurement procedure is closely linked to the selection of an exterior procedure. This leaves the location of the microphone as the most salient question. To this end, it has been found that in all EPA bus noise measurements, as displayed in Section 4, the noisiest location in the bus is the seat location nearest the main body of the engine. Thus, it may be concluded that measurements at this seat location (nearest the main body of the engine) characterize the loud extreme of the noise environment inside a bus.

8. RECOMMENDED TEST PROCEDURES FOR MEASUREMENT OF EXTERIOR SOUND LEVELS

(a) Instrumentation. The following instrumentation must be used, where applicable.

(1) A sound level meter and microphone system which meets the Type 1 requirements of ANSI SI.4-1971, "Specification for Sound Level Meters." A noise measuring system with a magnetic tape recorder and/or a graphic level recorder and/or indicating meter, may be used providing the system meets the requirements of ANSI S6.1-1973, "Qualifying a Sound Data Acquisition System."

(i) Systems other than those specified may be used provided the system yields noise levels which are equivalent to those measured by a Type 1 sound level meter.

(2) A windscreen must be employed with the microphone during all sound measurements. The windscreen must not affect the A-weighted sound levels from the vehicle in excess of ± 0.5 dB.

(3) A sound level calibrator. The calibrator must produce a sound pressure level, at the microphone diaphragm that is known to within an accuracy of ± 0.5 dB. The calibrator must be checked annually to verify that its output has not changed.

(4) An engine-speed tachometer which is accurate within ± 2 percent of meter reading.

(5) An anemometer or other device for measurement of ambient wind speed accurate within ± 10 percent at 19.3 km/hr (12 mph).

(6) A thermometer for measurement of ambient temperature accurate within ±1 C°.

(7) A barometer for measurement of ambient pressure accurate within ± 1 percent of the meter reading.

(b) Test site requirements.

(1) The test site must be such that the bus radiates sound into a free field over a reflecting plane. This condition may be considered fulfilled if the test site consists of an open space free of large reflecting surfaces, such as parked vechicles, signboards, buildings or hillsides, located within 30.4 meters (100 feet) of both the vehicle path and the microphone.

(2) The microphone must be located 15.2 ± 0.1 meters (50 feet ± 4 inches) from the centerline of vehicle travel and 1.2 ± 0.1 meters (4 feet ± 4 inches) above the ground plane. The microphone point is defined as the point of intersection of the vehicle path and the normal to the vehicle path drawn from the microphone.

The microphone must be oriented with respect to the source in a fixed position so that the sound strikes the diaphram at the angle for which the microphone was calibrated to have the flattest frequency response characteristic over the frequency range 100 Hz to 10 KHz.

(3)(i) For vehicles with manual transmission or with automatic transmissions which can manually be held in gear, an acceleration point must be established on the vehicle path 15.2 meters (50 feet) before the microphone point.

(ii) For vehicles with automatic transmissions, which cannot be manually held in gear, a starting point must be established as described in paragraph (c)(2) of this section.

(4) An end point must be established on the vehicle path 30.4 meters (100 feet) from the acceleration point and 15.2 meters (50 feet) from the microphone point.

(5) The test zone is the last 12.2 meters (40 feet) of vehicle path prior to the end.

(6) The measurement area must be the triangular-paved (concrete or sealed asphalt) area formed by the acceleration point, the end point, and the microphone location.

(7) The reference point on the vehicle, used to indicate when the vehicle is at any of the points on the vehicle path, must be the front surface (other than the bumper) of the vehicle except as follows:

(i) If the engine is front-mounted and the horizontal distance from the front of the vehicle to the exhaust outlet is more than 5.1 meters (200 inches), tests must be run using either the front or rear surface of the vehicle as the reference point, whichever is the louder position.

(ii) If the engine is located rearward to the center of the chassis or at the approximate center (± 1.5 meters or ± 5 feet) of the chassis, the rear of the vehicle must be used as the reference point.

(8) The plane containing the vehicle path and the microphone location (plane ABCDE in Figure 8-1) must be flat within ± .05 meters (± 2 inches).

(9) Measurements must not be made during precipitation or when the road surface or the measurement area is covered with snow or water.

(10) Bystanders have an appreciable influence on sound level meter readings when they are in the vicinity of the vehicle or microphone;

therefore, not more than one person, other than the observer reading the meter, must be within 15.2 meters (50 feet) of the vehicle path or measuring instrument and the person must be directly behind the observer reading the meter, on a line through the microphone and observer. To minimize the effect of the observer and the container of the sound level meter electronics on the measurements, cable should be used between the microphone and the sound level meter. No observer shall be located within 1 meter (3.3 feet) in any direction of the microphone location.

(11) The maximum A-weight fast response sound level observed at the test site immediately before and after the test must be at least 10 dB below the regulated level.

(12) The road surface of the measurement area must be smooth concrete or smooth scaled asphalt, free of extraneous material such as gravel.

(13) Vehicles with diesel engines must be tested using Number 1D or Number 2D diesel fuel possessing a cetane rating from 42 to 50 inclusive.

(14) Vehicles with gasoline engines must use the grade of gasoline recommended by the manufacturer for used by the purchaser.

(15) Vehicles equipped with thermostatically controlled radiator fans (clutch fans) must be tested with the fan engaged in a "lock up" mode, such that the drive hub and fan are turning at the same speed or as near the same speed as is possible within the design limits of the particular fan clutch design.

(16) School buses, cowl chassis, and buses incorporating cowl chassis may be tested with the fan not operating.

(c) Procedures

(1) Buses equipped with manual (standard) transmissions or buses with automatic transmissions which can be manually held in gear. Full throttle acceleration and closed throttle deceleration tests must be used. A beginning engine speed and proper gear ratio must be determined for use during measurements.

(i) Select the highest rear axle and/or transmission gear ("highest gear" is used in the usual sense; it is synonymous to the lowest numerical ratio) and an initial vehicle speed such that at wide-open throttle the vehicle will accelerate from the acceleration point:

(A) Starting at no more than two-thirds (66.7 percent) of maximum rated engine speed.

(B) Reaching maximum rated (if the vehicle is not equipped with an engine governor) or governed engine speed (if the vehicle is equipped with an engine governor) within the test zone.

(1) Should maximum rated or governed rpm be attained before reaching the test zone, decrease the approach rpm in 100 rpm increments until maximum rpm is attained within the test zone.

(2) Should maximum rated or governed rpm not be attained until beyond the test zone, select the next lower gear until maximum rated or governed rpm is attained within the test zone.

(3) Should the lowest gear still result in reaching maximum rated or governed rpm beyond the permissible test zone, increase the approach rpm in 100 rpm increments until the maximum rated or governed rpm is reached within the test zone.

(4) Should the maximum rated or governed rpm still be attained before entering the test zone, and the engine rpm during approach cannot be further lowered, begin acceleration at a point 10 feet closer to the beginning of the test zone. The approach rpm to be used is to be that rpm used prior to the moving of the acceleration point 10 feet closer to the beginning of the test zone.

(5) Should the maximum rated or governed rpm still be attained before entering the test zone, repeat the instructions in the preceeding paragraph until the maximum rated or governed rpm is attained within the test zone.

(C) Do not exceed 56km/hr (35 mph) before reaching the end point.

(D) Wheel slip which affects maximum sound level must be avoided.

(ii) For the acceleration test, approach the acceleration point using the engine speed and gear ratio selected in paragraph (c)(1)(i) of this procedure and at the acceleration point rapidly establish wide-open throttle. The vehicle reference point must be as indicated in paragraph (b)(7) of the recommended exterior noise measurement procedure. Acceleration must continue until maximum rated or governed engine speed is reached.

(A) Buses equipped with governed engines must be held at wide open throttle until the entire vehicle is out of the test zone.

(B) Buses equipped with ungoverned engines must not be allowed to drop more than 100 rpm below maximum rated engine speed until the vehicle is out of the test zone.

(2) Buses equipped with automatic transmissions which cannot be manually held in any gear.

(i) Select the highest gear axle ratio and/or transmission gear ("highest gear" is used in the usual sense; it is synonymous to the lowest numerical ratio) to accelerate the bus under wide open throttle from a stationary position.

(ii) A starting point along the test path at which the vehicle will begin the acceleration test must be determined by the following procedure:

(A) The vehicle's reference point must be placed within ± 0.3 meters, (± 1 foot) of the midpoint of the test zone with the front end of the vehicle facing back along the test path in the opposite direction of travel that is used for the sound measurement tests.

(B) The vehicle must then be accelerated as rapidly as possible to establish a wide open throttle, until the first transmission shift point is reached.

(C) The location along the test path at which the reference point of the vehicle is passing when the first transmission shift point occurs must be the designated starting point.

(D) The vehicle's direction of travel must then be reversed for noise testing.

(iii) Accelerate the vehicle from a standing position with the reference point of the vehicle at the selected stationary starting point, obtained by using the procedure outline above, as rapidly as possible to establish a wide open throttle. The acceleration must continue until the entire vehicle has vacated the test zone.

(iv) Wheel slip which affects maximum sound level must be avoided.

(3) <u>Measurements</u>

(i) The meter must be set for "fast response" and the A-weighted network.

(ii) The sound meter must be observed during the period while the vehicle is accelerating. The applicable reading must be the highest sound level obtained for the run. The test is to be rerun if unrelated peaks should occur due to extraneous ambient noises.

(iii) Sound level measurements must be taken on both sides of the vehicle. The noise level associated with a given side must be the average of two pass-by measurements for that side, if they are within 2 dB of each other. An average noise level must be computed for each side of the vehicle. If the first two measurements for a given side differ by more than 2 dB, two additional measurements must be made on each side, and the average of the two highest measurements of each side, within 2 dB of each other, must be taken as the measured vehicle noise level for that side. The reported measured vehicle noise level must be the higher of the two averages.

(d) General Requirements

(1) Measurements must be made only when wind velocity is below 19.3 km/hr (12 mph).

(2) Proper usage of all test instrumentation is essential to obtain valid measurements. Operating manuals or other literature furnished

by the instrument manufacturer must be referred to for both recommended operation of the instrument and precautions to be observed. Specific items to be adequately considered are:

(i) The effects of ambient weather conditions on the performance of the instruments (for example, temperature, humidity, and barometric pressure).

(ii) Proper signal levels, terminated impedances and cable lengths on multi-instrument measurement systems.

(iii) Proper acoustical calibration procedure, to include the influence of extension cables, etc. Field calibration must be made immediately before and after each test sequence. Internal electrical calibration is acceptable for field use, provided that acoustical calibration is accomplished immediately before or after field use.

(3) (i) A complete calibration of the instrumentation and acoustical calibrator shall be performed at least annually to insure compliance with the standards cited in American National Standard S1 4-1971 "Specifications for Sound Level Meters" for a Type 1 instrument over the frequency range 100 Hz - 10KHz.

(ii) If calibration devices are utilized which are not independent of ambient pressure (e.g., a pistonphone) corrections must be made for barometric or altimetric changes according to the recommendation of the instrument manufacturer.

(4) The vehicle must be brought to its normal operating temperature prior to commencement of testing. During testing appropriate caution must be taken to maintain the engine at temperatures within the normal operating range.

(e) Alternative procedures

The Administrator will consider applications for exterior noise level test procedures which differ from those previously described if the alternative procedures demonstrate a correlation with the prescribed procedure. To be acceptable, alternative procedures must ensure that the results will identify all vehicles which would not comply with the noise emission standards when tested. Tests conducted by manufacturers under approved alternative procedures may be accepted by the Administrator for all purposes including, but not limited to, production verification testing and selective enforcement audit testing.

9. RECOMMENDED PROCEDURE FOR MEASUREMENT OF INTERIOR SOUND LEVELS

Interior sound levels must be measured using the same vehicle operation and measuring equipment as described in the Recommended Procedure for Measurement of Exterior Sound Levels.

(a) Instrumentation. The instrumentation of interior noise measurements must be identical to those used for exterior noise emission measurements.

(b) Microphone placement.

(1) For all buses other than those with a front-mounted engine, the microphone must be located next to the seat location closest to the main body of the engine at a height of 1.25 meters (4.1 ft.) from the bus floor.

(2) For front engine buses the microphone must be placed next to the vehicle operator's seat, at a height of 1.25 meters (4.1 ft.) from the floor.

(3) With the sound receiving portion of the microphone apparatus in the uppermost position directed toward the maximum noise, the apparatus must be tilted at an angle of 20^o - 30^o from an original position with the longitudinal axis of the apparatus being vertical.

(c) Procedure

(1) Vehicle operation. The vehicle must be operated in the same manner as stated in the recommended exterior noise measurement procedure. The same axle ratios, gear rations, and transmission as that of the vehicle tested for external noise.

(2) All windows and doors must be closed on the vehicle and all interior fan accessories, (including the heater or air conditioner fan, whichever is the noisier) must be turned on.

(3) Only two people (the driver and the observer who is reading the meter) are permitted on the bus at the time of measurement.

(4) An ambient noise level must be measured before and after the testing. That level must be at least 10 dB below the appropriate regulatory level with engine and accessories turned off.

(d) Measurements

(1) The meter shall be set for "fast response" and the A-weighted network.

(2) The applicable reading shall be the highest noise level obtained for the run. The observer is cautioned to rerun the test if unrelated peaks should occur due to extraneous ambient noise. A minimum of two tests shall be run.

(3) The average of the two highest levels within 2 dB of each other shall be reported as the interior level of the bus. Should the two initial levels not be within 2 dB, additional tests must be run until the two highest levels measured are within 2 dB.

(e) General requirements

The general requirements previously discussed for exterior noise level measurements shall apply in this section.

(f) Alternative procedures

The Administrator will consider applications for interior noise level test procedures which differ from those described if the alternative procedures demonstrate a correlation with the prescribed procedure. To be acceptable, alternative procedures must ensure the results will identify all those buses which would not comply with the noise emission standard prescribed when tested. Tests conducted by manufacturers under approved alternative procedures may be accepted by the Administrator for all purposes, including, but not limited to, production verification testing and selective enforcement audit testing.

REFERENCES

SECTION 8

1. ISO Recommendation R362-1967 (E), "Measurement of Noise Emitted by Vehicles," February, 1964.

2. Swetnam, G. W. and Murray, W.S., "Proposed Standard Noise Measurement Procedure for Diesel Transit Buses," Report No. UMTA-VA-06-0028-75-1, Prepared by MITRE Corp., for U. S. Dept. of Transportation, Washington, D.C., July 1975.

3. "California Steam Bus Project Final Report," Prepared by The Assembly Office of Research , Sacramento, Calif., January 1973.

4. "A Status Report of an Environmental Noise Study of Transit Buses," by the Environmental Activities Staff (Vehicular Noise Control), General Motors Corp., December 1975.

5. Oswald, L. J. and Hickling, R., "An Overhead Microphone Facility for Recording Vertically-Radiated Vehicle Noise," Research Publication GMR-1944, GM Research Laboratories, November 1975.

6. "An Assessment of the Technology for Bus Noise Abatement," Draft Final Report submitted by Booz-Allen Applied Research, under EPA Contract No. 68-01-3509, prepared for the Office of Noise Abatement and Control, June 22, 1976.

SECTION 9

ENFORCEMENT

1. General. The EPA enforcement strategy will place a major share of the responsibility on the manufacturers for pre-sale testing to determine the compliance of buses with the regulation. This approach, besides relieving EPA of an administrative burden, benefits the manufacturers by leaving their personnel in control of many aspects of the compliance program and imposes only a minimum burden on their operations. The regulation, however, does provide for EPA enforcement officers to be present to observe any testing required by the regulation. In addition, enforcement officers, under previously promulgated regulations [40 CFR Part 205 Subpart A], are empowered to inspect records and facilities in order to assure that manufacturers are carrying out their responsibilities properly.

The enforcement strategy in the regulation, applicable to both exterior and interior standards consists of three parts: (1) Production Verification (PV), (2) Selective Enforcement Auditing (SEA), and (3) In-Use Compliance Provisions.

The manufacturer who assembles the completed bus, as in the case of intercity and transit buses, is responsible for satisfying the PV, SEA and in-use requirements of the regulation for both the exterior and interior standards. In the case of vehicles which are assembled by two manufacturers, such as many conventional school buses, the cowl chassis manufacturers must comply with the PV, SEA and in-use provisions of this regulation with respect to the vehicle exterior noise emission standard. The body assembler/mounter of such a bus which is assembled by two manufacturers is responsible for compliance with the provisions with respect to the vehicle interior noise emission standard. In addition, the body assembler is prohibited from causing the vehicle exterior noise emissions to exceed the standard and is subject to SEA provisions of the regulations for the exterior standard.

2. Production Verification.

(§205.105-1) Production verification is testing by a manufacturer of selected early production models of a configuration intended for sale, to verify that a manufacturer has applied the requisite noise control technology to comply with the standard at the time of sale and that the model will continue to comply with the standard during the Acoustical Assurance Period (AAP). The first production models of a configuration tested must not exceed the level of the standard if any models in that configuration are to be distributed in commerce. All testing must be done in accordance with the test procedures.

(§205.105-2) Production verification does not involve any formal EPA approval or issuance of certificates subsequent to manufacturer testing, nor is any extensive testing required by EPA. The regulation will require prior to distribution in commerce of any model of a configuration, as defined in the regulation, that the configuration must undergo production verification. All testing is performed by the manufacturer. However, the Administrator reserves the right to be present to monitor any test (including simultaneous testing with his equipment) or to require that a manufacturer supply him with vehicles for testing at EPA's Noise Enforcement Facility in Sandusky, Ohio, or at any other site the Administrator may find appropriate. This will provide the Administrator an opportunity to determine that the manufacturer's test facility and equipment are technically qualified for conducting the required tests. If it is determined that the equipment and/or facilities are not technically qualified, the Administrator may disqualify them from further use for bus testing under this regulation. Procedures that are available to the manufacturer subsequent to test site disqualification are addressed in the regulation.

The production unit selected for testing is a vehicle configuration. A vehicle configuration is defined on the basis of various parameters including the exhaust system, the air induction system, the cooling fan type, and horsepower. The interior configurations are identified by the manufacturer based on the exterior noise configuration parameters.

A manufacturer must verify production vehicles prior to sale by one of two methods. The first method will involve testing any early production vehicle intended for sale of each configuration. A vehicle configuration is considered to be production verified after the manufacturer has shown, based on the application of the noise measurement tests, that a configuration does not exceed a noise level defined by the new product standard and a timely report indicating such compliance has been mailed to EPA.

The second method allows a manufacturer, in lieu of testing vehicles of every configuration, to group configurations into categories. A category will be defined by basic parameters such as engine and fuel type, engine manufacturers, engine displacement, engine configuration, engine location, and bus body style. Again, the manufacturer may designate additional categories based on additional parameters of his choice. Within a category, the configuration estimated by the manufacturer to be emitting the greatest A-weighted sound pressure level at the end of the Acoustical Assurance Period is determined either by testing or good engineering judgement. The manufacturer can then satisfy the production verification requirements for all configurations within that category by demonstrating that the configuration complies with the applicable standards. This can eliminate the need for a substantial amount of testing. However, it must be emphasized that the loudest configuration at the end of the Acoustical Assurance Period must be clearly identified.

If a manufacturer is unable to test due to weather conditions or other conditions beyond his control, the production verification of a configuration is automatically waived by the Administrator for a period of 90 consecutive days without the manufacturer's request provided that he tests on the first day that he is able. If, on the 45th day following distribution in commerce or shipment to a subsequent manufacturer, the manufacturer has not performed the tests, he must, within five days, notify the Administrator that such vehicles have been distributed or shipped and provide documentation of the conditions which have made production verification impossible. This procedure will minimize disruptions to manufacturing facilities. However, to avoid any penalties under the regulation, the manufacturer must test for purposes of production verification on the first day that he is able.

(§205.105-4) A production verification report must be filed by the manufacturer performing the required production verification test before any vehicles of the configuration represented are distributed in commerce.

(§205.105-8) If a manufacturer plans to add a new configuration to his product line or change or deviate from an existing configuration with respect to any of the parameters which define a configuration, the manufacturer must verify the new configuration either by testing a vehicle and submitting data or by filing a report which demonstrates verification on the basis of previously submitted data.

(§205.105-9) Production verification is an annual requirement. However, the manufacturer need not verify configurations at any particular point in a year. The only requirement is that he verify a configuration prior to distribution in commerce. The inherent flexibility in the scheme of categorization, in many instances, will allow a manufacturer to either verify a configuration that he may not produce until late in a year based on presentation or else wait until actual production of that configuration to verify it.

The Administrator, upon request by a manufacturer, may permit the use of data from previous production verification reports for specific vehicle configurations and/or categories. The considerations that are cited in the regulation as being relevant to the Administrator's decision are illustrative and not exclusive. The manufacturer can submit all data and information that he believes will enable the Administrator to make a proper decision. It must be again emphasized that the manufacturer must request the use of previous data. If he fails to do so, then he must production verify all categories and configurations for each subsequent year.

(§205.105-10) If a manufacturer fails to production verify and a configuration is found to be in non-conformity with the regulation, the Administrator may issue an order requiring the manufacturer to cease the distribution in commerce of vehicles of that configuration. The Administrator will provide the manufacturer the opportunity for a hearing prior to the issuance of such an order.

Production verification performed on the early production models provides EPA with confidence that production models will conform to the standards and limits the possibility that non-conforming products will be distributed in commerce. Because the possibility still exists that subsequent models may not conform, selective enforcement audit testing of assembly line vehicles is made a part of this enforcement strategy in order to determine whether production vehicles continue to comply with the standards.

3. Selective Enforcement Auditing.

(§205.107-1) Selective Enforcement Auditing (SEA) is the term used in the regulation to describe the testing of a statistical sample of production vehicles from a specified vehicle category or configuration selected from a particular assembly plant in order to determine whether production vehicles comply with the noise emission standards including the in-use standard and to provide the basis for further action in the case of non-compliance.

Testing is initiated by a test request which will be issued to the manufacturer by the Assistant Administrator for Enforcement or his authorized representative. A test request will address itself to either a category or a configuration. The test request will require the manufacturer to test a sample of vehicles of the specified category or configuration produced at a specified plant. An alternative category or configuration may be designated in the test request in the event vehicles of the first category or configuration are not available.

One important factor that will influence the decision of the Administrator not to issue a test request to a manufacturer is the evidence that a manufacturer has demonstrated that his vehicles comply with the applicable standard. If a manufacturer can provide evidence that his vehicles are meeting the noise emission standards based on testing results, the issuance of a test request may not be necessary.

The Selective Enforcement Audit Plan is designed to determine the acceptability of a sample of buses for which one or more inspection criteria have been established. As applied to vehicle noise emissions, the items being inspected are buses and the inspection criterion is the noise emission standard.

After the sample has been selected, each item is tested to determine whether it meets the prescribed criteria; this is generally referred to as inspection by attributes. The basic criteria for acceptance or rejection of a sample is the number of vehicles whose parameters do not meet specifications.

(§205.107-6) A sample's passage or failure under a Selective Enforcement Audit is determined by the number of failing vehicles. (See applicable tables) in Appendix I of the regulation). If the number of failing vehicles is greater than or equal to the number in column B, the sample fails the SEA. If the number of failing vehicles is less than or equal to the number in column A, the sample passes the audit.

An Acceptable Quality Level (AQL) of ten percent was chosen to take into account some test variability.

Regardless of whether a sample is accepted or rejected, failed vehicles will have to be repaired and/or adjusted and pass a retest before they can be distributed in commerce.

Since the number of vehicles tested in response to a test order may vary considerably, a fixed time limit cannot be placed on completing all testing. The approach is to establish the time limit on a test time per vehicle basis, taking transportation requirements, if any, into consideration. The manufacturer would be allowed a reasonable amount of time for transport of vehicles to a test facility if one were not available at the assembly plant.

The Administrator estimates that the manufacturers can test a minimum of five (5) vehicles per day. However, manufacturers are requested to present any data or information that may affect a revision of this estimate.

4. Administrative Orders.

(§205.105-10) Section 11 (d)(1) of the Noise Control Act of 1972 provides that:

> "Whenever any person is in violation of Section 10(a)of this Act, the Adminstrator may issue an order specifying such relief as he determines is necessary to protect the public health and welfare."

Clearly, this provision of the Act is intended to grant to the Administrator discretionary authority to issue administrative orders to supplement the criminal and civil penalties of Section 11(a). If vehicles which were not designed, built, and equipped to comply with the noise emission standard, including the in-use requirement, at the time of sale to the ultimate purchaser were distributed in commerce, such act would be a violation of Section 10(a) and remedy of such non-compliance would be appropriate. Remedy of the affected vehicles shall be carried out pursuant to an administrative order.

The regulation provides for the issuance of such orders in the following circumstances: (1) recall for the failure of a vehicle or group of vehicles to comply with the applicable noise emission standard, (2) cease to distribute vehicles not properly production verified, and (3) cease to distribute vehicles for failure to test.

These provisions do not limit the Administrator's authority to issue orders, but give notice of cases where such orders would in his judgment be appropriate. In all such cases, notice and opportunity for a hearing will be given.

5. Compliance Labeling.

(§205.105-11) The regulation requires that buses subject to this provision must be labeled that the product complies with the exterior and/or interior noise emission standards. The label must contain a notice of tampering prohibitions.

6. Applicability of Previously Promulgated Regulations.

Manufacturers who will be subject to the regulation must also comply with the general provisions of 40 CFR Part 205 Subpart A. These include the provisions for inspection and monitoring by EPA enforcement officers of manufacturers' actions taken in compliance with the regulation and for granting exemptions from the regulation for testing, pre-verification vehicles, national security reasons, and exported vehicles.

7. <u>In-Use Compliance</u>.

(§205.108) The manufacturer is required to design, build and equip vehicles subject to the regulation so that the degradation of emitted noise levels is minimized provided that they are properly maintained, used, and repaired.

In-use compliance provisions are included in the regulation to insure that this obligation is satisfied.

These provisions include a requirement that the manufacturer provide a warranty to purchasers [required by Section 6(d)], assist the Administrator in fully defining those acts which constitute tampering [under Section 10(a)(2)(A)], and provide retail purchasers with instructions specifying the maintenance, use, and repair required to minimize degradation during the life of the bus, and with a log book to record maintenance and repairs performed.

In the case of a bus which is assembled by two manufacturers such as the conventional school bus, the manufacturer who assembles the chassis must satisfy these requirements with respect to the exterior standard. The manufacturer who then assembles the body must satisfy these requirements as they relate to the interior noise emissions standard.

Section 6(d)(1) of the Act requires the manufacturer to warrant to the ultimate and subsequent purchasers that the buses subject to the regulation are designed, built, and equipped to conform at the time of sale with the applicable Federal noise emission standards. The regulation requires that the manufacturer furnish this time-of-sale warranty to the ultimate purchaser in a prescribed written form. The regulation also provides for EPA review of the written warranty and related information furnished to purchasers, dealers, zone representatives, etc., in order that the Agency can determine whether the manufacturer's warranty policy is consistent with the intent of the Act.

The tampering regulations require the manufacturer furnish the Agency a list of those acts which in the manufacturer's estimation might be done to a vehicle and result in that vehicle emitting noise levels above the standards. The Adminstrator will respond to the manufacturer's list within 30 days by developing a list of specific tampering acts that the manufacturer must include in the owner's manual for each product. It is stressed that the Adminstrator's list is not all inclusive; any act of tampering is unlawful and subject to Federal penalty.

The provisions dealing with instructions for proper operation, use, and repair are intended to assure that purchasers know exactly what is required to minimize any degradation of the vehicle's emitted noise level during use. The instructions are necessary to minimize degradation and also must be reasonable in the burden placed on the purchaser. A record or log book must be provided to the ultimate purchaser to assist purchasers in demonstrating proper maintenance should a record be necessary at any time during the life of the vehicle. The instructions may not contain language which tends to give manufacturers or their dealers an unfair competitive advantage over the after-market manufacturers. Finally, the regulation provides for Agency review of the instructions and related language.

SECTION 10

EXISTING NOISE REGULATIONS APPLICABLE TO BUSES

A. INTRODUCTION

Federal noise regulations applied to any particular product are developed primarily on the basis of the assessment of available technology together with associated economic and health and welfare impacts as required by Section 6 of the Noise Control Act of 1972. In most cases, actions by the EPA in proposing and finalizing new product noise regulations will not be the first cases of regulatory action, but will have been preceded by various State and local regulations. These State and local regulations refer, in some cases, to the noise emissions of the product at the time of sale, and in other cases to the control of noise produced during the product's operation. It may be expected that the scope and stringency of State and local noise standards will differ from place to place in a way that is dependent on the degree of annoyance, local citizen pressures and the amount of work put into the development of the regulation. The results of these regulations will also probably differ considerably based on the degree of enforcement and compliance.

B. REVIEW OF EXISTING NOISE ORDINANCES

The increased interest in noise brought about in recent years by the wider understanding of its potential effects on people has resulted in the development of a large number of State and local noise ordinances. Many of these ordinances can be classified as "nuisance" laws that make it unlawful to conduct certain acts that would disturb the peace of "a reasonable person of normal sensitivity." However, there are an increasing number of State laws and local ordinances that refer quantitatively to specific noise sources in the community.

The first motor vehicle noise regulations were introduced in the State of California in 1967, which established noise standards for different types of vehicles, including trucks and buses with a Gross Vehicle Weight Rating (GVWR) in excess of 10,000 lbs. The regulations were applicable both to the sale of new vehicles and the operation of vehicles on the highway. Since 1967, a number of other States and cities have introduced such regulations, many of them identical to regulations applicable to trucks and buses operated by interstate motor carriers. Again, the lower limit on the GVWR was 10,000 lbs.

In each of the many regulations applicable to medium and heavy vehicles described above, there is no distinction in noise standards between the various clases. Thus the category of vehicles having a GVWR in excess of 10,000 lbs. includes not only trucks but intercity buses, transit buses and school buses. In other words, buses are combined with trucks in every case. There are therefore no separate noise regulations for buses in the United States. A summary of State and local noise standards applicable to buses and trucks is given in Reference 10-1. Since the publication of this referenced document, many of these regulations have been preempted in part by the issuance of Federal regulations for new medium and heavy trucks and for new and in-service interstate motor carriers, the latter also including in-service intercity buses. However, there has been no Federal preemption of newly manufactured intercity, transit, or school buses, so these standards remain as stated in Reference 10-1.

The situation concerning the nonspecificity of buses in noise regulations is similar in the vehicle noise regulations of many other countries. A distinction between buses and trucks is made in Australia, Sweden, and the United Kingdom, as well as by EDE (Geneva) and EEC (Brussels), but in each case the noise standards are identical. It appears that only one country, Portugal, has a different set of noise standards for new buses and trucks. A summary of the foreign noise standards applicable to buses is given in Table 10-1.

C. ANALYSIS OF EXISTING REGULATIONS

In view of the fairly uniform approach taken towards the regulation of medium and heavy vehicles, it is interesting to determine the reasons for not separating buses from trucks. A review of the decision criteria for noise regulations adopted at the State and local level revealed the following information:

- Many considered that buses and trucks exhibit very similar noise characteristics. It is true that the two vehicles use the same type of engines--whether diesel or gasoline--and some of the same auxiliary components, but the conclusion that their noise emissions are the same must be taken advisedly because of the lack of available data.
- Whereas there was a considerable amount of data on the noise characteristics of heavy trucks, the same was not true of buses. Hence, the two vehicles were combined into one category in the absence of reasons to do otherwise.
- Some states not having the resources to perform their own background studies have incorporated the results of testing done in other states.
- As an aid to enforcement, it was considered unwise to have a large number of vehicle categories with different noise standards.
- At the state level, the enforcement activities are often restricted to highways outside of the cities. In these areas, buses were not considered to pose significant problems.

TABLE 10-1

Summary of Noise Standards*

Applicable to Buses in Foreign Countries

Country	Type of Regulation and Effective Date	Applicability	Max. Noise Level (dBA)
Australia Sweden	• New vehicles manuf'd after 1975	• > 3.5 Mg w/engine < 200 HP	89
W. Germany Yugoslavia		• > 3.5 Mg w/engine < 200 HP	92
Belgium	• New vehicles manuf'd after 1968	• diesel engine > 200 HP DIN	92
	• Operation		2 dB greater than above
Canada	• New vehicles manuf'd after 1970	• Heavy Duty Vehicles	88
Czechoslovakia	• New vehicles manuf'd after 1969	• > 3.5 Mg	88
		• > 220 BHP engine power	89
	• Operation		2 dB greater than above
Denmark	• New vehicles	• > 3.5 Mg	89
		• > 200 HP DIN	92
	• Operation		3 dB greater than above
ECE (Geneva)	• New vehicles	• > 3.5 Mg > 9 Seats	89
		• > 200 HP DIN > 9 Seats	91
EEC (Brussels)	• New vehicles	As for ECE	

*Measured according to ISO R362 at 25 feet.

TABLE 10-1 (Cont.)

Country	Type of Regulation and Effective Date	Applicability	Max. Noise Level (dBA)
Finland	• New vehicles	• > 200 DIN HP	92
France	• New vehicles	• Public Service Vehicles	90
	• Operation		2 dB greater than above
Italy	• New vehicles manuf'd after 1968	• > 1500 cc	93
Luxembourg Netherlands	• New vehicles manuf'd after 1973	• > 3.5 Mg	88
		• > 200 HP DIN	92
	• Operation		2 dB greater than above
Portugal	• New vehicles	• < 5 Mg	85
		• > 5 Mg	88
Great Britain	• New vehicles	• > 12 passengers, excluding driver	89
	• Operation		92

- There are indications that some agencies did not consider buses at all, but were mainly concerned with heavy trucks.

In no case has there been reported any impetus to treat buses separately from heavy trucks. Furthermore, many State and local officials have indicated they do not now believe that such a separation is required, although some indicate that a special case might be made for transit buses.

REFERENCES

SECTION 10

1. U.S. Environmental Protection Agency, "Noise Source Regulation in State and Local Noise Ordinances," Report No. 550/9-75-020, February 1975.

2. Society of Automotive Engineers, "Exterior Sound Level for Heavy Trucks and Buses," SAE Standard J366b.

3. "Interstate Motor Carrier Noise Emission Standards," Federal Register, Vol. 38, No. 144, July 27, 1973.

4. "Interstate Motor Carrier Noise Emission Standards--Final Regulations on Compliance," Federal Register, Vol. 40, No. 178, September 12, 1975.

5. "Existing Noise Regulations Applicable to Buses," Draft Final Report submitted by Wyle Laboratories under EPA Contract No. 68-01-3516, prepared for the Office of Noise Abatement and Control, June 24, 1976.

APPENDIX A

FOREIGN TECHNOLOGY BUSES

Two European bus manufacturers currently produce urban transit buses that claim to be considerably quieter than any available in the United States.

1. SAAB SCANIA CR111M BUSES

In 1971, Scania-Bussar AB, Katrineholm (Sweden) presented a bus in which the noise level had been effectively reduced. The bus is an integrally constructed city bus, the Scania CR111M, with a suburban version, the CR111MF.

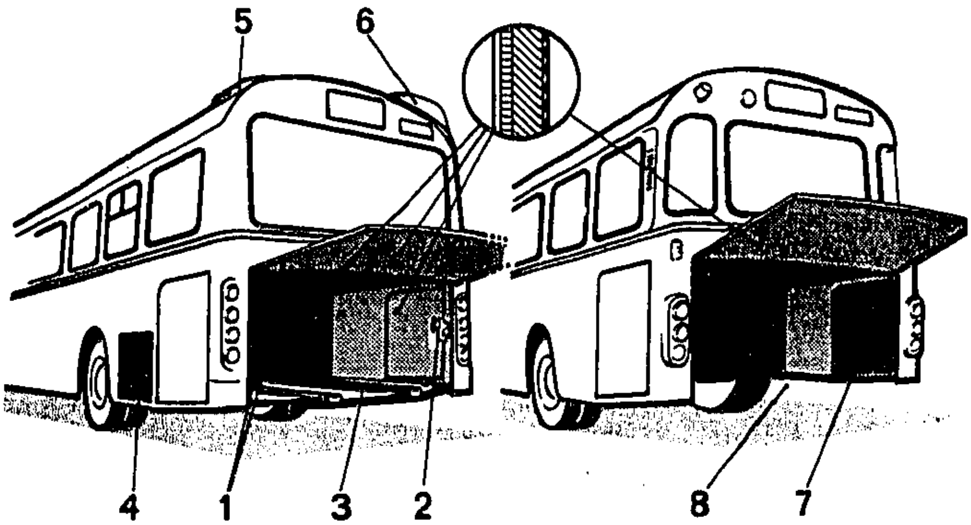
Scania CR111M and CR111MF, the "quiet buses," have a reduced noise level as low as 77 dB for buses with automatic transmission and 80 dB for buses with standard transmission when measured in accordance with the ISO R362 procedure for noise measurement. Other non-quieted modern Swedish buses (CR110) generate noise levels of 86 to 87 dB (ISO R362).

The reduction in noise level on the Scania CR111M (see Figure A-1) has been achieved primarily by insulating the engine compartment and relocating the cooling system. The engine compartment is lined with sound-insulating materials attached directly to the exterior panels. Within this sound-insulating wall is a thicker covering of sound-absorbent glass fiber which in turn is covered with perforated aluminum sheet. Insulated belly pans are mounted underneath the engine. The engine, consequently, is almost entirely encased in sound-absorbent material.

As a result of this insulation, problems arise in disposing of the heat generated by the engine. The bus has, therefore, been equipped with a water-cooled exhaust manifold and heat-insulated exhaust pipe up to the silencer. A special fan located on the roof provides the engine compartment, by way of a channel through the bus rear section, with effective ventilation.

FIGURE A-1

Comparison of Scania CR111M City Bus
and the CR110M Standard Bus



1. Insulated Engine Compartment
2. Fan for Engine Compartment Ventilation
3. Belly Pan
4. Air Intake for Radiators, One on Each Side
5. Engine Air Intake
6. Ventilation Air Intake
7. Radiator Air Intake (Standard Version)
8. Bottom Opening

The CR111M has two radiators (each 0.42 m^2 in area), instead of the one as is normal on U.S. transit buses. The radiators are mounted in front of the insulated engine compartment to cope with the increased cooling requirements caused by the insulation. By using two fans of 480 mm diameter, a lower peripheral speed is achieved than if only one fan was used for cooling. The fans are thermostatically controlled in three steps up to 1400 rpm. If required, the fans can run at full speed even while the engine is working at a minimum speed. For cross-country operation, 10 to 15 percent larger radiators are employed.

Noise levels within the bus vary in relation to the distance from the engine. The noise level at the driver's seat is as low as 68 dB under acceleration. Levels of 78 dB are reported at the rear seat. Further reductions are expected from development work currently in progress.

Due to the relocation of the radiators and a change in design of the rear overhand, the number of seats has been increased by four in comparison with other versions of the same bus type. The number of seats in the "quiet bus" is 36 to 41 depending on the type of bus.

The Scania CR111M is designed specifically as a city bus and is equipped with air suspension and power steering. The engine is a transversely mounted diesel providing 151 KW (295 hp), ISO 2534 gross.

The Scania CR111M is 11.55 m long (37.9 feet) and carries 36 seated and 45 standing passengers. As a comparison, the 35-foot GMC 45 series transit bus seats 45 passengers and the 40-foot GMC 53 series seats 53 passengers. It is not known whether the reduced seating capacity of the CR111M is due to compromises made for noise reduction, such as the fully encapsulated engine and remote cooling packages, or for other reasons. The cost increase due to engine encapsulation for noise reduction purposes is given to be 2% by Scania engineers.

The CR111M engine is derated for urban operation on request. This is a compromise in performance that may not be acceptable in the U.S. On the other hand, derating the engine may cut down on maintenance and increase the life of the engine.

The cooling system of the CR111M is designed for an air-to boil temperature of 85-90^{0} F. This would not be acceptable for buses operating in the U.S.

Air-conditioning is not offered on Scania Buses, even as an option. Exclusion of air-conditioning reduces horsepower requirements and engine cooling requirements significantly. In contrast, almost all transit coaches in this country are air-conditioned.

There are a total of 360 single-decker and 300 double-decker CR111M Buses operating in the following:

Sweden: Stockholm, Gothenburg, Malmo, Vasteras, Orebro, and Uppsala

Norway: Oslo

Finland: Helsingfors

England: London, Leeds, Glasgow, New Castle, and Liverpool

2. BRITISH LEYLAND SUPER QUIET BUS

Research versions of a Super Quiet Leyland National were shown in December 1972 and April 1974. Work on developing this bus centers around modifications to the bus interior with prime advantage to the passengers, backed up by exterior modifications aimed at improving the acceptance of the bus in quiet suburban environments where background noise is vastly lower than in typical city centers.

These changes combine to obtain an external noise level of 76 dB on a British standard 3425 "pass-by" test. Alteration of the torque characteristics of the turbocharged 510 engine to an alternative form achieves a more silent running power unit without detriment to available torque. A reworked engine air intake and exhaust system further contribute to noise attenuation.

A major item of the noise reduction treatment of the Super Quiet Leyland National is the structural enclosure around the engine, which is of laminated sheet metal construction spot welded in a way that permits the inner skin to reflect noise back to the engine. The outer skin of the bus is designed with an air gap to reduce the transmission of noise. Fitting of this enclosure involves the provision of an electric fan mounted in an aluminum duct on the left hand rear valance door with cooling air exiting around the flywheel housing. The radiator cooling fan features a fluid drive coupling effecting a maximum fan speed reduction and hence a lowering of fan noise. As a safety requirement, a thermostatically controlled fire extinguishing system is a safety measure incorporated in the specification of the engine enclosure.

Noise generated by the transmission of the bus has also been reduced by the specification of final drive gears designed to minimize whine on drive and over-run. The hot shift pneumocyclic gearbox is replaced by a fully automatic transmission involving reduced gear noise and jerk-free up-changing.

Reduction of "road noise" entering the structure is achieved by a more compliantly mounted Vee-frame rear axle location assembly tuned to isolate road vibration inputs.

Hatches to the engine compartment feature improved sealing. To this end, the hatches and the vehicle floor are lined with Revertex noise insulant.

Regarding the maintenance difficulties generally encountered with engine enclosure technology the semi-monocoque construction of the engine enclosure allows for acoustic panel suspension from brackets welded onto the engine support longitudinals. Panels are secured with quick-release fasteners for easy service access to the engine; a single panel gives access to inner and outer sump drain plugs and the oil filter. Vertical walls (panels) of the enclosure are fitted where possible with sheets of glass fiber "wool" held in position by perforated sheet aluminum.

Toward interior noise reduction, seats are fully upholstered and have squab backs trimmed in foam based moquette in the interests of covering any large reflective surface. The seat squab upper rails are shrouded by an enveloping safety crash pad and the vertical "grab" stanchions in the bus are nylon covered. Another aspect of interior noise control applies to the redesigned heater recirculation duct which has provided a "spin-off" of considerably improved air circulation. The noise reduction achieved on the vehicle is so considerable that "canned music" is provided in the vehicle to alay the uncanny feeling of sitting in what has been stated as virtually an anechoic chamber.

Subtle changes to the interior specification include stapling of a 25-mm closed cell pvc foam to the top of the floor over the rear saloon only; at the edges this is compressed between the lower stainless cover panel and the body side. Beneath the whole floor, aluminum trays enclosing glass wool insulant are suspended between floor support members. Teroform sheeting is bonded to the front of the saloon access step riser channel; similar treatment applies to the rear whell arches and rear seat box. Interior trim panels have their 25 mm polyether heat insulating backing panels replaced by 66.5 mm expanded polyethylene foam with heat and very adequate noise insulation. Backing the rear corner cove panels are Teroform moulded shapes around the heater piping and air ducting entry points; these are overlaid with flexible polyether foam to a depth of 6 inches.

REFERENCES

APPENDIX A

1. "An Assessment of the Technology for Bus Noise Abatement," Draft Final Report submitted by Booz-Allen Applied Research, under EPA Contract No. 68-01-3509, prepared for the Office of Noise Abatement and Control, June 22, 1976.

APPENDIX B

THERMOSTATICALLY CONTROLLED FANS

The regulation requires thermostatically controlled fans in transit and intercity buses to be "locked-on" during testing. This means that the fan must be operating at its maximum speed, and therefore, maximum noise emitting level.

Cooling systems are designed to prevent engine overheating during the worst heat producing circumstances under which the vehicle is expected to operate. Under average circumstances, the cooling requirements are likely to be much less stringent than under the worst case. Engines run more efficiently and with less wear and tear when they are operating in the proper temperature range. It is often useful, especially for diesel engines, to make the fan speed variable in order to avoid over cooling.

There are several types of thermostatically controlled fan drives available:

(1) On-off clutches which are either completely disconnected or operating at the input speed (a constant proportion, usually 100%, of the engine speed),

(2) Wet clutches which are able to slip and thereby to modulate between completely disconnected and operating at maximum fan speed,

(3) Viscous drives which can operate anywhere between about 33% and 95% of the input speed,

(4) Hydraulic drives which can operate anywhere between about 5% and 95% of the input speed.

Since these drive systems allow the fan to operate at less than maximum speed at times, they eliminate or reduce the work transferred from the engine to the fan during those times, thereby reducing fuel consumption. In addition, when the fan is not operating at full speed it emits lower noise levels and sucks less debris into the radiator and engine compartment.

The rationale behind the installation of thermostatically controlled fan drives varies according to the type of bus. In the transit industry 100 percent of the newly manufactured buses are equipped with thermostatically controlled drives, generally either hydraulic or on-off. These drives were originally installed to prevent the diesel engines, which tend to dissipate heat well, from becoming overcooled. Only about 30 percent of all existing intercity buses are presently equipped with thermostatically controlled fan drives. However, the two largest operators are planning to equip all of their new buses with wet clutch fans in order to reduce fuel consumption. It is expected that a substantial number intercity buses will soon have thermostatically controlled fans, and eventually all will be so equipped.

It has been suggested that the lock-up test requirement might discourage the use of thermostatically controlled fans. Operators generally consider noise control to be a secondary benefit of thermostatically controlled fan drives. Since fuel consumption and overcooling will continue to be source problems with or without the regulation, EPA's requiring fans to be locked on during testing is unlikely to discourage operators from buying thermostatically controlled fans.

Thermostatically controlled fans, when operating at maximum speed, emit no more noise than fixed fans. The same noise control techniques are necessary to quiet the two types of fans. Therefore, if the requirement to test with fans locked on is implemented there will be no incentive for manufacturers to discontinue installing thermostatically controlled fan drives, except to the extent that there are some testing costs associated with locking the drive on.

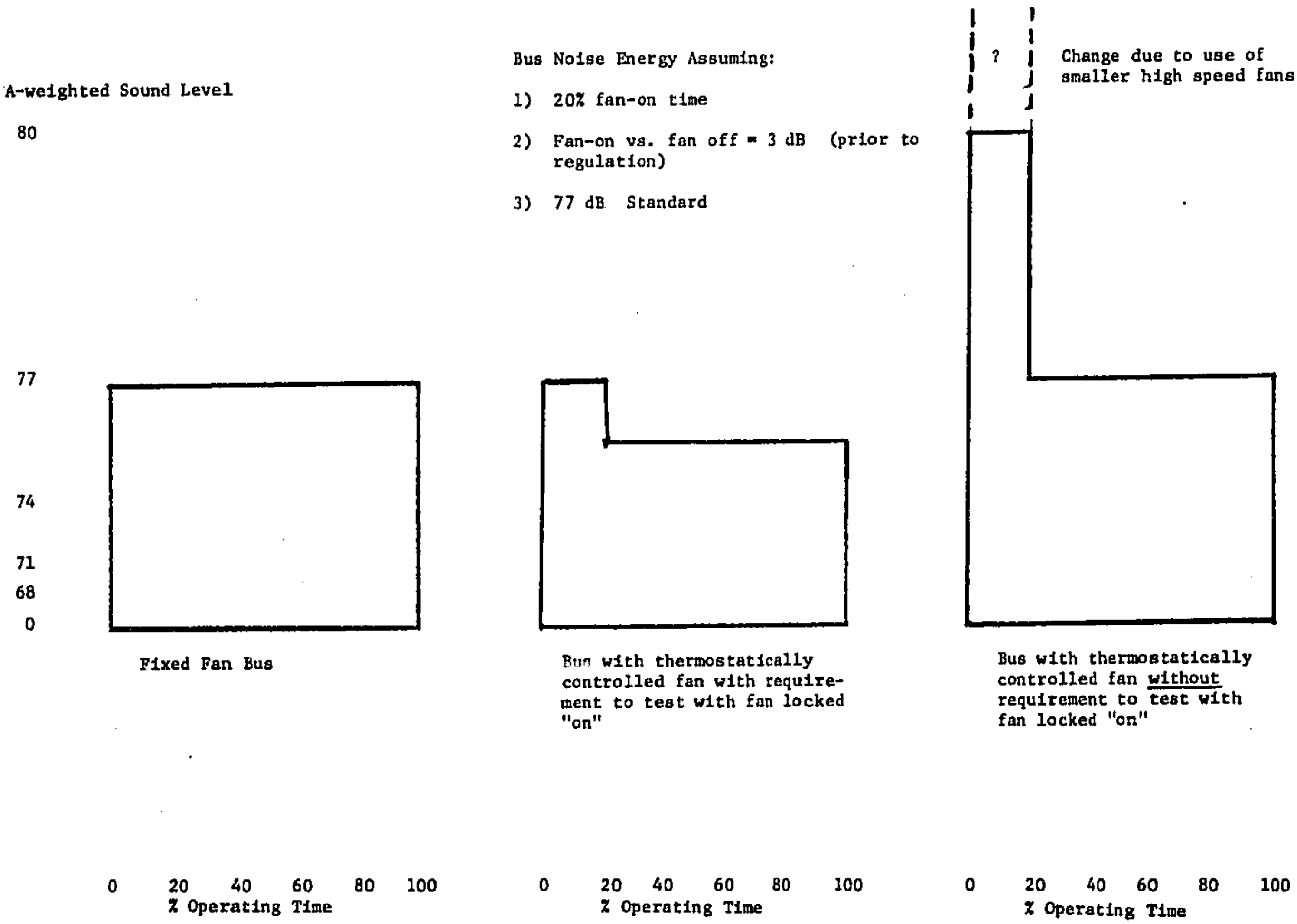
It has also been suggested that there is a potential for destruction of the fan drive calibrations due to the requirement. Most fan drives are relatively easy to lock on. On-off clutches and wet clutches are generally operated through the use of springs and air pressure. The air pressure is usually controlled electronically by some type of thermostat. This electronic circuitry can be deceived, forcing the fan to remain on. Hydraulic and viscous fan drives are controlled by the amount of fluid present between the input disc and the output disc or housing. This fluid is supplied from an external source in the case of hydraulic drives. It is quite easy to stop the flow out of the drive by activating an electronic control or by installing a simple valve. The supply of fluid in a viscous fan drive is internal. The bimetal coil thermostat is attached directly to the spring which controls the fluid valve. These systems might be difficult to keep locked on during testing. However, a careful mechanic can remove the coil, allowing the spring to open the feed valve fully and replace it after the test without affecting the calibration, a relatively simple procedure.

Docket commenters state that the requirement should be deleted because it is inconsistent with the EPA truck regulation. The only buses which are similar to medium trucks are conventional design front engine buses, such as those commonly used by school districts. However, school buses have been exempted from the lock up requirement.

It is important to consider the impact of fan noise on the noise level of the bus. Figure B-1 shows how the requirement could affect the noise level of the bus during passby accelerations. If the regulation requires thermostatically controlled fans to be locked on during testing then the noise emitted during full throttle acceleration of the bus is likely to be somewhat less than the regulated level during the times when the fan is off. If the requirement is deleted and buses are allowed to be tested with thermostatically controlled fans in the off mode then the noise emitted during full throttle acceleration is likely to exceed the regulated level during the times that the fan is on. Since the regulation might cause transit and intercity bus manufacturers to encounter smaller engine compartments, they may begin using smaller, faster, and therefore, noisier fans. This would cause the fan-on noise level to exceed the regulatory level by a greater amount. Since the testing procedure is designed to test the bus in its worst (loudest) operating mode, it seems reasonable to require the fan, which can be a significant noise emitting source, to be locked on.

It is important to examine the effect of the fan noise on average sound levels (L_{eq}) emitted by transit and intercity buses. In order to meet a 77 dB (A-weighted) regulation buses will have to be quieted to an A-weighted level of 75 dB. Based on data measured, the difference in the noise levels of a regulated bus with the fan-on requirement retained versus a regulated bus with the fan-on requirement deleted is 4.1 dB. In other words, the noise level of a regulated bus with the requirement retained is 75 dB, whereas the noise level of a regulated bus with the requirement deleted will be 79.1 dB when the fan is on. The expected fan-on time for transit buses is

FIGURE B-1


Bus Noise Energy Assuming:
1) 20% fan-on time
2) Fan-on vs. fan off = 3 dB (prior to regulation)
3) 77 dB Standard
A-weighted Sound Level
80
77
74
71
68
0
?
Change due to use of smaller high speed fans
Fixed Fan Bus
Bus with thermostatically controlled fan with requirement to test with fan locked "on"
Bus with thermostatically controlled fan without requirement to test with fan locked "on"
0 20 40 60 80 100
% Operating Time
0 20 40 60 80 100
% Operating Time
0 20 40 60 80 100
% Operating Time

16.5 percent in an average ambient temperature. In warmer climates the percent fan-on time will be higher, and in cooler climates the percent fan-on time will be lower. For intercity buses the fan-on time is 15.6 percent on a GMC intercity bus. These data were used in a parametric model to determine the impact of deleting the fan-on requirement on the L_{eq} of the bus. The results showed that the deletion of the requirement would raise the L_{eq} by more than 1 dB, assuming average ambient temperatures.

The results of the parametric model demonstrated different results for a conventional front engine school bus. To meet a 77 dB regulation school buses will have to be quieted to 75 dB to meet a 77 dB regulation. Based on measured data, the difference in the noise level of regulated buses with the fan-on requirement deleted is 1.2 dB. The noise level of a regulated bus with the requirement retained is 75 dB whereas the noise level of a regulated bus with the requirement deleted will be 76.1 dB when the fan is on. A GM/Schwitzer test showed the annual average operating time (above 2500 rpm) for a viscous fan in a conventional front engine bus operating in Indianapolis to be 2.3 percent. The model results showed that deletion of the requirement for these buses would raise the L_{eq} of the bus by less than a tenth of 1 dB (a very small change).

In order to estimate the significance of the increased L_{eq} for transit and intercity buses it is useful to examine its impact upon health and welfare calculations. The difference between benefits derived in 2010 from regulating transit and intercity buses to an A-weighted sound level of 77 dB in 1987 with the fan lock-on requirement retained, and the benefits derived in 2010 from regulating transit and intercity buses to 77 dB in 1987 with the fan lock-on requirement deleted were found by using the National Roadway Traffic Noise

Exposure Model. The model showed the deletion of the fan lock-on requirement lowers the benefits (for purposes of this analysis in terms of potential single event sleep disruptions) derived from regulating to 77 dB by 30 percent for transit buses and 5.3 percent for intercity buses for the statistically average case. Similar negative changes were found using other single event activity interference measures.

Although the fan noise emitted by buses varies widely, there is a clear separation between the impact of fans on the average noise level of transit and intercity buses and the impact of fans on the average noise level of conventional front engine buses.

The impact of retaining the requirement on transit buses would be to lower the average noise emissions. Manufacturers would probably be forced to install effective fan shrouds at some expense. They would neither increase nor decrease the use of thermostatically controlled fans significantly because of this requirement. The same is also true for the intercity bus industry.

The impact of retaining the requirement for conventional front engine buses is somewhat different. Two of the docket comments are directed primarily toward the imposition of this requirement upon school bus manufacturers. Conventional front engine bus chassis are built on the same lines as medium trucks. In addition, the type of fan drive which is the hardest to lock up, the viscous drive, is most often applied to conventional front engine buses. The fans on these buses are much less aggressive than transit and intercity bus fans, and they tend to be about 5 dB quieter. Also, in their typical operation as school buses, they do not operate as frequently in the summer, when the fan-on time would be the greatest. They benefit from the ram air effect because of their front mounted radiators, allowing the fan to remain off much of the time. If diesel engine usage for such buses increase, as a fuel economy measure, the fan-on time should decrease further. Because conventional front engine buses are less expensive than other buses, the additional noise abatement equipment necessary to quiet the fan is a greater proportion of the total cost of the bus.

Present purchasers of thermostatically controlled fan drives on conventional front engine buses buy them because of the fuel economy benefits. The imposition of this requirement will neither encourage nor discourage potential purchasers from installing thermostatically controlled fans. However, the deletion of the requirement will probably further encourage conventional front engine bus manfacturers to install thermostatically controlled fan drives on all of their models. For bus purchasers an initial capital cost for the thermostatically controlled fan will be incurred which will be offset by the fuel savings.

The impact of deleting the requirement is different for transit and intercity bus manufacturers than it is for conventional front engine bus manufacturers. Since integral manufacturers are likely to encounter smaller engine compartments, they may be expected to install smaller, faster and, therefore, noisier fans if the requirement is deleted. Conventional front engine bus engine compartments, on the other hand, are generally spacious by comparison. Unlike transit bus manufacturers, there is no incentive for conventional front engine bus manufacturers to install smaller, noisier fans, even with the requirement deleted. Most conventional front engine buses are not, at this time, being ordered with thermostatically controlled fans, therefore, deleting the requirement will encourage the use of such fuel saving units in conventional front engine buses.

REFERENCES

APPENDIX B

1. Correspondence from E.N. Kravitz, Flxible Co. to Henry Thomas, EPA, December 19, 1978.

2. "The Effect of Engine Fan Usage on Transit Bus Noise Exposures" Task Report submitted by M.A. Staino, Booz-Allen and Hamilton, under EPA Contract #68-01-3509 prepared for the Office of Noise Abatement and Control, March, 1979.

3. Correspondence from M.A. Staino, ORI, Inc. to F. Ely, EPA, July 10, 1979.

4. Correspondence from J.F. Shaffer, Grumman Flxible, to H. Hilliard, EPA, July 25, 1979.

5. Telephone communications from Mr. Szkolnicki, MCI to H. Hilliard, EPA. May 4, 1979.

6. "Review of Operating Characteristics of Viscous Fan Clutches for Motor Vehicle Usage", presented by Ford Motor Company to EPA, May 8, 1979.

7. "Viscous Fan Drive Measurements of Cooling Fan Engagement Times on School Buses" Report 5-528, prepared by J. Pisaski and M. Williams, Schwitzer, Wallace Murray Corporation, June 11, 1979.

8. "A Study of Operating Characteristics of Viscous Fan Clutches on School Buses in Normal Operation", prepared by General Motors Corporation, May 30, 1979.

9. Correspondence from M.C. Kaye to Francine Ely, EPA, July 27, 1979.

10. "Intercity Bus Noise Level Analysis" prepared by Booz-Allen and Hamilton under EPA Contract #68-01-3509 for the Office of Noise Abatement and Control, August 23, 1979.

11. Telephone Conversation from H. Hilliard, EPA to Jim Nelson, Eagle, May 6, 1979.

APPENDIX C

FRACTIONAL IMPACT PROCEDURE*

An integral element of an environmental noise assessment is to determine or estimate the distribution of the exposed population to given levels of noise for given lengths of time. Thus, before implementing a project or action, one should first characterize the existing noise exposure distribution of the population in the area affected by estimating the number of people exposed to different magnitudes of noise as described by metrics such as the Day-Night Sound Level (L_{dn}). Next, the distribution of people who may be exposed to noise anticipated as a result of adopting various projected alternatives should be predicted or estimated. We can judge the environmental impact by simply comparing these successive population exposure distributions. This concept is illustrated in Figure C-1 which compares the estimated distribution of exposure for the population prior to inception of a hypothetical project (Curve A) with the population distribution after implementation of the project (Curve B). For each statistical distribution, numbers of people are simply plotted against noise exposure, where L_i represents a specific exposure in decibels to an arbitrary unit of noise. A measure of noise impact is ascertained by examining the shift in distribution of population exposure attributable either to increase or lessened project-related noise. Such comparisons of population exposure distributions allow us to determine the extent of noise impact in terms of changes in the number of people exposed to different levels of noise.

---

* Adapted, in part, from Goldstein, J., "Assessing the Impact of Transportation Noise: Human Response Measures," Proceedings of the 1977 National Conference on Noise Control Engineering, G. C. Maling (ed.), NASA Langley Research Center, Hampton, Virginia, 17-19 October 1977, pp. 79-98.

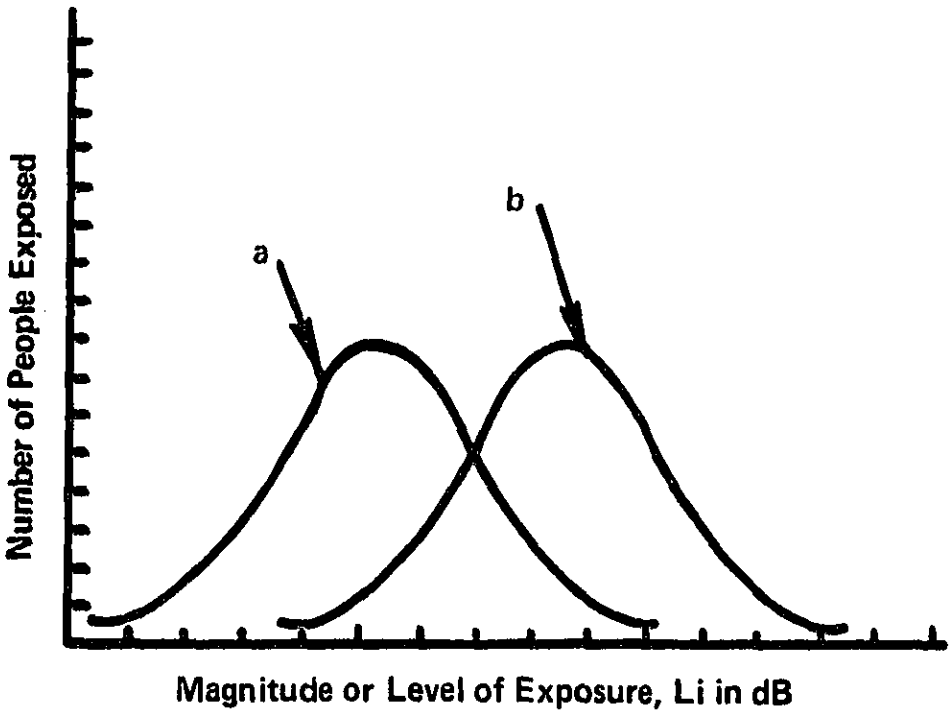


FIGURE C-1

EXAMPLE ILLUSTRATION OF THE NOISE DISTRIBUTION OF POPULATION AS A FUNCTION OF NOISE EXPOSURE

The intensity of severity of a noise exposure may be evaluated by the use of suitable noise effects criteria, which exist in the form of dose-response or cause-effect relationships. Using these criteria, the probability or magnitude of an anticipated effect can be statistically predicted from knowledge of the noise exposure incurred. Illustrative examples of the different forms of noise effects criteria are graphically displayed in Figure C-2. In general, dose-response functions are statistically derived from noise effects information and exhibited as linear or curvilinear relationships, or combinations thereof. Although these relations generally represent a statistical "average" response, they may also be defined for any given population percentile. The statistical probability or anticipated magnitude of an effect at a given noise exposure can be estimated using the appropriate function. For example, as shown in Figure C-2 using the linear function, if it is established that a number of people are exposed to a given value of L_i, the incidence of a specific response occurring within that population would be statistically predicted at 50 percent.

A more comprehensive assessment of environmental noise may be performed by cross-tabulating both indices of extent (number of people exposed) and intensity (severity) of impact. To perform such an assessment we must first statistically estimate the anticipated magnitude of impact upon each individual exposed at each given level, L_i, by applying suitable noise effects criteria. At each level, L_i, the impact upon all people exposed is then obtained by simply comparing the number of people exposed with the magnitude or probability of the anticipated response. As illustrated in Figure C-1, the extent of a noise impact is functionally described as a distribution of exposures. Thus, the total impact of all exposures is a distribution of people who are affected to varying degrees. This may be expressed by using

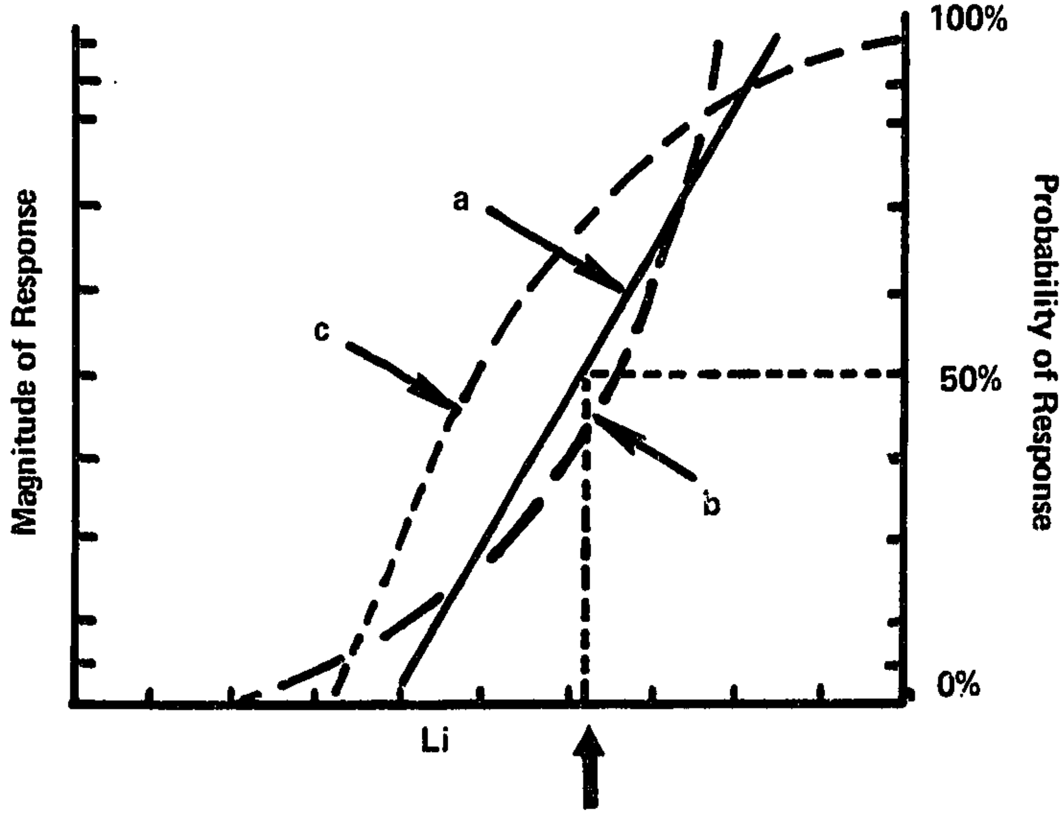


FIGURE C-2

EXAMPLE OF FORMS OF NOISE EFFECTS CRITERIA
(a) LINEAR, (b) POWER, (c) LOGARITHMIC

an array or matrix in which the severity of impact at each L_i is plotted against the number of people exposed at that level. Table C-1 presents a hypothetical example of such an array.

TABLE C-1

EXAMPLE OF IMPACT MATRIX FOR A HYPOTHETICAL SITUATION

Exposure	Number of people	Magnitude or Probability of Response in Percent
L_i	1,200,000	4
L_{i+1}	900,000	10
L_{i+2}	200,000	25
L_{1+3}	50,000	50
. . .		
L_{i+n}	2,000	85

An environmental noise assessment usually involves analysis, evaluation and comparison of many different planning alternatives. Obviously, comparing multiple arrays of population impact information is quite cumbersome, and subsequently evaluating the relative effectiveness of each of the alternatives generally tends to become rather complex and confusing. These comparisons can be simplified by resorting to a single number interpretation or descriptor of the noise environment which incorporates both attributes of extent and intensity of impact. Accordingly, the National Academy of Sciences, Committee on Bioacoustics and Biomechanics (CHABA), has recommended a procedure for assessing environmental noise impact which mathematically takes into account both extent and intensity of impact (Ref. 9).* This procedure, the fractional impact method, computes total noise impact by simply counting the number of people exposed to noise at different levels and statistically weighting each person by the intensity of response to the noise exposure. The result is a single number value which represents the overall magnitude of the impact.

The purpose of the fractional impact analysis method is to quantitatively define the impact of noise upon the population exposed. This, in turn, facilitates trade-off studies and comparisons of the impact between different projects or alternative solutions. To accomplish an objective comparative environmental analysis, the fractional impact method defines a series of "partial noise impacts" within a number of neighborhoods or groups, each of which is exposed to a different level of noise. The partial noise impact of each neighborhood is determined by multiplying the number of people residing within the neighborhood by the "fractional impact" of that neighborhood, i.e., the statistical probability or magnitude of an anticipated response as functionally derived from relevant noise effects criteria. The total community impact is then determined by simply summing the partial impacts of all neighborhoods (Ref. 9).

It is quite possible, and in some cases very probable, that much of the noise impact may be found in subneighborhoods exposed to noise levels of only moderate value. Although people living in proximity to a noise source are generally more severely impacted than those people living further away, this does not imply that the latter should be totally excluded from an assessment where the purpose is to fully evaluate the magnitude of a noise impact.

* Reference is listed at the end of Section 6.

People exposed to lower levels of noise may still experience an adverse impact, even though that impact may be small in magnitude. The fractional impact method considers the total impact upon all people exposed to noise recognizing that some individuals incur a significantly greater noise exposure than others. The procedure duly ascribes more importance to the more severely affected population.

As discussed previously, any procedure which evaluates the impact of noise upon people or the environment, as well as the health and behavioral consequences of noise exposure and resultant community reactions, must encompass two basic elements of the impact assessment. The impact of noise may be intensive (i.e., it may severely affect a few people) or extensive (i.e., it may affect a larger population less severely). Implicit in the fractionalization concept is that the magnitude of human response varies commensurately with the degree of noise exposure, i.e., the greater the exposure, the more significant the response. Another major assumption is that a moderate noise exposure for a large population has approximately the same noise impact upon the entire community as would a greater noise exposure upon a smaller number of people. Although this may be conceptually envisioned as a trade-off between the intensity and extent of noise impact, it would be a misapplication of the procedure to disregard those persons severely impacted by noise in order to enhance the environment of a significantly larger number of people who are affected to a lesser extent. The fact remains, however, that exposing many people to noise of a lower level would have roughly the same impact as exposing a fewer number of people to a greater level of noise when considering the impact upon the community or population as a whole. Thus, information regarding the distribution of the population as a function of noise exposure should always be developed and presented in conjunction with use of the fractional impact method.

Because noise is an extremely pervasive pollutant, it may adversely affect people in a number of different ways. Certain effects are well documented. Noise can:

- cause damage to the ear resulting in permanent hearing loss
- interfere with spoken communication
- disrupt or prevent sleep
- be as source of annoyance.

Other effects of noise are less well documented but may become increasingly important as more information is gathered. They include the nonauditory health aspects as well as performance and learning effects.

It is important to note, however, that quantitatively documented cause-effect relationships which may functionally characterize any of these noise effects may be applied within a fractionalization procedure. The function for weighting the intensity of noise impact with respect to general adverse reaction (annoyance) is displayed in Figure C-3 (Ref. 9). The nonlinear weighting function is normalized to unity at L_{dn} = 75 dB. For convenience of calculation, the weighting function may be expressed as representing percentages of impact in accordance with the following equation:

$$W(L_{dn}) = \frac{[3.364 \times 10^{-6}]\,[10^{0.103 L_{dn}}]}{[0.2]\,[10^{0.03 L_{dn}}] + [1.43 \times 10^{-4}]\,[10^{0.08 L_{dn}}]} \qquad \text{(C-1)}$$

A simple linear approximation that can be used with reasonable accuracy in cases where day-night sound levels range between 55 and 80 dB is shown as the dashed line in Figure C-3, and is defined as:

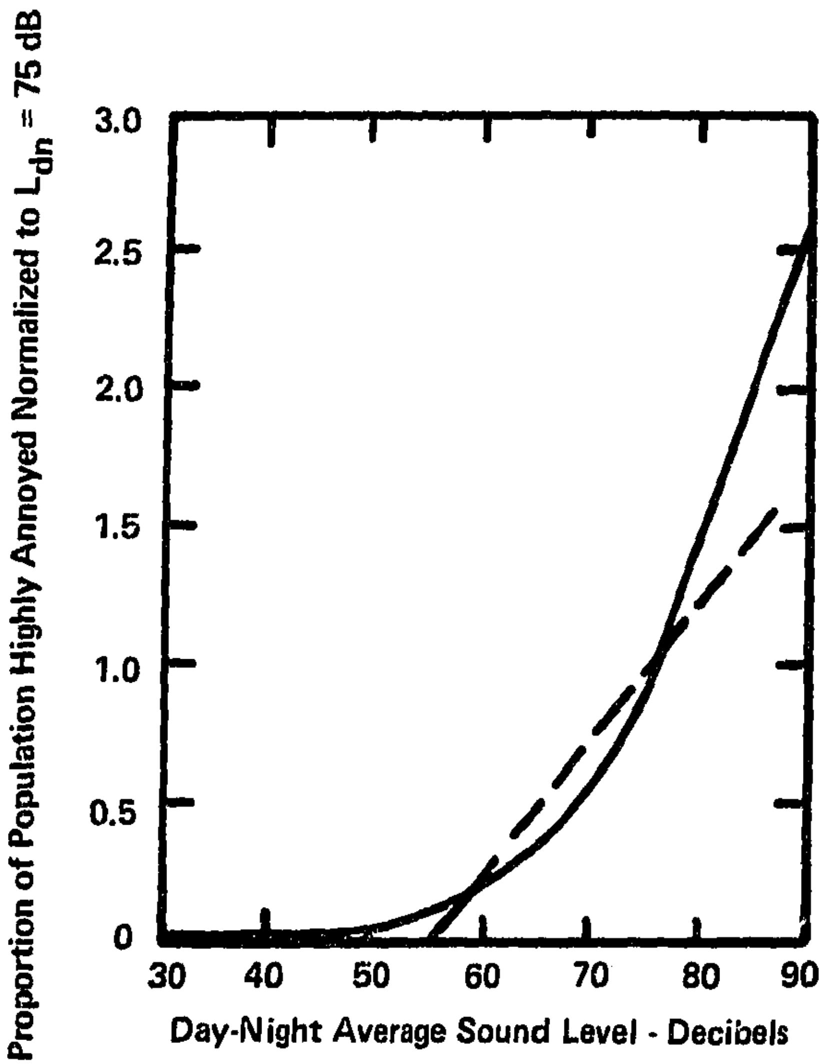


FIGURE C-3

WEIGHTING FUNCTION FOR ASSESSING
THE GENERAL ADVERSE RESPONSE TO NOISE

$$W(L_{dn}) = \begin{cases} 0.05\ (L_{dn} - 55) & \text{for } L_{dn} \geq 55 \\ 0 & \text{for } L_{dn} < 55 \end{cases} \quad \text{(C-2)}$$

Using the fractional impact concept, an index referred to as the Level-Weighted Population (LWP)* may be derived by multiplying the number of people exposed to a given level of traffic noise by the fractional or weighted impact associated with that level as follows:

$$LWP_i = W(L_{dn}^{\ i}) \times P_i \quad \text{(C-3)}$$

where LWP_i is the magnitude of the impact on the population exposed at $L_{dn}^{\ i}$, $W(L_{dn}^{\ i})$ is the fractional weighting associated with a noise exposure of $L_{dn}^{\ i}$, and P_i is the number of people exposed to $L_{dn}^{\ i}$.

Because the extent of noise impact is characterized by a distribution of people all exposed to different levels of noise, the magnitude of the total impact may be computed by determining the partial impact at each level and summing over each of the levels. This may be expressed as:

$$LWP = \sum_i LWP_i = \sum_i W(L_{dn}^{\ i}) \times P_i \quad \text{(C-4)}$$

The average severity of impact over the entire population may be derived from the Noise Impact Index (NII) as follows:

$$NII = \frac{LWP}{P_{total}} \quad \text{(C-5)}$$

In this case, NII represents the normalized percentage of the total population who describe themselves as highly annoyed. Another concept, the Relative Change in Impact (RCI) is useful for comparing the relative difference between two alternatives. This concept takes the form expressed as a percent change in impact:

$$RCI = \frac{LWP_i - LWP_j}{LWP_i} \quad \text{(C-6)}$$

where LWP_i and LWP_j are the calculated impacts under two different conditions.

*Terms such as Equivalent Population (Peq), and Equivalent Noise Impact (ENI), hav[e] often been used interchangeably with LWP. The other indices are conceptually iden[tical] to the LWP notation.

An example of the fractional impact calculation procedure is presented in Table C-2.

Similarly, using relevant criteria, the fractional impact procedure may be employed to calculate relative changes in hearing damage risk, sleep disruption, and speech interference.

TABLE C-2

EXAMPLE OF FRACTIONAL IMPACT CALCULATION
FOR GENERAL ADVERSE RESPONSE

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exposure Range (L_{dn})	Exposure Median (L_{dn})	P_i	$W(L_{dn})$ (Curvilinear)	$W(L_{dn})$ (Linear approx.)	LWP_i (Curvilinear) (Column (3) x(4))	LWP_i (Linear) (Column (3) x (5)
55-60	57.5	1,200,000	0.173	0.125	207,600	150,000
60-65	62.5	900,000	0.314	0.375	282,600	337,500
65-70	67.5	200,000	0.528	0.625	105,600	125,000
70-75	72.5	50,000	0.822	0.875	41,000	43,750
75-80	77.5	10,000	1.202	1.125	12,000	11,250
		2,360,000			648,920	667,500

LWP (Curvilinear) = 648,920
LWP (Linear) = 667,500
NII (Curvilinear) = 648,920 ÷ 2,360,000 = 0.27
NII (Linear) = 667,500 ÷ 2,360,000 = 0.28

APPENDIX D

NATIONAL ROADWAY TRAFFIC NOISE EXPOSURE MODEL

This appendix contains a detailed discussion of the National Roadway Traffic Noise Exposure Model. The discussion encompasses the data, the calculations, and the assumptions that underlie the model. Focus is on those details relevant to considerations of noise emission standards for buses.

This detailed discussion shows the interrelation of the data groups presented in Table 6-2. This interrelation centers around people, and how all persons are distributed throughout the United States. Briefly, each person is assigned to one of the 33 pop/density "cells" of Table 6-2. These cells are defined by (1) the total population in the city/town/area where that person lives, and (2) the population density in his neighborhood within his city/town/area. Then each person is matched to all the roadways within his own pop/density cell, and his total noise from these roadways is predicted.

The discussion that follows is based on Figures 6-10 through 6-13 which can be found in the main text. The logic flow proceeds from vehicles, to roadways, to propagation, to the noise level experienced at each residential location in the United States. The analysis continues with the sorting of all person/noise pairs, and the conversion from noise levels to impact estimates. These impact estimates are then summed into total, nationwide impact.

Full details and references to this discussion are included in the single volume documentation report of the National Roadway Traffic Noise Exposure Model (Reference 42).*

*References are listed at the end of Section 6.

<u>Details of Vehicles</u> (Figures 6-10 and 6-11, Key (1)).

The model contains 14 vehicle types, listed in Table 6-2. For each of these vehicle types, the model uses for computation a set of noise emission levels (ELs) that reflect operating modes, speed, and selected years. Noise emission levels may also be entered for the regulated vehicle of interest (or other vehicle types, if appropriate).

A vehicle's emission level is a measure of its total noise output. Technically, it is the noise level measured at a position perpendicular to the side of the vehicle and at a distance of 50 feet.

The vehicle emission level is a function of vehicle type, operating mode, and vehicle speed.

$$\text{Emission levels} = f(\overbrace{\text{vehicle type}}^{14}, \overbrace{\text{operating mode}}^{4}, \underbrace{\text{speed}}_{5}, \underbrace{\text{year}}_{\text{base year + 4 user-chosen years}}) \qquad \text{(D-1)}$$

Equation D-1 shows the functional relationship between emission levels and the parameters upon which emissions depend. In other words, the noise emissions vary for each of the 14 vehicle types; for each vehicle type, noise varies for each of the 4 operating modes; and for each mode, noise varies for each of the 5 grouped speeds. Since the idle mode has only one speed (zero), this functional relationship yields 16 emission levels for each vehicle type, for a total of 224 emission levels.

These 224 emission levels are used to describe the average emissions of each type of vehicle operating on roadways in specified years.

The complete set of emission levels used within this regulatory analysis appear in Table D-1 (Reference 54). Each of the noise emission values in this table represents an energy-average level. The energy average represents a time average of the time-varying emissions for vehicles accelerating and decelerating. In addition, each energy average emission level is derived from a level-average emission level and a standard deviation, σ, of the level about that average. It is assumed that the scatter of levels among all the vehicles of each vehicle type is Gaussian, and thus the energy-average emission level is computed as (Reference 49):

$$\text{Energy-average EL} = \text{Level-average EL} + 0.115\,\sigma^2 \qquad \text{(D-2)}$$

Again, as indicated in equation D-1, sixteen emission levels are defined for each vehicle for each of four selected years.

The future-year emission levels for buses as a function of regulatory option, speed, and mode appear in Tables D-2 to D-4. In these Tables, baseline acceleration data are taken from References 2 and 16, and are adjusted using equation D-2. Conversions to different modes and speed ranges are accomplished following the procedures presented in Reference 54.

In each year of interest, the model adds new vehicle sales to the vehicles already on the road, and depletes the general population of vehicles by those that retire from service. Only the new vehicles added each year are built to the reduced emission standard. For example, new buses added for the years 1975 through 1980 will have current-value noise emissions, while those introduced during 1981 to 1987 will have reduced noise emissions as shown in Tables D-2 to D-4. In other words, all new vehicle sales conform to the regulated limit in effect during the year of sale.

TABLE D-1

BASELINE VEHICLE NOISE EMISSION DATA*
(Source: Reference 54)

Type 1: Car/8-Cylinder/Automatic

Acceleration Mode					
Years>	1974				
0-20 MPH	59.60				
0-30	61.50				
0-40	63.10				
0-50	64.90				
0-60	66.80				
Deceleration Mode					
Years>	1974				
20-0 MPH	50.50				
30-0	56.10				
40-0	60.10				
50-0	63.20				
60-0	65.80				
Cruise Mode					
<25 MPH	59.80				
25-34	62.40				
35-44	66.40				
45-54	69.50				
>55	72.00				
Idle Mode					
Years>	1974				
	46.00				

Type 2: Car/6-Cylinder/Automatic

Acceleration Mode					
Years>	1974				
0-20 MPH	60.80				
0-30	62.50				
0-40	63.90				
0-50	65.50				
0-60	67.10				
Deceleration Mode					
Years>	1974				
20-0 MPH	50.50				
30-0	56.10				
40-0	60.10				
50-0	63.20				
60-0	65.80				
Cruise Mode					
<25 MPH	59.80				
25-34	62.40				
35-44	66.40				
45-54	69.50				
>550	72.00				
Idle Mode					
Years>	1974				
	46.00				

*Levels at 50 feet from vehicle

TABLE D-1 (cont.)

Type 3: Car/6-Cylinder/Manual

Acceleration Mode					
Years>	1974				
0-20 MPH	60.30				
0-30	62.50				
0-40	64.00				
0-50	65.60				
0-60	67.20				
Deceleration Mode					
Years>	1974				
20-0 MPH	50.50				
30-0	56.10				
40-0	60.10				
50-0	63.20				
60-0	65.80				
Cruise Mode					
<25 MPH	59.80				
25-34	62.40				
35-44	66.40				
45-54	69.50				
>55	72.00				
Idle Mode					
Years>	1974				
	46.00				

Type 4: Car and Light Truck/4-Cylinder/Automatic

Acceleration Mode					
Years>	1974				
0-20 MPH	62.90				
0-30	64.30				
0-40	65.40				
0-50	66.60				
0-60	68.00				
Deceleration Mode					
Years>	1974				
20-0 MPH	50.50				
30-0	56.10				
40-0	60.10				
50-0	63.20				
60-0	65.80				
Cruise Mode					
<25 MPH	59.80				
25-34	62.40				
35-44	66.40				
45-54	69.50				
>550	72.00				
Idle Mode					
Years>	1974				
	46.00				

TABLE D-1 (cont.)

Type 5: Car and Light Truck/4-Cylinder/Manual

Acceleration Mode					
Years>	1974				
0-20 MPH	62.60				
0-30	64.60				
0-40	65.90				
0-50	67.30				
0-60	68.70				

Deceleration Mode					
Years>	1974				
20-0 MPH	51.70				
30-0	57.30				
40-0	61.30				
50-0	64.40				
60-0	67.00				

Cruise Mode					
Years>	1974				
<25 MPH	61.00				
25-34	63.60				
35-44	67.60				
45-54	70.70				
>55	73.20				

Idle Mode					
Years>	1974				
	46.00				

Type 6: Light Truck/6-Cylinder

Acceleration Mode					
Years>	1974				
0-20 MPH	63.30				
0-30	65.10				
0-40	66.50				
0-50	68.20				
0-60	69.90				

Deceleration Mode					
Years>	1974				
20-0 MPH	53.40				
30-0	59.00				
40-0	63.00				
50-0	66.10				
60-0	68.70				

Cruise Mode					
Years>	1974				
<25 MPH	62.70				
25-34	65.30				
35-44	69.30				
45-54	72.40				
>550	74.90				

Idle Mode					
Years>	1974				
	46.00				

TABLE D-1 (cont.)

Type 7: Car and Light Truck/Diesel

Acceleration Mode

Years>	1974			
0-20 MPH	65.30			
0-30	66.70			
0-40	67.50			
0-50	68.40			
0-60	69.40			

Deceleration Mode

Years>	1974			
20-0 MPH	52.30			
30-0	57.90			
40-0	61.90			
50-0	65.00			
60-0	67.60			

Cruise Mode

Years>	1974			
<25 MPH	61.60			
25-34	64.20			
35-44	68.20			
45-54	71.30			
>55	73.80			

Idle Mode

Years>	1974			
	46.00			

Type 8: Medium Trucks

Acceleration Mode

Years>	1974	1978	1982	
0-20 MPH	75.10	75.10	74.80	
0-30	75.60	75.60	75.30	
0-40	76.20	76.20	75.90	
0-50	76.80	76.80	76.60	
0-60	77.70	77.70	77.50	

Deceleration Mode

Years>	1974	1978	1982	
20-0 MPH	65.80	65.80	65.50	
30-0	70.00	70.00	69.80	
40-0	73.00	73.00	72.70	
50-0	75.10	75.10	74.90	
60-0	76.80	76.80	76.70	

Cruise Mode

Years>	1974	1978	1982	
<25 MPH	77.20	77.20	76.90	
25-34	77.20	77.20	76.90	
35-44	78..10	78.10	77.90	
45-54	80.20	80.20	80.00	
>55	81.70	81.70	81.60	

Idle Mode

Years>	1974	1978	1982	
	54.00	54.00	54.00	

TABLE D-1 (cont.)

Type 9: Heavy Trucks

Acceleration Mode			
Years>	1974	1978	1982
0-20 MPH	82.70	78.90	75.90
0-30	82.80	79.10	76.30
0-40	83.00	79.60	77.10
.0-50	83.40	80.40	78.40
0-60	84.00	81.50	80.10

Deceleration Mode			
Years>	1974	1978	1982
20-0 MPH	73.90	70.20	67.50
30-0	77.30	73.90	71.40
40-0	79.60	76.50	74.40
50-0	81.40	78.60	77.00
60-0	82.70	80.40	79.10

Cruise Mode			
Years>	1974	1978	1982
<25 MPH	83.60	79.80	77.00
25-34	83.40	80.00	77.70
35-44	84.20	81.50	79.90
45-54	85.70	83.70	82.60
>55	86.80	85.60	85.00

Idle Mode			
Years	1974	1978	1982
	63.00	60.00	57.00

Type 10: Intercity Buses

Acceleration Mode	
Years>	1974
0-20 MPH	81.60
0-30	82.00
0-40	82.30
0-50	82.60
0-60	82.80

Deceleration Mode	
Years>	1974
20-0 MPH	68.10
30-0	71.40
40-0	73.80
50-0	75.60
60-0	77.10

Cruise Mode	
Years>	1974
<25 MPH	76.00
25-34	76.00
35-44	78.40
45-54	80.20
>55	81.70

Idle Mode	
Years>	1974
	62.00

TABLE D-1 (cont.)

Type 11: Transit Buses

Acceleration Mode

Years>	1974				
0-20 MPH	81.00				
0-30	81.00				
0-40	81.10				
0-50	81.20				
0-60	81.50				

Deceleration Mode

Years>	1974				
20-0 MPH	63.70				
30-0	67.80				
40-0	70.60				
50-0	72.90				
60-0	74.70				

Cruise Mode

Years>	1974				
<25 MPH	73.00				
25-34	73.00				
35-44	75.80				
45-54	78.10				
>55	79.90				

Idle Mode

Years>	1974				
	58.00				

Type 12: School Buses

Acceleration Mode

Years>	1974				
0-20 MPH	77.60				
0-30	78.10				
0-40	78.40				
0-50	78.90				
0-60	79.40				

Deceleration Mode

Years>	1974				
20-0 MPH	63.70				
30-0	67.80				
40-0	70.60				
50-0	72.90				
60-0	74.70				

Cruise Mode

Years>	1974				
<25 MPH	73.00				
25-34	73.00				
35-44	75.80				
45-54	78.10				
>55	79.90				

Idle Mode

Years>	1974				
	58.00				

TABLE D-1 (cont.)

Type 13: Unmodified Motorcycles

Acceleration Mode

Years>	1974	1981	1983	1986
0-20 MPH	73.30	71.50	68.50	66.50
0-30	74.90	73.10	70.10	68.10
0-40	75.40	73.60	70.60	68.60
0-50	75.70	73.90	70.90	68.90
0-60	75.90	74.10	71.10	69.10

Deceleration Mode

Years>	1974	1981	1983	1986
20-0 MPH	61.50	59.70	56.70	54.70
30-0	65.90	64.10	61.10	59.10
40-0	69.00	67.20	64.20	62.20
50-0	71.40	69.60	66.60	64.60
60-0	73.40	71.60	68.60	66.60

Cruise Mode

Years>	1974	1981	1983	1986
<25 MPH	66.90	65.10	62.10	60.10
25-34	71.30	69.50	66.50	64.50
35-44	74.40	72.60	69.60	67.60
45-54	76.90	75.10	72.10	70.10
>55	78.90	77.10	74.10	72.10

Idle Mode

Years>	1974	1981	1983	1986
	58.90	58.20	55.20	53.20

Type 14: Modified Motorcycles

Acceleration Mode

Years>	1974			
0-20 MPH	87.50			
0-30	89.10			
0-40	89.60			
0-50	89.90			
0-60	90.10			

Deceleration Mode

Years>	1974			
20-0 MPH	75.70			
30-0	80.10			
40-0	83.20			
50-0	85.60			
60-0	87.60			

Cruise Mode

Years>	1974			
<25 MPH	81.10			
25-34	85.50			
35-44	88.60			
45-54	91.10			
>55	93.10			

Idle Mode

Years>	1974			
	72.00			

TABLE D-2

NOISE LEVELS FOR TRANSIT BUSES UNDER
REGULATORY ALTERNATIVES

ACCELERATION MODE

REGULATORY LEVELS (A-Weighted)	BASELINE	83 dB	80 dB	77 dB	75 dB	65 dB
Speed Range						
0-20 MPH	81.00	81.00	78.20	75.20	73.20	63.20
0-30	81.00	81.00	78.20	75.30	73.30	63.30
0-40	81.10	81.10	78.40	75.60	73.80	63.80
0-50	81.20	81.20	78.70	76.20	74.70	64.70
0-60	81.50	81.50	79.20	77.10	75.90	65.90

DECELERATION MODE

REGULATORY LEVELS (A-Weighted)	BASELINE	83 dB	80 dB	77 dB	75 dB	65 dB
Speed Range						
20-0 MPH	63.70	63.70	61.30	58.90	57.60	47.60
30-0	67.80	67.80	65.60	63.80	62.80	52.80
40-0	70.60	70.60	68.90	67.50	66.80	56.80
50-0	72.90	72.90	71.50	70.50	70.10	60.10
60-0	74.70	74.70	73.70	73.10	72.90	62.90

CRUISE MODE

REGULATORY LEVELS (A-Weighted)	BASELINE	83 dB	80 dB	77 dB	75 dB	65 dB
Speed Range						
<25 MPH	73.00	73.00	70.40	67.80	63.40	53.40
25-34	73.00	73.00	71.10	69.60	68.90	58.90
35-44	75.80	75.80	74.50	73.60	73.10	63.10
45-54	78.10	78.10	77.30	76.80	76.60	66.60
>55	79.90	79.90	79.60	79.50	79.50	69.50

IDLE MODE

REGULATORY LEVELS (A-Weighted)	BASELINE	83 dB	80 dB	77 dB	75 dB	65 dB
	58.00	58.00	55.00	53.00	53.00	43.00

TABLE D-3

NOISE LEVELS FOR INTERCITY BUSES UNDER REGULATORY ALTERNATIVES

ACCELERATION MODE

REGULATORY LEVELS (A-Weighted)	BASELINE	83 dB	80 dB	77 dB	75 dB	65 dB
Speed Range						
0-20 MPH	81.60	77.80	74.80	71.80	69.80	59.80
0-30	82.00	78.30	75.30	72.40	70.60	60.60
0-40	82.30	78.60	75.80	73.20	71.60	61.60
0-50	82.60	79.00	76.50	74.30	73.00	63.00
0-60	82.80	79.60	77.40	75.60	74.70	64.70

DECELERATION MODE

REGULATORY LEVELS (A-Weighted)	BASELINE	83 dB	80 dB	77 dB	75 dB	65 dB
Speed Range						
20-0 MPH	68.10	64.50	61.80	59.30	57.90	47.90
30-0	71.40	68.10	65.70	63.80	62.80	52.80
40-0	73.80	70.80	68.90	67.40	66.80	56.80
50-0	75.60	73.00	71.50	70.50	70.10	60.10
60-0	77.10	75.00	73.90	73.20	72.90	62.90

CRUISE MODE

REGULATORY LEVELS (A-Weighted)	BASELINE	83 dB	80 dB	77 dB	75 dB	65 dB
Speed Range						
<25 MPH	76.00	72.40	69.60	67.10	65.60	55.60
25-34	76.00	73.00	71.00	69.60	68.90	58.90
35-44	78.40	75.90	74.50	73.50	73.10	62.10
45-54	80.20	78.30	77.40	76.80	76.60	66.60
>55	81.70	80.50	80.00	79.70	79.60	69.60

IDLE MODE

REGULATORY LEVELS (A-Weighted)	BASELINE	83 dB	80 dB	77 dB	75 dB	65 dB
	62.00	58.00	56.00	53.00	53.00	43.00

TABLE D-4

NOISE LEVELS FOR SCHOOL BUSES UNDER
REGULATORY ALTERNATIVES

ACCELERATION MODE

REGULATORY LEVELS (A-Weighted)	BASELINE	83 dB	80 dB	77 dB	75 dB	65 dB
Speed Range						
0-20 MPH	77.60	77.60	74.80	71.80	69.80	59.80
0-30	78.10	78.10	75.30	72.40	70.60	60.60
0-40	78.40	78.40	75.80	73.20	71.60	61.60
0-50	78.90	78.90	76.50	74.30	73.00	63.00
0-60	79.40	79.40	77.40	75.60	74.70	64.70

DECELERATION MODE

REGULATORY LEVELS (A-Weighted)	BASELINE	83 dB	80 dB	77 dB	75 dB	65 dB
Speed Range						
20-0 MPH	63.70	63.70	61.30	58.90	57.60	47.60
30-0	67.80	67.80	65.60	63.80	62.80	52.80
40-0	70.60	70.60	68.90	67.50	66.80	56.80
50-0	72.90	72.90	71.50	70.50	70.10	60.10
60-0	74.70	74.70	73.70	73.10	72.90	62.90

CRUISE MODE

REGULATORY LEVELS (A-Weighted)	BASELINE	83 dB	80 dB	77 dB	75 dB	65 dB
Speed Range						
<25 MPH	73.00	73.00	70.40	67.80	66.20	56.20
25-34	73.00	73.00	71.10	69.60	68.90	58.90
35-44	75.80	75.80	74.50	73.60	73.10	63.10
45-54	78.10	78.10	77.30	76.80	76.60	66.60
>55	79.90	79.90	79.60	79.50	79.50	69.50

IDLE MODE

REGULATORY LEVELS (A-Weighted)	BASELINE	83 dB	80 dB	77 dB	75 dB	65 dB
	58.00	58.00	55.00	53.00	53.00	43.00

The sales rate and the vehicle depletion rate are discussed further in the following subsection.

In addition to noise emission levels, the model considers the fraction of time each vehicle spends in each of the four operating modes. These mode fractions depend also upon the roadway type, as shown in equation D-3

$$\text{Fraction of time in mode} = f(\underbrace{\text{vehicle type}}_{\text{only 10}},\ \underbrace{\text{operating mode}}_{4},\ \underbrace{\text{roadway type}}_{\text{only 2}}) \qquad \text{(D-3)}$$

It should be noted that the mode fraction does not vary for all 14 vehicle types, but is the same for several of them. Similarly, it does not vary for all of the roadway types, but regroups all roadways into two groups for this purpose.

The functional relationship in equation D-3 yields 80 values. These values are contained in 14 tables, three of which are included here as Table D-5. Specifically, Table D-5 documents the mode fractions for the three bus vehicle types. The remainder of the tables are contained in Reference 42. This information contained in all 14 tables was extrapolated from References 52 and 53.

<u>Details of Roadway (Figures 6-10 and 6-11, Key ②)</u>

The model contains 6 roadway types, as listed in Table 6-2. For each of these roadway types, the model contains six specific pieces of data:

- o Fraction of mileage at each speed range
- o Average daily traffic
- o Traffic mix

TABLE D-5 Mode Fraction (Percent of Time) in Operating Mode: Transit Buses

Roadway Type	OPERATING MODE				
	Acceleration M=1	Deceleration M=2	Cruise M=3	Idle M=4	Total
1	5.00	5.00	85.00	5.00	100.00
2	5.00	5.00	85.00	5.00	100.00
3	5.00	5.00	85.00	5.00	100.00
4	20.00	20.00	26.00	34.00	100.00
5	20.00	20.00	26.00	34.00	100.00
6	20.00	20.00	26.00	34.00	100.00

TABLE D-5 (cont.) Mode Fraction (Percent of Time) in Operating Mode: Intercity Buses

Roadway Type	OPERATING MODE				
	Acceleration M=1	Deceleration M=2	Cruise M=3	Idle M=4	Total
1	5.00	5.00	85.00	5.00	100.00
2	5.00	5.00	85.00	5.00	100.00
3	5.00	5.00	85.00	5.00	100.00
4	13.00	17.00	56.00	14.00	100.00
5	13.00	17.00	56.00	14.00	100.00
6	13.00	17.00	56.00	14.00	100.00

TABLE D-5 (cont.) Mode Fraction (Percent of Time) in Operating Mode: School Buses

Roadway Type	OPERATING MODE				
	Acceleration M=1	Deceleration M=2	Cruise M=3	Idle M=4	Total
1	5.00	5.00	85.00	5.00	100.00
2	5.00	5.00	85.00	5.00	100.00
3	5.00	5.00	85.00	5.00	100.00
4	9.00	9.00	21.00	61.00	100.00
5	9.00	9.00	21.00	61.00	100.00
6	9.00	9.00	21.00	61.00	100.00

- o Lane width
- o Number of lanes
- o Clear-zone width

In actual fact, each roadway has a large range of speeds associated with it. Although vehicle speeds vary on each roadway from moment to moment, the program considers only the average speed for any given segment of roadway. In other words, within each population area the program distributes all the mileage of a given type of roadway into the five speed groups, based upon that mileage's average speed. Resulting is the fraction of roadway mileage in each of the five speed groups for each population area.

These fractions of mileage contain only those miles that pass through occupied land areas. Other mileage is excluded before distribution into speed groups. This mileage exclusion was computed using Figure A.2.2 of Reference 42.

Next, the program multiplies these mileage fractions by the total mileages, to obtain the number of miles of that roadway type in the given speed group on a national basis.

```
                          ┌──▶5      ┌──▶6
                          │          │
Number of miles in        │          │
  a given speed group = f(speed group, roadway type,        (D-4)
                          │ population, population
                          │ density)  │
                          └──▶4       └──▶9
```

This allocation of roadway mileage by speed group is also a function of the two population groups shown in equation D-4. These population groups are discussed further below.

In all, this functional relationship yields 216 values for each speed group, for a total of 1080 values. The complete set of values is contained in a set of 20 tables (Reference 42, Table A.3.2), two of which are included here in Table D-6.

A partial summary of these 20 tables appear in Table D-7. There the total roadway mileage through occupied land is split by population and roadway type. Information concerning speed grouping and grouping by population density is not presented in Table D-7, although included in the 20 tables.

Next, the program contains average daily traffic for each of the roadway types.

```
                    ┌──►6          ┌──►9
Average daily       │              │
  traffic     =  f (roadway type, place population,        (D-5)
                 │  year)
                 └───► base year + 8 selected years
```

For the baseline year, this functional relationship yields 54 values (Reference 44). These appear in Table D-8.

Each of these traffic values is then further divided by vehicle type. The resulting traffic mix appears in Table D-9 (References 2, 51, 55, 56, and 58).

```
                      ┌──────► only 8  ┌──►6
                      │                │
1974 Traffic mix =  f(vehicle type, roadway type,          (D-6)
                      │ population)
                      └──────► only 4
```

These data are sufficient to define vehicle mix for the baseline year 1974. To predict future-year traffic mixes, however, a breakdown of vehicles by their year of production is carried out. This breakdown resides within the computer program, and appears here as Tables D-10 and D-11 (see Figure

TABLE D-6

ROADWAY MILEAGE DATA
AVERAGE TRAVEL SPEED 20 MPH

ID = 1

HIGH POPULATION DENSITY AREAS

	K = 1	2	3	4	5	6	All K
J = 1	0	3	16	41	37	94	191
2	0	7	21	/1	71	172	342
3	0	1	4	11	12	31	59
4	0	3	17	45	42	119	226
5	0	5	24	58	61	149	297
6	0	5	29	67	69	171	341
7	0	1	6	14	15	33	69
8	0	3	27	59	63	140	292
9	0	0	0	8698	6159	215859	230716
ALL J>	0	28	144	9064	6529	216768	232533

ID = 2

MEDIUM TO HIGH POPULATION DENSITY AREAS

	K = 1	2	3	4	5	6	All K
J = 1	6	78	438	1085	989	2494	5090
2	1	19	59	201	203	491	974
3	1	6	31	84	95	242	459
4	7	69	360	963	886	2514	4799
5	2	23	110	273	283	699	1390
6	1	18	99	229	233	5/9	1159
7	1	10	97	210	228	504	1050
8	1	16	154	336	364	804	1675
9	0	0	0	0	0	0	0
ALL J>	20	239	1348	3381	3281	8327	16596

J 1 = Population over 2 million (M)
J 2 = 1 M to 2 M
J 3 = 500K to 1 M
J 4 = 200K to 500K
J 5 = 100K to 200K
J 6 = 50K to 100K
J 7 = 25K to 50K
J 8 = 5K to 25K
J 9 = Rural

K 1 = Interstate Highways
K 2 = Freeways and Expressways
K 3 = Major Arterials
K 4 = Minor Arterials
K 5 = Collectors
K 6 = Local Roads and Streets

TABLE D-7 Distribution of Road Mileage, Average Daily Traffic (ADT) and Daily Vehicle Miles Traveled (DVMT) by Place Size (J) and Roadway Type (K)

Place Size		ROADWAY TYPE: INTERSTATE	OTHER E'WAY & EXP'WAY	MAJOR ARTERIALS	MINOR ARTERIALS	COLLECTORS	LOCAL
>2M	Miles	1,998	1,749	9,861	14,103	12,854	84,247
	ADT	74,866	66,470	18,768	9,315	3,783	1,129
	DVMT	149,582,268	116,256,030	185,071,248	131,369,445	48,626,682	95,114,863
1M to 2M	Miles	1,869	1,527	5,156	10,219	10,308	64,678
	ADT	60,228	32,548	17,397	6,898	3,496	656
	DVMT	112,566,132	49,700,796	89,698,932	70,490,662	36,036,768	42,428,768
500K to 1M	Miles	1,477	739	4,034	6,320	7,190	47,466
	ADT	46,997	34,036	16,359	8,045	3,760	672
	DVMT	69,414,569	25,152,604	65,992,206	50,844,400	27,034,400	31,897,152
200K to 500K	Miles	1,743	1,076	5,566	8,569	7,897	58,252
	ADT	40,367	28,812	16,029	8,470	3,812	839
	DVMT	70,359,681	31,001,712	89,217,414	75,579,430	30,103,364	48,873,428
100K to 200K	Miles	854	803	3,851	5,502	5,714	36,697
	ADT	32,190	22,984	14,984	7,301	3,287	649
	DVMT	27,490,260	18,456,152	57,352,943	40,170,102	18,781,918	23,816,353
50K to 100K	Miles	512	600	3,335	4,445	4,534	29,284
	ADT	21,913	19,971	12,376	6,057	2,917	645
	DVMT	11,219,456	11,982,600	41,273,960	26,923,365	13,225,678	18,888,180
25K to 50K	Miles	397	447	4,282	5,377	5,828	33,454
	ADT	23,251	16,875	11,384	5,430	2,484	631
	DVMT	9,230,647	7,543,125	48,746,298	29,197,110	14,476,752	21,109,479
5K to 25K	Miles	899	1,099	9,652	12,124	13,130	75,431
	ADT	18,206	13,244	8,922	4,255	1,946	495
	DVMT	16,367,144	13,343,016	86,115,144	61,587,620	25,550,980	37,338,345
Rural	Miles	31,744	85,716	155,547	435,517	307,917	1,942,733
	ADT	13,700	4,623	2,523	899	370	98
	DVMT	434,892,800	396,265,068	392,445,081	387,174,613	113,929,290	190,387,834

Note: ADT-DVMT/Miles is the derived quality.

TABLE D-8

Average Daily Traffic (ADT)
By Roadway Type (K) and Place Size (J)
Baseline Year 1974

	K = 1	2	3	4	5	6
J=1	74866	66470	18768	9315	3783	1129
2	60228	32548	17397	6898	3496	656
3	46997	34036	16359	8045	3760	672
4	40367	28812	16029	8470	3812	839
5	32190	22984	14984	7301	3287	649
6	21913	19971	12376	6057	2917	645
7	23251	16876	11384	5430	2484	631
8	18206	13224	8922	4255	1946	495
9	13700	4623	2523	889	370	98

TABLE D-9

Percentage Vehicle Mix in Traffic Flow by Place Size
and Functional Roadway Classification Baseline Conditions

URBAN PLACES SIZES: Over 2M; 1M-2M; 500K-1M

VEHICLE TYPE	ROADWAY TYPE (INDEX K)					
Light Vehicles	87.62	87.62	91.82	90.52	90.51	95.76
Medium Trucks	2.11	2.11	3.05	4.31	3.61	1.16
Heavy Trucks	9.17	9.17	4.03	3.11	3.82	0.99
Intercity Buses	0.03	0.03	0.03	0.00	0.00	0.00
Transit Buses	0.08	0.08	0.08	0.54	0.54	0.54
School Buses	0.00	0.00	0.00	0.02	0.02	0.02
Unmodified Motorcycles	0.88	0.88	0.88	1.32	1.32	1.32
Modified Motorcycles	0.12	0.12	0.12	0.18	0.18	0.18
	100.00	100.00	100.00	100.00	100.00	100.00

URBAN PLACES SIZES: Over 200K-500K; 100K-200K; 50K-100K

VEHICLE TYPE	ROADWAY TYPE (INDEX K)					
	1	2	3	4	5	6
Light Vehicles	87.64	87.64	91.84	90.71	90.70	95.98
Medium Trucks	2.11	2.11	3.05	4.31	3.61	1.16
Heavy Trucks	9.17	9.17	4.03	3.11	3.82	0.99
Intercity Buses	0.04	0.04	0.04	0.04	0.04	0.04
Transit Buses	0.04	0.04	0.04	0.30	0.30	0.30
School Buses	0.00	0.00	0.00	0.08	0.08	0.08
Unmodified Motorcycles	0.88	0.88	0.88	1.32	1.32	1.32
Modified Motorcycles	0.12	0.12	0.12	0.18	0.18	0.18
	100.00	100.00	100.00	100.00	100.00	100.00

NOTE: Some columns do not add up to exactly 100 because of rounding

K 1 = Interstate Highways
K 2 = Freeways and Expressways
K 3 = Major Arterials
K 4 = Minor Arterials
K 5 = Collectors
K 6 = Local Roads and Streets

TABLE D-9 (cont.)

Percentage Vehicle Mix in Traffic Flow
by Place Size and Functional Roadway

URBAN PLACES SIZES: 25K-50K; 5K-25K

VEHICLE TYPE	ROADWAY TYPE (INDEX K)					
	1	2	3	4	5	6
Light Vehicles	87.67	87.67	91.67	90.34	90.33	95.61
Medium Trucks	2.11	2.11	3.05	4.31	3.61	1.16
Heavy Trucks	9.17	9.17	4.03	3.11	3.82	0.99
Intercity Buses	0.03	0.03	0.03	0.00	0.00	0.00
Transit Buses	0.05	0.05	0.05	0.21	0.21	0.21
School Buses	0.00	0.00	0.00	0.52	0.52	0.52
Unmodified Motorcycles	0.88	0.88	0.88	1.32	1.32	1.32
Modified Motorcycles	0.12	0.12	0.12	0.18	0.18	0.18
	100.00	100.00	100.00	100.00	100.00	100.00

RURAL AREAS
ROADWAY TYPE (INDEX K)

	1	2	3	4	5	6
Light Vehicles	79.67	79.67	85.78	88.27	93.33	96.74
Medium Trucks	2.74	2.74	3.80	4.39	0.56	0.41
Heavy Trucks	16.16	16.16	8.99	5.14	3.91	0.65
Intercity Buses	0.24	0.24	0.24	0.00	0.00	0.00
Transit Buses	0.00	0.00	0.00	0.00	0.00	0.00
School Buses	0.19	0.19	0.19	0.70	0.70	0.70
Unmodified Motorcycles	0.88	0.88	0.88	1.32	1.32	1.32
Modified Motorcycles	0.12	0.12	0.12	0.18	0.18	0.18
	100.00	100.00	100.00	100.00	100.00	100.00

NOTE: Some columns do not add up to exactly 100 because of rounding

TABLE D-10

Baseline Year (1974) Vehicle Population by Model Year and Vehicle Category

Model Year	Light Vehicles	Trucks	Intercity Buses	Transit Buses	School Buses	Motorcycles
1974	13,959,524	447,576	1,479	12,571	58,226	518,315
1973	14,599,524	457,770	2,246	6,706	47,511	579,971
1972	13,145,920	387,705	1,886	4,819	38,378	522,226
1971	11,107,210	281,879	1,084	3,319	28,263	443,740
1970	11,003,084	274,759	13,905*	42,057*	184,460*	437,103
1969	11,161,141	291,911	-	-	-	443,380
1968	10,274,987	229,451	-	-	-	408,177
1967	8,581,706	211,166	-	-	-	340,911
1966	8,461,220	211,814	-	-	-	336,125
1965	7,397,576	185,276	-	-	-	293,871
1964	5,151,096	152,266	-	-	-	204,629
1963	3,658,626	121,684	-	-	-	145,340
1962	2,348,827	97,573	-	-	-	93,308
1961	1,167,288	69,094	-	-	-	46,317
1960	883,563	70,227	-	-	-	35,063
1959	506,559	59,871	-	-	-	20,129
1958	2,100,082*	370,391*	-	-	-	83,436*

*Population includes all vehicles in this model year and older.

TABLE D-11

Distribution of Vehicle Population by Vehicle Type for Model Years 1974 and Earlier

Vehicle*	Fraction of Vehicle Category Population
Type 1	0.4673
Type 2	0.1420
Type 3	0.0167
Type 4	0.0168
Type 5	0.1603
Type 6	0.1514
Type 7	0.0005
Total	1.0000
Type 8	0.6146
Type 9	0.3854
Total	1.0000
Type 10	1.0000
Type 11	1.0000
Type 12	1.0000
Type 13	0.8800
Type 14	0.1200
Total	1.0000

* See Table D-1

A-4.2 of Reference 42, derived from References 55 and 56). Table D-10 provides vehicle information in six vehicle groups, while Table D-11 further subdivides these groups into the total of 14 as illustrated in equation D-7.

$$\text{1974 vehicle mix} = f(\overset{\to 14}{\text{vehicle type}}, \overset{\to 17}{\text{model year}}) \qquad \text{(D-7)}$$

The average daily traffic is also derived for future years. First we account for new vehicles sold each year that increase the average daily traffic.

$$\text{Vehicle sales} = f(\overset{\to \text{only } 4}{\text{vehicle type}}, \overset{\to 40}{\text{year}}) \qquad \text{(D-8)}$$

This functional relationship illustrated by equation D-8 represents growth factors relative to sales in 1974 (see Figure A-4.2 of Reference 42 for growth factors of vehicles other than buses, derived from References 55 and 56).

The projected number of bus sales used in this regulatory health and welfare analysis are discussed in Section 3.

For future years, the average daily traffic is also depleted as shown by equation D-9 by those vehicles that retire from service (References 55 and 56).

$$\text{Percentage of vehicles retiring} = f(\overset{\to \text{only } 2}{\text{vehicle type}}, \overset{\to 20}{\text{vehicle age}}) \qquad \text{(D-9)}$$

Examples of this depletion rate are contained in Appendix G of Reference 42. Table D-12 presents vehicle population by type for each year. This table takes into account vehicle sales and depletion rates.

In summary, average daily traffic flow plus vehicle mix starts at the 1974 values (baseline) for each roadway (equations D-5, D-6, and D-7). Daily traffic flow grows according to new-vehicle sales (equation D-8), and is depleted by the number of vehicles retiring (equation D-9). As the traffic changes in this manner, all new-vehicle sales consist of noise-regulated vehicles -- where such vehicles have been specified (equation D-1).

For the Single Event Response part of the model, the average daily traffic flow and vehicle mix is used in the same manner as above. However, the noise impact from only one vehicle type at a time is computed.

The basic roadway configuration appears in Figure D-1. A roadway is shown to the left, with the adjacent land extending to the right.

Each roadway type consists of a definite number of travel lanes, of definite width, then a clear zone of definite width, and then occupied land.

(roadway type → only 2)

Lane width = f(roadway type) (D-10)

(roadway type → only 2)

Number of travel lanes = f(roadway type) (D-11)

(roadway type → 6; population size → 9; population density → 4)

Clear-zone width = f(roadway type, population size, population density) (D-12)

Lane widths are 15 feet for interstate roadways and 12 feet for all other roadways. The number of travel lanes is two for all local roadways and four for all other roadways. The clear-zone widths are more complicated functions, as indicated in equation D-12. The clear-zone widths used in the model appear in Table D-13. The definition of the clear-zone distance is based upon the best information currently available (References 44, 46, 59).

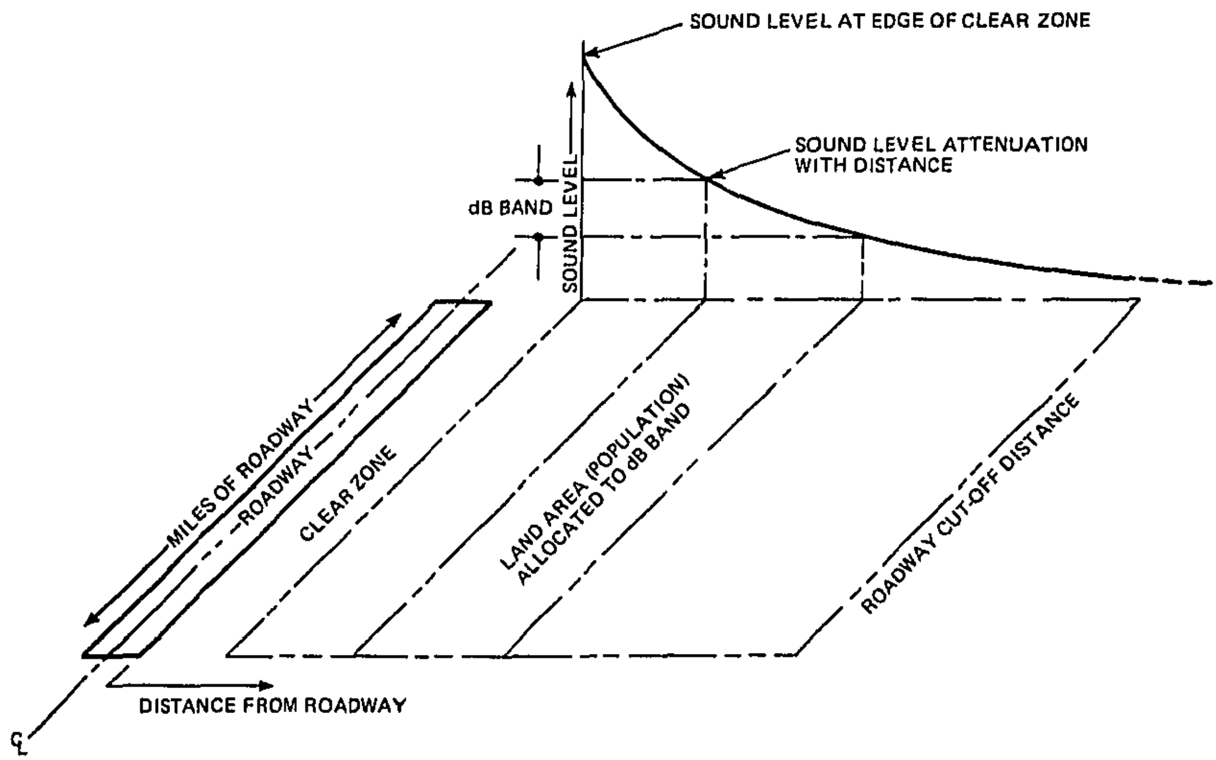
TABLE D-12

VEHICLE POPULATION BY TYPE

TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	ALL TYPES
Cylinders	8	6	6&8	4	4	6&8									
Engine	Gas	Gas	Gas	Gas	Gas	Gas	Diesel								
Trans-mission	Auto-matic	Auto-matic	Man-ual	Auto-matic	Man-ual	---	---	---	---	---	---	---	---	---	
VEH. Type>	PC	PC	PC	PC&LT	PC&LT	LT TRK	PC&LT	MED TRK	HVY TRK	IC BUS	TR BUS	SCH BUS	UM MTCY	MD MTCY	
UNIT	MILLIONS									TENS OF THOUSANDS			MILLIONS		
Year															
1974	58.68	17.83	2.10	7.76	20.13	19.01	0.06	2.41	1.51	2.06	6.95	35.68	4.36	0.59	134.89
1980	65.13	21.41	2.69	11.16	22.74	26.85	0.11	2.87	1.80	1.63	8.98	49.14	4.44	0.61	160.41
1985	57.21	28.03	3.69	23.04	25.74	32.23	0.16	3.38	2.12	2.10	12.34	62.58	5.76	0.79	182.91
1990	45.60	35.84	4.78	37.58	29.48	34.84	0.19	3.78	2.37	2.43	14.16	67.43	7.80	1.06	204.17
1995	42.44	41.92	5.60	47.13	33.21	41.35	0.23	4.18	2.62	2.72	15.37	70.13	9.40	1.18	226.43
2000	45.73	46.60	6.22	52.82	33.21	41.35	0.23	4.61	2.89	3.01	16.42	72.81	10.53	1.44	250.10
2005	50.45	51.44	6.87	58.31	40.57	45.64	0.25	5.09	3.19	3.31	17.48	75.50	11.30	1.54	275.62
2010	55.69	56.78	7.58	64.37	44.78	50.37	0.28	5.62	3.52	3.60	18.54	78.19	11.61	1.58	303.18

FIGURE D-1

ROADWAY TRAFFIC NOISE EXPOSURE OF LAND AREA



NOTE: LAND AREA AND POPULATION IS UNIFORMLY DISTRIBUTED ON BOTH SIDES OF ROADWAY.

Clear-zones consist of the area between the roadway pavement and the adjacent, occupied land. These clear-zones include parking lanes, and sidewalks. In all but the rural population group, clear-zones also include front yards of residences -- but only along arterials, collectors, and local roadways. For interstates and freeways, clear-zones include the right-of-way adjacent to the roadway pavement.

Details of Propagation (Figures 6-10 and 6-11, Key (2))

Propagation of bus noise from the roadway into the adjacent occupied land is influenced, in part, by:

- o Distance
- o Ground effects
- o Shielding

For persons close by a roadway, the roadway appears relatively straight. The roadway also appears "infinitely long" to nearby persons. Both these approximations are made for all roadway propagation calculations in the model. Therefore, the only geometric quantity of concern is the perpendicular distance between the person and the roadway.

The model utilizes a random process to determine the perpendicular distances between all roadways and all persons. In essence, the model distributes people randomly over a well-defined land area (lying wholly outside the clear-zones for each roadway), and then the distribution of perpendicular distances is calculated. The details of this distance calculation are presented in the following subsection.

Once the distance between any person and roadway is determined, then the noise propagation can be measured in terms of this distance, the attenuation characteristics of the intervening ground (the clear-zone), and the shielding provided by intervening buildings.

TABLE D-13

CLEAR ZONE DISTANCES (IN FEET) BY ROADWAY TYPE (K), POPULATION DENSITY CATEGORY (ID), AND POPULATION PLACE SIZE (J)*

		Population Place Size, Index J								
K	ID	1	2	3	4	5	6	7	8	9
1	ALL	50.	50.	50.	50.	50.	50.	50.	50.	50.
2	ALL	30.	30.	30.	40.	40.	40.	40.	40.	40.
3	1	10.	10.	10.	10.	10.	10.	10.	10.	40.
	2	15.	15.	15.	20.	20.	20.	20.	20.	40.
	3	20.	20.	20.	30.	30.	30.	30.	30.	40.
	4	30.	30.	30.	40.	40.	40.	40.	40.	40.
4	1	10.	10.	10.	10.	10.	10.	10.	10.	40.
	2	15.	15.	15.	20.	20.	20.	20.	20.	40.
	3	20.	20.	20.	30.	30.	30.	30.	30.	40.
	4	30.	30.	30.	40.	40.	40.	40.	40.	40.
5	1	5.	5.	5.	10.	10.	10.	10.	10.	40.
	2	10.	10.	10.	20.	20.	20.	20.	20.	40.
	3	15.	15.	15.	30.	30.	30.	30.	30.	40.
	4	20.	20.	20.	40.	40.	40.	40.	40.	40.
6	1	5.	5.	5.	10.	10.	10.	10.	10.	40.
	2	10.	10.	10.	20.	20.	20.	20.	20.	40.
	3	15.	15.	15.	30.	30.	30.	30.	30.	40.
	4	20.	20.	20.	40.	40.	40.	40.	40.	40.

Index K denotes highway type; Index ID denotes population density category.

*See Table 6-2 for roadway type, population place size and population density groups

To determine ground attenuation the model assumes a noise divergence of 3 dB per distance doubling from the roadway (line sources), and 6 dB per distance doubling for individual vehicles as they pass by. In addition, the model assumes an excess ground attenuation of 1.5 dB per distance doubling over absorptive clear-zones.

→only 2 (roadway type) →only 2 (population groups)

Ground attenuation = f(roadway type, population groups) . (D-13)

Such excess attenuation is assumed for:

- o Interstate roadways plus freeways and expressways for place population groups over 25,000 people
- o Major and minor arterials plus collectors and local roadways, for place populations over 500,000 people

Average shielding due to intervening buildings is assumed to depend only the width of the clear-zone, and the population density as illustrated in equation D-14.

→4 (clear-zone width)

Building shielding = f(clear-zone width, population density) (D-14)

→3 (population density)

The building shielding and ground attenuation factors are combined with the 3 dB or 6 dB per distance doubling. The resulting propagation curves are provided in Figures D-2 and D-3. Figure D-2 applies to roadway line sources (where the source is made up of a stream of vehicles), and is used in the General Adverse Response part of the model. Figure D-3 is for individual vehicle point sources, and is used in the Single Event Response part of the model. Attenuation values extracted from these curves are used by the computer to calculate the propagation of the noise into occupied land, starting at the edge of the clear-zone. (See References 42, 57 and 60 for more detailed discussions of the propagation rates used.)

The Single Event part of the model accounts for building attenuation so that indoor noise can be predicted. To estimate indoor noise levels from outside noise sources, the sound attenuation offered by building walls and windows is calculated. Although dwelling walls effectively attenuate sound, windows generally provide poorer sound insulation from exterior noise. When windows are open the difference between indoor and outdoor noise varies from 8 to 25 dB; with windows closed, the attenuation varies from 19 to 34 dB, and with double-glazed windows, noise may be reduced as much as 45 dB. Average differences between values for open window and closed window conditions are 15 dB and 25 dB respectively (Reference 48).

The analysis assumes an attenuation value of 15 dB for the suburban single-family detached and the suburban duplex dwelling areas (assuming window open conditions), and a value of 20 dB for other dwellings to account for the attenuation of outdoor noise by the exterior shell of the house (assuming a mixture of windows open and closed). These attenuation values represent an average between summer and winter, and new construction and old construction.

$$\text{Building noise isolation} = f(\overset{\rightarrow 9}{\text{population}}, \overset{\rightarrow 4}{\text{population}}\ \text{density}) \qquad (D\text{-}15)$$

The building noise insulation values used in the computer analysis are presented in Table D-14.

Details of Receivers (Figures 6-10 and 6-11, Key ③)

First, each person in the United States is assigned to one of the 33 pop/density "cells" of Table 6-2. These cells are defined by (1) the total population in the city/town/area where that person lives, and (2) the population density in his neighborhood within his city/town/area. These assignments to pop/density cells reside within the computer program, and appear here in Table D-15. The land areas of each of these pop/density cells also appear in

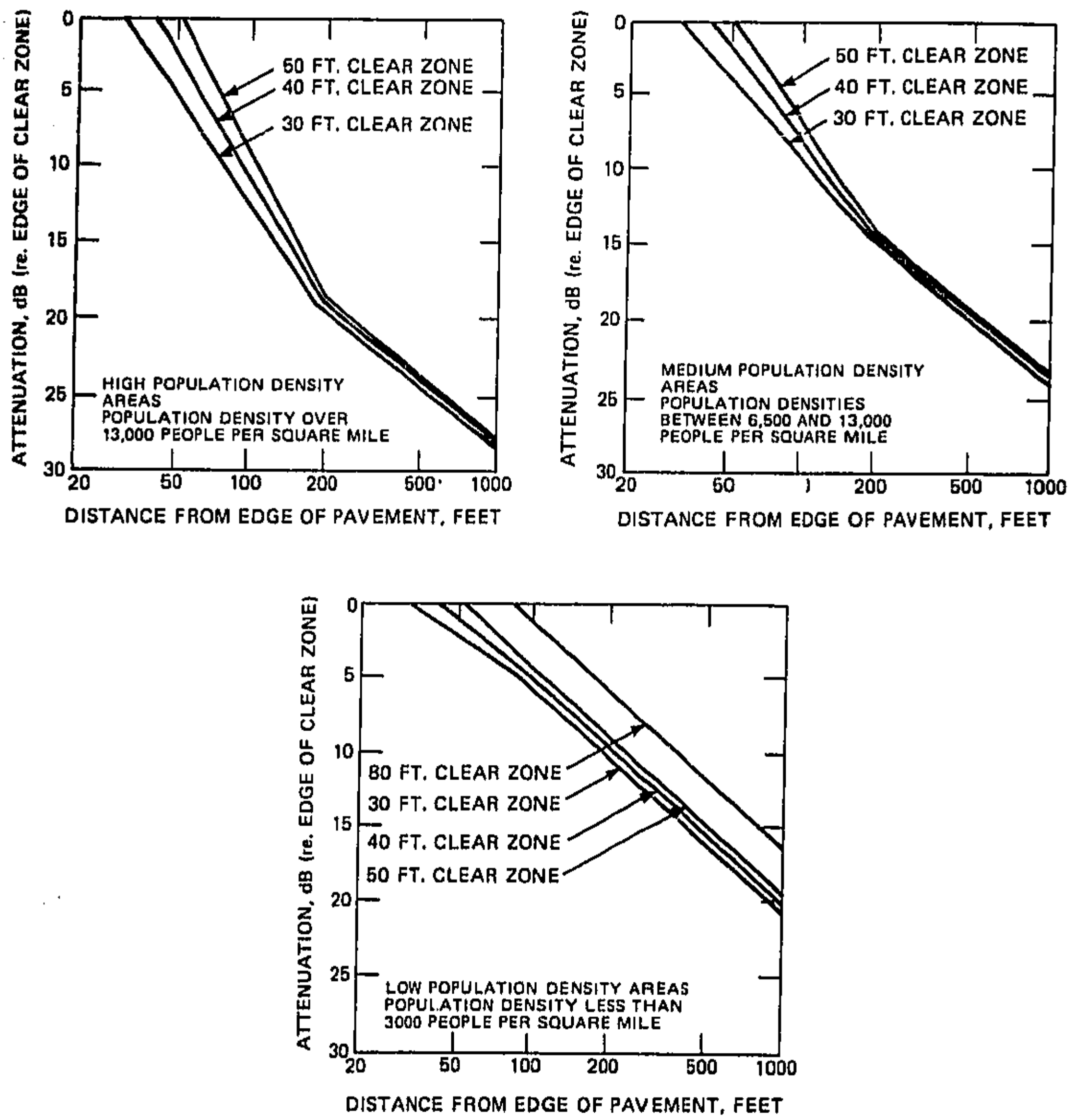


FIGURE D-2. SOUND LEVEL ATTENUATION CURVES: LINE SOURCE

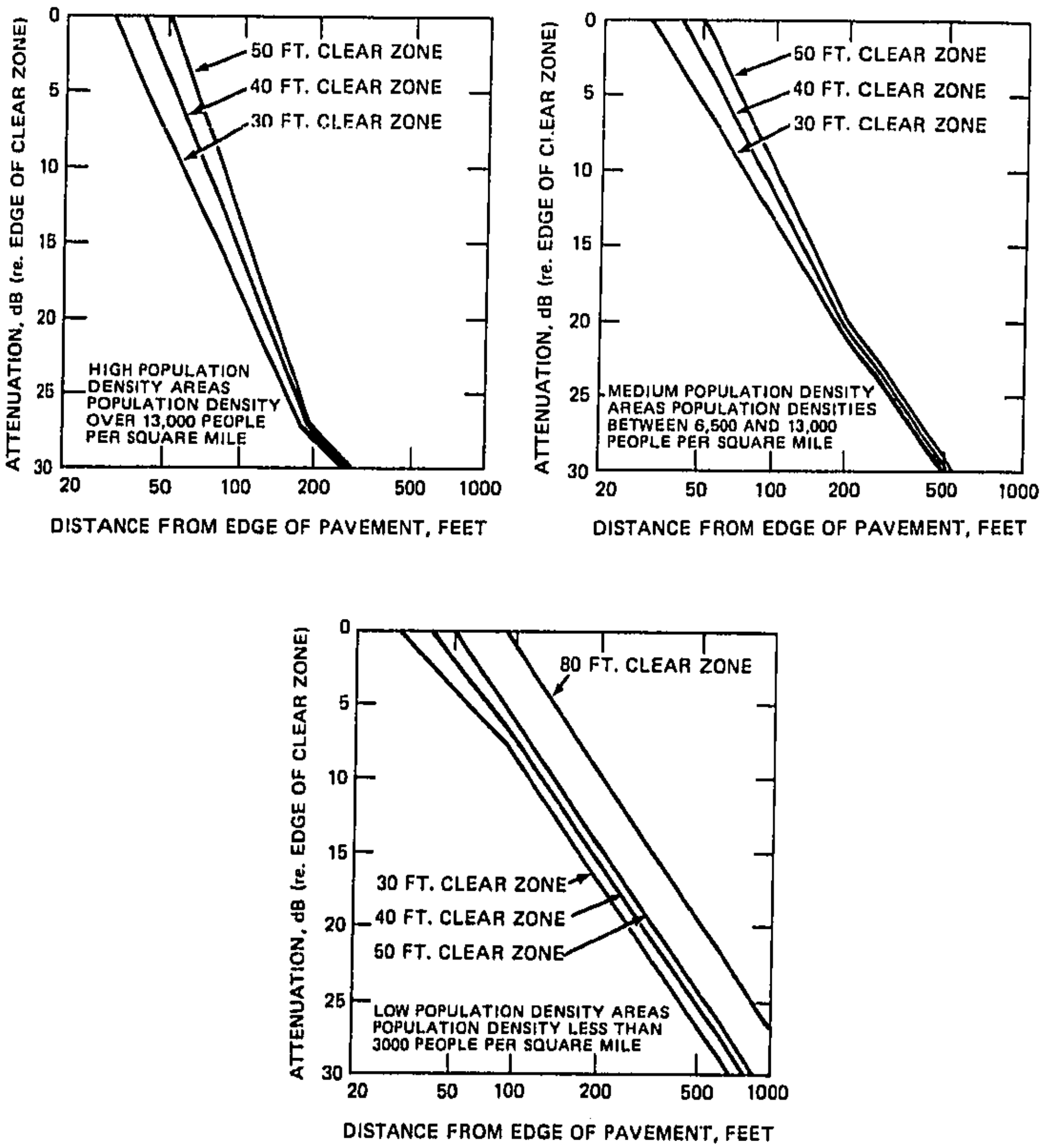


FIGURE D-3. SOUND LEVEL ATTENUATION CURVES: POINT SOURCE

TABLE D-14

Building Exterior Noise Reduction (in decibels)
by Place Size (Index J) and Population Density Area (Index ID)

Population Density Area Index, ID	Population Place Size, Index J								
	1	2	3	4	5	6	7	8	9
	Over 2M	1M 2M	500K 1M	200K 500K	100K 200K	50K 100K	25K 50K	5K 25K	Rural Areas
1 High Density	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 Medium to High Density	20.0	20.0	20.0	15.0	15.0	15.0	20.0	20.0	15.0
3 Medium to Low Density	20.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
4 Low Density	20.0	15.0	15.0	15.0	15.0	11.0	15.0	15.0	15.0

TABLE D-15

DISTRIBUTION OF POPULATION AND LAND AREA BY PLACE SIZE (INDEX J) AND POPULATION DENSITY CATEGORY (INDEX ID)

Population Density Area Index ID	Parameter	1 >2M	2 1M -2M	3 500K -1M	4 200K -500K	5 100K -200K	6 50K -100K	7 25K -50K	8 5K -25K	Urban Total	9 Rural
1	Population	5.61	2.10	0.36	1.61	1.16	1.07	0.47	1.85	14.23	64.18*
	Area	134.2	272	63	215	279	329	58	220	1570.2	3,476,938
	p*	64,711	13,451	9,368	9,368	5,831	13,091	13,091	16,988	-	18.0
2	Population	22.28	4.08	2.04	10.43	2.93	2.12	2.98	4.97	51.83	0.0
	Area	3576	775	488	4558	1305	1115	8.96	1261	13970.0	0.0
	p*	12,638	9,092	6,967	3697.0	3,384	2,863	8,506	10,681	-	
3	Population	21.59	11.13	8.40	6.75	6.84	4.53	3.51	8.46	71.20	0.0
	Area	8358	5080	4426	5790	5266	4195	2230	4527	39872.0	0.0
	p*	6,107	5,014	3,842	2,264	2,011	1,612.0	4,698	6,271	-	
4	Population	0.0	5.35	5.30	0.0	0.0	0.0	1.92	2.70	15.27	0.0
	Area	0.0	4039	4584	0.0	0.0	0.0	2769	5820	17262.0	0.0
	p*	-	2,505	2,336	-	-	-	2,147	1,673	-	
Total Population		49.48	22.66	16.09	18.78	10.93	7.71	8.88	17.98	152.52	64.18
Total Area		12064.2	10216.0	9561.0	10563.0	6850.0	5639.0	5953.0	11828.0	72674.2	3476938

Total population = 216.70 million
Total land area - 3,549,612.2 square miles
p* = Population/(Area) (Area Factor), Adjusted Population Density in People per Square Mile

the table. The model distributes the 1974 U.S. population of 216.7 million people over 3.549 million square miles.

In Table D-15, population densities have been computed by dividing the population by <u>occupied</u> land area. This occupied land area excludes bodies of water, airports, roadways themselves (including their clear-zones), parking areas, and open spaces. The conversion from total area to occupied area is termed the "area factor" within the model. It is the fraction of total land area that is occupied. By this distribution, the average population density is 2,099 people per square mile for urban environments and 18 people per square mile for rural environments (see Figure A.2.2 of Reference 42).

The data in Table D-15 are based upon 1974 populations. For future years the population densities are assumed to increase as population grows.

$$\text{Population growth factors} = f(\overset{\rightarrow 9}{\text{population}}, \overset{\rightarrow 9}{\text{year}}) \qquad \text{(D-16)}$$

The functional relationship of equation D-16 yields the 81 growth factors, presented in Table D-16. Growth factors were derived from the Bureau of Census' (Series I) assumption of an immigration and fertility rate based upon historical trends.

As discussed above, each person is assigned to one of 33 population/density cells. Each cell also contains a definite mileage value for each of the six roadway types (see Tables D-6 and D-7). The total mileage within each cell is used to compute the noise level to which persons in that cell are exposed.

To compute this noise level, the distance between people and roadways must be estimated. This estimation is done statistically, since the precise distance distributions are not known.

TABLE D-16

Population Growth Factors by Place Size

		AREA TYPE, J									
		1	2	3	4	5	6	7	8	9	ALL J
PLACE SIZE, THOUSANDS		OVER 2000	1000-2000	500-1000	200-500	100-200	50-100	25-50	5-25	RURAL	
YEAR	VARIABLE	POP(YEAR)/POP(BASELINE)									
1974		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
1980		1.08	1.07	1.07	1.02	1.02	1.02	1.02	1.02	1.12	
1985		1.15	1.14	1.14	1.04	1.04	1.04	1.04	1.04	1.22	
1990		1.22	1.22	1.22	1.05	1.05	1.05	1.05	1.05	1.31	
1995		1.29	1.29	1.29	1.07	1.07	1.07	1.07	1.07	1.39	
2000		1.36	1.36	1.36	1.08	1.08	1.09	1.09	1.09	1.48	
2005		1.43	1.44	1.44	1.10	1.10	1.10	1.10	1.10	1.57	
2010		1.50	1.51	1.51	1.12	1.12	1.12	1.12	1.12	1.65	
2013		1.55	1.56	1.56	1.13	1.13	1.13	1.13	1.13	1.70	

First the cell's occupied land area is divided by the roadway mileage within that cell to determine the area allotted to each roadway mile. This area is then split in half and placed on each side of a one mile length of roadway, beyond the clear-zone. The far edge of this portion of land area is shown as the cutoff distance in Figure D-1.

All persons within the cell are then randomly assigned a particular roadway mile. They are then distributed uniformly on both sides of that one mile of roadway, between the edge of the clear-zone and the cutoff distance. This assignment determines each person's "primary" roadway -- in essence, the roadway closest to that person's place of residence.

Statistically, this random distribution of all persons, over a well-defined area, determines each person's distance to his primary roadway.

Each person is also affected by noise from other roadways within his cell. These are called "secondary" roadways. To compute secondary-roadway noise exposure the distance between the receiver and these roadways is also determined statistically.

The assumption is made that each secondary-roadway distance is greater than the cutoff distance computed for the "primary" roadway. In other words, it is assumed that each person is within the cutoff distance for one and only one roadway, his "primary" roadway. All others are further away. This cutoff distance then provides a minimum distance for the random distribution of person/secondary-roadway combinations.

The maximum distance between persons and roadways obviously depends upon the shape of the land area that comprises that person's cell. If the cell is near-circular in shape, then the maximum distances are not extreme. On the other hand, if the shape is very long and narrow, then the maximum distances could be huge. Thus the approximate shape is assumed to be rectangular, and is bisected by the secondary roadway of interest. The length of the rectangular area is equal to the total length of the secondary roadway in that cell. The rectangle's width is the cell's area divided by the rectangle's length, so that the total cell's area is included in the rectangle.

With this cell shape, then, all persons are distributed randomly within the rectangle, outside the cutoff distance. Statistically, this random distribution of all persons, over a well-defined area, determines each person's distance to each secondary roadway and considers the total mileage for each roadway type within the cell.

The rectangle mathematics are then repeated for all other secondary roadway types, until distances to all of them are determined in this random manner.

Out of this statistical process comes a full list of each person's distances to all roadways in his cell. His distance to his closest roadway is less than the cutoff distance, while his distances to all other roadways is larger than this cutoff distance.

Consequently, what is computed is the joint probability distribution of the set of all distances between each receiver and all roadways within his pop/density cell. For computational efficiency, the computer determines the noise level distribution instead of the distance distribution. And it determines this in 3-decibel increments, rather than in infinitesimal increments.

For the General Adverse Response part of the model, the average outdoor day-night noise level, L_{dn}, is the measure of noise exposure. This is calculated for each person at his place of residence. On the other hand, for the Single Event Response part of the model, several different noise level values are calculated, as presented in Figure 6-11. These measures are:

Single-event equivalent noise level, $L_{eq(T)}$:

- o Indoors, day and night
- o Outdoors, day

Sound exposure level, L_S:

- o Indoors, day and night

The single-event equivalent noise level, $L_{eq(T)}$, is used to measure speech communication interference. The sound exposure level, L_S, is used to measure sleep interference. To relate these noise levels to potential impact for a typical 24 hour day a person's activities over that 24 hours must also be allocated between indoors and outdoors, and separately for day and night as illustrated in equation D-17.

$$\text{Fraction of activity times} = f(\overset{\rightarrow 3}{\text{location}},\ \overset{\rightarrow 2}{\text{time of day}},\ \overset{\rightarrow 6}{\text{activity}}) \qquad \text{(D-17)}$$

This activity allocation is addressed at Key 3 in Figure 6-11 and it is detailed in Table D-17. Persons are located away from home, or at home outdoors, or at home indoors. Then separately by day and night, each person spends his time at the activities shown to the right of the Table.

Separately, then, by these activity groups, the average person's time has been fractioned as in Figure D-4. (See Appendix B of Reference 42 for a more detailed discussion.) These activity fractions are a composite of separate fractions for distinct groups of persons within the U.S.: (1) employed men, (2) employed women, (3) housepersons, and (4) other persons (persons younger than 17, persons older than 65 and not employed, persons in institutions, and unemployed persons).

As Figure D-4 indicates, even during the daytime a small portion of the population is sleeping. This potential daytime sleep interference is accounted for in the impact estimates.

TABLE D-17

ACTIVITY GROUPS FOR THE SINGLE EVENT RESPONSE

PERSON's LOCATION	TIME OF DAY	ACTIVITY GROUP
Away from home	Day and Night	Working
		Travelling
At home, outdoors	Day	Walking
		Outside-home leisure activities
At home, indoors	Day	Sleeping
		Other indoor activities such as TV viewing, enjoying other media, other leisure or semi-leisure activities, home and family type activities, and eating
	Night	Sleeping
		Other indoor activities such as TV viewing, enjoying other media, other leisure or semi-leisure activites, home-and-family-type activities, and eating

NOTE: Day is the period between 7 am and 10 pm.
Night is the remainder of the 24-hours, 10 pm to 7 am .

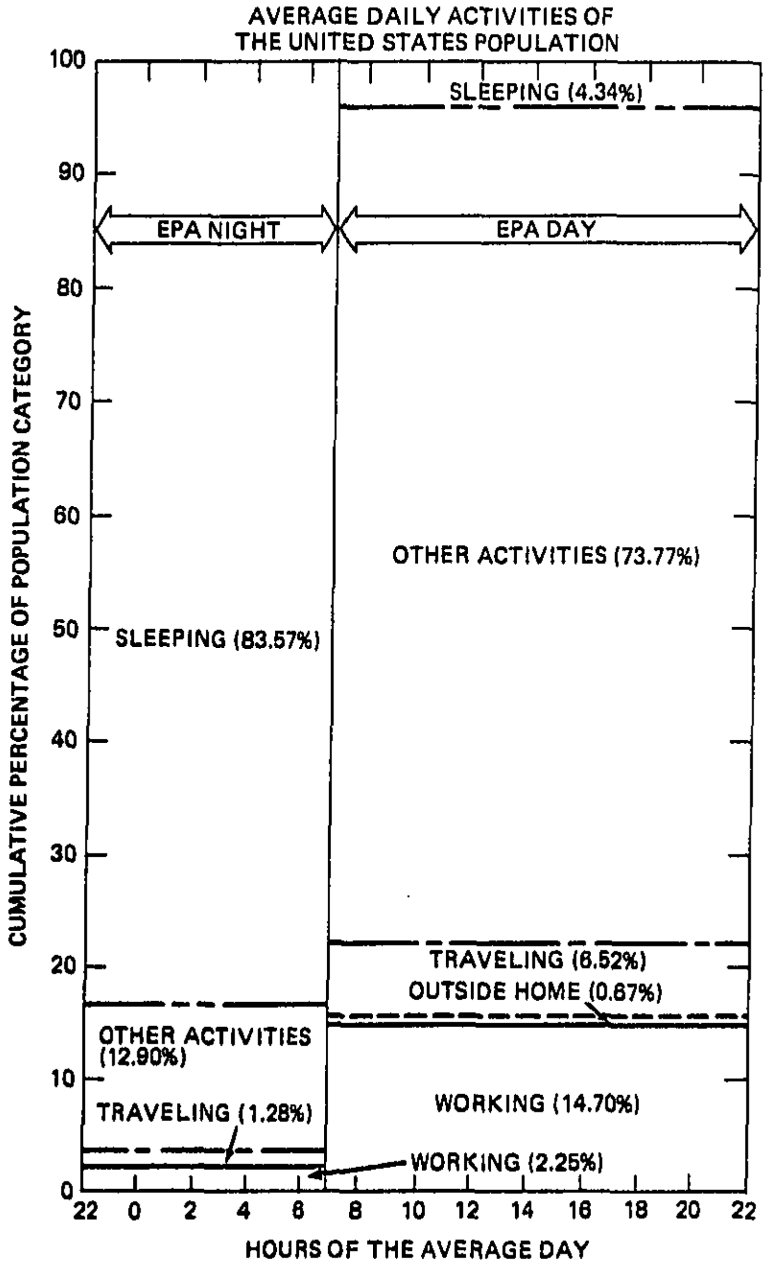


FIGURE D-4. AVERAGE ACTIVITY PATTERN FOR THE U.S. POPULATION

Some Equations of Importance

The discussion above focused upon the data that are used in the noise exposure calculations. Presented here are some equations (simplifications of those that appear in Reference 42) of importance in this noise prediction with some further assumptions concerning their use within the model.

The General Adverse Response part of the model yields the day-night noise level, L_{dn}, at each person's home:

Total $$10^{Ldn/10} = \sum_{\text{all roads } r} \left[10^{Ldn/10}\right]_r \qquad \text{(D-18)}$$

Each road $$10^{Ldn/10} = \sum_{\text{all lanes } \ell} \left[10^{Ldn/10}\right]_\ell 10^{-A/10}$$

Each lane (at clear-zone edge) $$10^{Ldn/10} = \left(\frac{15}{24}\right) \sum_{\text{daytime hours } d} \left[10^{Leq/10}\right]_d + \left(\frac{90}{24}\right) \sum_{\text{night hours } n} \left[10^{Leq/10}\right]_n$$

Each day or night hour $$10^{Leq/10} = \left(\frac{1.49}{Dc}\right)\left(\frac{Dp}{Dc}\right)^{\gamma} \sum_{\substack{\text{280 vehicle combinations}\\ t,\ m,\ s}}^{n} \left[\left(\frac{N}{S}\right)10^{Lo/10}\right]_{tms}$$

where L_{dn} = day-night noise level, in decibels

L_{eq} = hourly equivalent noise level, in decibels

A = building attenuation + distance attenuation, from edge of clear zone to receiver, in decibels - line source

D_p = distance from travel-lane centerline to edge of pavement, ft

D_c = distance from travel-lane centerline to edge of clear zone, ft

t = index over 14 vehicle types

m = index over 4 operational modes

s = index over 5 vehicle speed ranges

(for 14x4x5=280 vehicle combinations)

N = number of vehicles per hour for each combination

S = speed for each combination, miles per hour

L_o = energy-average emission level (at 50 ft) for each combination, in decibels

γ = ground attenuation constant for clear zone
= 0 for hard ground
= 0.5 for absorptive ground

The Single Event Response part of the model yields two measures of the noise at each person's home. The first of these is the sound exposure level, L_s:

<u>Single-event</u>

$$10^{L_s/10} = \left[\frac{4260}{D_c}\right]\left[\frac{D_p}{D_c}\right]^{\gamma}\left[\frac{1}{S}\right] 10^{L_o/10} 10^{-A/10} \qquad \text{(D-19)}$$

where L_s = sound exposure level, in decibels

A = same as for D-18 (also <u>line</u> source)

D_p = same as for D-18

D_c = same as for D-18

S = speed for this vehicle, miles per hour

= same as for D-18

The second measure of single-event noise is the single-event equivalent sound level $L_{eq(T)}$:

<u>Single-event</u>

$$10^{L_{eq}(T)/10} = \left[\frac{S}{4.1\ D}\right] 10^{L_s/10} \qquad \text{(D-20)}$$

where $L_{eq(T)}$ = single-event equivalent sound level over duration T, in decibels

T = duration of event, between 10 dB-down points

D = total distance from travel line to receiver, ft

S = speed for a vehicle, miles per hour

L_S = sound exposure level, in decibels

The input data to these equations are detailed in the sections above. In addition, the following assumptions are inherent in the structure of these equations themselves:

- o Each person sees each roadway as indefinitely long and straight.
- o The distance between vehicles is the same for acceleration, deceleration and cruise operational modes.
- o A single average speed for each roadway segment is sufficient to predict that roadway's noise levels.
- o 87 percent of the total traffic passes during the daytime (7 am through 10 pm), and the remaining 13 percent passes during night -- for the General Adverse Response only.
- o Traffic is distributed equally among all traffic lanes.
- o Roadway median widths are minimal, compared to the total width of the roadway.
- o The single-event noise is computed within the 10 dB down points, during the passby of each vehicle.
- o Single events are counted in the analysis only if the maximum noise level during the vehicle's passby exceeds the background noise. To avoid underestimating intrusion, this background noise is assumed to be very low: 55 dB (A-weighted) outdoors and 45 dB (A-weighted) indoors. Essentially, these background levels are very long range goals in urban areas, and are far below the levels that now exist. However, they do reflect the desires of states and municipalities for a quieter environment, and they assume that ambient levels will, in

the future, be lowered by coordinated federal, state and local efforts. To a first approximation, this background noise is that due to noise sources other than transportation sources -- for example, building ventilation noise, both indoors and outdoors.

Details of Noise-level Sorting (Figures 6-12 and 6-13, Key (4))

As a result of the noise level predictions, all persons in the United States are paired with their respective noise levels. These person/noise pairs are then sorted by noise level. The sorting is done concurrently with the prediction procedure.

Details of Conversion from Noise Level to Impact (Figures 6-12 and 6-13, Key (5))

Exposure to a particular noise level does not necessarily mean that person is fully impacted by that noise (although may be partially impacted). Therefore, the number of persons exposed at each noise level is multiplied by certain "impact fractions" or weightings. These fractions are close to zero for low noise levels, and then increase with noise level, until they reach unity.

For particular effects of noise on people, the weightings differ. The fractions result from a large number of attitudinal surveys and laboratory studies of the effects of noise on people.

For the General Adverse Response portion of the model, the fractional weighting is derived from equation 7, which is an approximation to a quadratic equation that is the best fit to a large number of attitudinal survey results. The weighting values along with noise level and population information are used in equation 8 by the model to compute Level Weighted Population within each noise level band.

For the Single Event Response portion of the model, the most current estimates of weighting values are presented in equations 11 and 12 (for sleep interference) and Figures 6-5 and 6-6 (for speech interference). These weightings are also used in equation 8 along with noise level and population information.

For speech interference, the noise descriptor is the single-event equivalent sound level, $L_{eq(T)}$. For sleep interference, it is the sound exposure level, L_S.

Details of Total Nationwide Impact (Figures 6-12 and 6-13, Key ⑥)

After impact is estimated for each noise level separately, then the total nationwide impact is added over all noise levels. This process is overviewed in Figures 6-12 and 6-13, and is detailed here.

The General Adverse Response depends upon a full year's worth of noise at the person's home. It is assessed from the prediction of yearly-average L_{dn} at the residences of all persons in the U.S.

The Single Event Response depends upon an average day's worth of noise, and the number of intrusive single events that potentially occur during the day or night. It also depends upon the activities of people during the day and night, indoors and outdoors. (See Table D-17).

The estimations within the model do not account for persons when they are away from their homes (first group in Table D-17). Omitted are 20.53 percent of the population during the daytime (7 am through 10 pm) while these people are traveling or working away from home. Similarly omitted are 3.06 percent of the population during the nighttime (See Appendix B of Reference 42).

As shown in Table D-18 the model estimates speech interference while the average person is outdoors, or is indoors but not sleeping. It estimates the two types of sleep interference while the average person is indoors sleeping.

One activity group in Table D-17 is unique -- the group for people outdoors walking. For these "pedestrians," speech interference is not evaluated at their residences, but rather is evaluated at the edge of the clear-zone for each pedestrian's primary roadway. In essence, this represents speech interference while that person is walking along streets in his neighborhood. Speech interference is also estimated outdoors during a person's outside leisure activities around his home.

TABLE D-18

LOCATIONS OF ACTIVITIES

Sleep Interference	
Disruption	People Indoors at home day/night
Awakening	People Indoors at home day/night
Speech Interference	
Indoors	People indoors at home not sleeping
Outdoors	People outdoors at home
Pedestrians	Walking outdoors at the edge of a clear zone

APPENDIX E

DATA ON INTERIOR NOISE LEVELS

TABLE E-1

Interior Bus A-Weighted Noise Levels Near the Driver by Bus Type and Operational Mode

Not-to-Exceed Level of 86 dB

Bus Type	Interior Noise Levels Near Driver: Acceleration	Decel. and 30 mph	Cruise 55 mph	Idle	Energy Average Level: Street *	Highway *	Street & Highway**
Transit	79	74	78	60	74.4	77.8	75.2
School (Gas)	80	75	79	61	72.9	78.8	74.5
School (Diesel)	80	68	72	58	70.5	72.9	71.0
Inter-City	74	72	74	60	71.8	73.8	73.7

* Based on percentage of time spent in each operational mode (Table 6-5).
** Based on percentage of time spent in each roadway type (Table 6-6).

TABLE E-2

Interior Bus A-Weighted Noise Levels Near the Rear Seat by Bus Type and Operational Mode

Not-to-Exceed Level 86 dB

Bus Type	Interior Noise Levels Near Rear Seat: Acceleration	Decel. and Cruise: 30 mph	Decel. and Cruise: 55 mph	Idle	Energy Average Level: Street *	Energy Average Level: Highway *	Energy Average Level: Street & Highway**
Transit	80	79	80	65	77.6	79.8	78.0
School (Gas)	80	79	80	73	76.5	79.8	77.2
School (Diesel)	80	68	69	58	70.5	70.9	70.6
Inter-City	79	73	75	68	74.1	75.2	75.1

* Based on percentage of time spent in each operational mode (Table 6-5).
** Based on percentage of time spent in each roadway type (Table 6-6).

TABLE E-3

Interior Bus A-Weighted Noise Levels Near the Driver by Bus Type and Operational Mode

Not-to-Exceed Level of 83 dB

	Interior Noise Levels Near Driver				Energy Average Level		
		Decel. and Cruise					
Bus Type	Acceleration	30 mph	55 mph	Idle	Street *	Highway *	Street & Highway**
Transit	77	72	76	58	72.4	75.8	73.2
School (Gas)	77	72	76	58	70.0	75.8	71.5
School (Diesel)	77	65	69	55	67.5	69.9	68.0
Inter-City	74	72	74	60	71.8	73.8	73.7

* Based on percentage of time spent in each operational mode (Table 6-5).
** Based on percentage of time spent in each roadway type (Table 6-6).

TABLE E-4

Interior Bus A-Weighted Noise Levels Near the Rear Seat by Bus Type and Operational Mode

. Not-to-Exceed Level 83 dB

	Interior Noise Levels Near Rear Seat				Energy Average Level		
		Decel. and Cruise			Street	Highway	Street &
Bus Type	Acceleration	30 mph	55 mph	Idle	*	*	Highway**
Transit	77	76	77	62	74.6	76.8	75.0
School (Gas)	77	76	77	70	73.5	76.8	74.2
School (Diesel)	77	65	66	55	67.5	67.9	67.6
Inter-City	77	71	73	66	72.1	73.2	73.1

* Based on percentage of time spent in each operational mode (Table 6-5).
** Based on percentage of time spent in each roadway type (Table 6-6).

TABLE E-5

Interior Bus A-Weighted Noise Levels Near the Driver by Bus Type and Operational Mode

Not-to-Exceed Level 80 dB

	Interior Noise Levels Near Driver				Energy Average Level		
		Decel. and Cruise					
Bus Type	Acceleration	30 mph	55 mph	Idle	Street *	Highway *	Street & Highway**
Transit	74	69	73	55	69.4	72.8	70.2
School (Gas)	74	69	73	55	66.9	72.8	68.5
School (Diesel)	74	62	66	52	64.5	66.9	65.0
Inter-City	74	72	74	60	71.8	73.8	73.7

* Based on percentage of time spent in each operational mode (Table 6-5).
** Based on percentage of time spent in each roadway type (Table 6-6).

TABLE E-6

Interior Bus A-Weighted Noise Levels Near the Rear Seat by Bus Type and Operational Mode

Not-to-Exceed Level 80 dB

	Interior Noise Levels Near Rear Seat				Energy Average Level		
		Decel. and Cruise					
Bus Type	Acceleration	30 mph	55 mph	Idle	Street *	Highway *	Street & Highway**
Transit	74	73	74	59	71.6	73.8	72.0
School (Gas)	74	73	74	67	70.5	73.8	71.2
School (Diesel)	74	62	63	52	64.5	64.9	64.6
Inter-City	74	68	70	63	69.1	70.2	70.1

* Based on percentage of time spent in each operational mode (Table 6-5).
** Based on percentage of time spent in each roadway type (Table 6-6).

TABLE E-7

Interior Bus A-Weighted Noise Levels Near the Driver by Bus Type and Operational Mode

Not-to-Exceed Level 78 dB

	Interior Noise Levels Near Driver				Energy Average Level		
		Decel. and Cruise					
Bus Type	Acceleration	30 mph	55 mph	Idle	Street *	Highway *	Street & Highway**
Transit	72	67	71	53	67.4	70.8	68.2
School (Gas)	72	67	71	53	64.9	70.8	66.5
School (Diesel)	72	60	64	50	62.5	64.9	63.0
Inter-City	72	70	72	58	69.8	71.8	71.7

* Based on percentage of time spent in each operational mode (Table 6-5).
** Based on percentage of time spent in each roadway type (Table 6-6).

TABLE E-8

Interior Bus A-Weighted Noise Levels Near the Rear Seat by Bus Type and Operational Mode

. Not-to-Exceed Level 78 dB

	Interior Noise Levels Near Rear Seat				Energy Average Level		
		Decel. and Cruise					
Bus Type	Acceleration	30 mph	55 mph	Idle	Street *	Highway *	Street & Highway**
Transit	72	71	72	57	69.6	71.8	70.0
School (Gas)	72	71	72	65	68.5	71.8	69.2
School (Diesel)	72	60	61	50	62.5	62.9	62.6
Inter-City	72	66	68	61	67.1	68.2	68.1

* Based on percentage of time spent in each operational mode (Table 6-5).
** Based on percentage of time spent in each roadway type (Table 6-6).

TABLE E-9

Interior Bus A-Weighted Noise Levels Near the Driver by Bus Type and Operational Mode

. Not-to-Exceed Level 68 dB

	Interior Noise Levels Near Driver				Energy Average Level		
		Decel. and Cruise					
Bus Type	Acceleration	30 mph	55 mph	Idle	Street *	Highway *	Street & Highway**
Transit	59	54	58	40	54.4	57.8	55.2
School (Gas)	59	54	58	40	51.9	57.8	53.5
School (Diesel)	59	47	51	37	49.5	51.9	50.0
Inter-City	59	57	59	45	56.8	58.8	58.7

* Based on percentage of time spent in each operational mode (Table 6-5).
** Based on percentage of time spent in each roadway type (Table 6-6).

TABLE E-10

Interior Bus A-Weighted Noise Levels Near the Rear Seat by Bus Type and Operational Mode

. Not-to-Exceed Level 65 dB

	Interior Noise Levels Near Rear Seat					Energy Average Level	
		Decel. and Cruise			Street	Highway	Street &
Bus Type	Acceleration	30 mph	55 mph	Idle	*	*	Highway**
Transit	59	58	59	44	56.6	58.8	57.0
School (Gas)	59	58	59	52	55.5	58.8	56.2
School (Diesel)	59	47	48	37	49.5	49.9	49.6
Inter-City	59	53	55	48	54.1	55.2	55.1

* Based on percentage of time spent in each operational mode (Table E-5).
** Based on percentage of time spent in each roadway type (Table E-6).

TABLE F-1. POPULATION EXPOSED ABOVE L_{dn}=55 dB - BASELINE

PEXP	NOISE RANGE												
DB RANGE	91.-88.	88.-85.	85.-82.	82.-79.	79.-76.	76.-73.	73.-70.	70.-67.	67.-64.	64.-61.	61.-58.	58.-55.	TOTAL
YEAR	MILLIONS OF PEOPLE												
1980	0.0	0.00	0.00	0.19	0.57	1.52	3.39	6.48	11.06	16.02	23.13	30.73	93.12
1985	0.0	0.00	0.00	0.19	0.58	1.49	3.35	6.49	11.16	16.66	24.59	33.00	97.50
1990	0.0	0.00	0.00	0.19	0.58	1.46	3.29	6.48	11.25	17.34	26.22	35.48	102.31
1995	0.0	0.00	0.01	0.22	0.66	1.63	3.58	7.00	12.12	18.78	28.78	38.64	111.43
2000	0.0	0.00	0.03	0.29	0.78	1.93	4.11	7.88	13.48	20.74	31.96	42.09	123.29
2010	0.0	0.00	0.08	0.43	1.09	2.63	5.38	9.89	16.37	25.00	38.63	48.60	148.11

TABLE F-2. POPULATION EXPOSED ABOVE L_{dn}=55 dB - Option 1

PEXP	NOISE RANGE												
DB RANGE	91.-88.	88.-85.	85.-82.	82.-79.	79.-76.	76.-73.	73.-70.	70.-67.	67.-64.	64.-61.	61.-58.	58.-55.	TOTAL
YEAR	MILLIONS OF PEOPLE												
1980	0.0	0.00	0.00	0.19	0.57	1.52	3.39	6.48	11.06	16.02	23.13	30.74	93.12
1985	0.0	0.00	0.00	0.19	0.57	1.49	3.35	6.49	11.16	16.65	24.59	33.00	97.50
1990	0.0	0.00	0.00	0.19	0.58	1.46	3.29	6.48	11.25	17.34	26.22	35.47	102.29
1995	0.0	0.00	0.01	0.22	0.66	1.63	3.58	7.00	12.12	18.77	28.78	38.63	111.91
2000	0.0	0.00	0.03	0.29	0.78	1.93	4.11	7.88	13.48	20.74	31.96	42.08	123.26
2010	0.0	0.00	0.08	0.43	1.08	2.63	5.38	9.89	16.37	25.00	38.62	48.59	148.09

TABLE F-3. POPULATION EXPOSED ABOVE L_{dn}=55 dB - Option 2

PEXP	NOISE RANGE												
DB RANGE	91.-88.	88.-85.	85.-82.	82.-79.	79.-76.	76.-73.	73.-70.	70.-67.	67.-64.	64.-61.	61.-58.	58.-55.	TOTAL
YEAR	MILLIONS OF PEOPLE												
1980	0.0	0.00	0.00	0.19	0.57	1.52	3.39	6.48	11.06	16.01	23.13	30.74	93.12
1985	0.0	0.00	0.00	0.19	0.57	1.49	3.35	6.49	11.15	16.64	24.56	32.97	97.41
1990	0.0	0.00	0.00	0.19	0.58	1.46	3.28	6.45	11.20	17.24	26.04	35.29	101.74
1995	0.0	0.00	0.01	0.22	0.66	1.62	3.57	6.95	12.02	18.59	28.47	38.34	110.44
2000	0.0	0.00	0.03	0.28	0.78	1.92	4.08	7.81	13.36	20.51	31.57	41.79	122.14
2010	0.0	0.00	0.08	0.43	1.08	2.63	5.34	9.80	16.24	24.70	38.22	48.33	146.85

TABLE F-4. POPULATION EXPOSED ABOVE L_{dn}=55 dB - Option 2A

PEXP	NOISE RANGE											
DB RANGE	91.-88.	88.-85.	85.-82.	82.-79.	79.-76.	76.-73.	73.-70.	70.-67.	67.-64.	64.-61.	61.-58.	58.-55.	TOTAL
YEAR	MILLIONS OF PEOPLE												
1980	0.0	0.00	0.00	0.19	0.57	1.52	3.39	6.48	11.06	16.02	23.13	30.74	93.12
1985	0.0	0.00	0.00	0.19	0.57	1.49	3.35	6.49	11.15	16.64	24.56	32.97	97.42
1990	0.0	0.00	0.00	0.19	0.58	1.46	3.28	6.45	11.20	17.24	26.04	35.29	101.74
1995	0.0	0.00	0.01	0.22	0.66	1.62	3.57	6.95	12.02	18.59	28.47	38.34	110.44
2000	0.0	0.00	0.03	0.28	0.78	1.92	4.08	7.81	13.36	20.51	31.57	41.79	122.14
2010	0.0	0.00	0.08	0.43	1.08	2.63	5.34	9.80	16.24	24.70	38.22	48.33	146.85

TABLE F-5. POPULATION EXPOSED ABOVE L_{dn}=55 dB - Option 3

PEXP	NOISE RANGE												
DB RANGE	91.-88.	88.-85.	85.-82.	82.-79.	79.-76.	76.-73.	73.-70.	70.-67.	67.-64.	64.-61.	61.-58.	58.-55.	TOTAL
YEAR	MILLIONS OF PEOPLE												
1980	0.0	0.00	0.00	0.19	0.57	1.52	3.39	6.48	11.06	16.02	23.13	30.74	93.12
1985	0.0	0.00	0.00	0.19	0.57	1.49	3.35	6.49	11.15	16.64	24.56	32.97	97.41
1990	0.0	0.00	0.00	0.19	0.58	1.46	3.28	6.44	11.17	17.21	25.97	35.22	101.53
1995	0.0	0.00	0.01	0.22	0.65	1.62	3.56	6.92	11.97	18.51	28.32	38.19	109.98
2000	0.0	0.00	0.03	0.28	0.78	1.92	4.07	7.77	13.30	20.39	31.37	41.63	121.54
2010	0.0	0.00	0.08	0.43	1.08	2.62	5.32	9.75	16.17	24.54	38.00	48.18	146.18

TABLE F-6. POPULATION EXPOSED ABOVE L_{dn}=55 dB - Option 3A

PEXP	NOISE RANGE												
DB RANGE	91.- 88.	88.- 85.	85.- 82.	82.- 79.	79.- 76.	76.- 73.	73.- 70.	70.- 67.	67.- 64.	64.- 61.	61.- 58.	58.- 55.	TOTAL
YEAR	MILLIONS OF PEOPLE												
1980	0.0	0.00	0.00	0.19	0.57	1.52	3.39	6.48	11.06	16.02	23.13	30.74	93.12
1985	0.0	0.00	0.00	0.19	0.57	1.49	3.35	6.49	11.15	16.64	24.56	32.97	97.42
1990	0.0	0.00	0.00	0.19	0.58	1.46	3.28	6.44	11.18	17.21	25.97	35.22	101.53
1995	0.0	0.00	0.01	0.22	0.66	1.62	3.56	6.92	11.97	18.51	28.32	38.19	109.98
2000	0.0	0.00	0.03	0.28	0.78	1.92	4.07	7.77	13.30	20.39	31.37	41.63	121.54
2010	0.0	0.00	0.08	0.43	1.08	2.62	5.32	9.75	16.17	24.54	38.00	48.18	146.18

TABLE F-7. POPULATION EXPOSED ABOVE L_{dn}=55 dB - Option 3B

PEXP	NOISE RANGE											
DB RANGE	91.-88.	88.-85.	85.-82.	82.-79.	79.-76.	76.-73.	73.-70.	70.-67.	67.-64.	64.-61.	61.-58.	58.-55.	TOTAL
YEAR	MILLIONS OF PEOPLE												
1980	0.0	0.00	0.00	0.19	0.57	1.52	3.39	6.48	11.06	16.02	23.13	30.74	93.12
1985	0.0	0.00	0.00	0.19	0.58	1.49	3.35	6.49	11.16	16.66	24.59	33.00	97.50
1990	0.0	0.00	0.00	0.19	0.58	1.46	3.28	6.45	11.19	17.24	26.03	35.28	101.71
1995	0.0	0.00	0.01	0.22	0.66	1.62	3.56	6.93	11.98	18.53	28.36	38.23	110.09
2000	0.0	0.00	0.03	0.28	0.78	1.92	4.07	7.78	13.30	20.40	31.38	41.64	121.57
2010	0.0	0.00	0.08	0.43	1.08	2.62	5.32	9.75	16.17	24.54	38.00	48.18	146.18

TABLE F-8. POPULATION EXPOSED ABOVE L_{dn}=55 dB - Option 4

PEXP	NOISE RANGE												
DB RANGE	91.-88.	88.-85.	85.-82.	82.-79.	79.-76.	76.-73.	73.-70.	70.-67.	67.-64.	64.-61.	61.-58.	58.-55.	TOTAL
YEAR	MILLIONS OF PEOPLE												
1980	0.0	0.00	0.00	0.19	0.57	1.52	3.39	6.48	11.06	16.02	23.13	30.74	93.12
1985	0.0	0.00	0.00	0.19	0.57	1.49	3.35	6.49	11.15	16.64	24.56	32.97	97.41
1990	0.0	0.00	0.00	0.19	0.58	1.46	3.28	6.44	11.17	17.20	25.95	35.20	101.47
1995	0.0	0.00	0.01	0.22	0.65	1.62	3.55	6.91	11.95	18.48	28.27	38.14	109.81
2000	0.0	0.00	0.03	0.28	0.78	1.92	4.06	7.76	13.27	20.34	31.29	41.57	121.31
2010	0.0	0.00	0.08	0.43	1.08	2.62	5.31	9.73	16.15	24.48	37.91	48.13	145.92

TABLE F-9. POPULATION EXPOSED ABOVE L_{dn}=55 dB - Option 5

PEXP	NOISE RANGE												
DB RANGE	91.-88.	88.-85.	85.-82.	82.-79.	79.-76.	76.-73.	73.-70.	70.-67.	67.-64.	64.-61.	61.-58.	58. 55.	TOTAL
YEAR	MILLIONS OF PEOPLE												
1980	0.0	0.00	0.00	0.19	0.57	1.52	3.39	6.48	11.06	16.02	23.13	30.74	93.12
1985	0.0	0.00	0.00	0.19	0.57	1.49	3.35	6.49	11.15	16.64	24.56	32.97	97.40
1990	0.0	0.00	0.00	0.19	0.58	1.46	3.28	6.44	11.18	17.21	25.97	35.23	101.54
1995	0.0	0.00	0.01	0.22	0.65	1.62	3.56	6.92	11.97	18.51	28.33	38.21	110.04
2000	0.0	0.00	0.03	0.28	0.78	1.92	4.07	7.77	13.30	20.40	31.38	41.65	121.58
2010	0.0	0.00	0.08	0.43	1.08	2.62	5.32	9.75	16.18	24.55	38.01	48.20	146.22

TABLE F-10. POPULATION EXPOSED ABOVE L_{dn}=55 dB - Option Q

PEXP	NOISE RANGE											
DB RANGE	91.-88.	88.-85.	85.-82.	82.-79.	79.-76.	76.-73.	73.-70.	70.-67.	67.-64.	64.-61.	61.-58.	58.-55.	TOTAL
YEAR	MILLIONS OF PEOPLE												
1980	0.0	0.00	0.00	0.19	0.57	1.52	3.39	6.48	11.06	16.02	23.13	30.74	93.12
1985	0.0	0.00	0.00	0.19	0.57	1.49	3.33	6.44	11.07	16.51	24.28	32.67	96.54
1990	0.0	0.00	0.00	0.19	0.58	1.45	3.26	6.38	11.07	17.02	25.61	34.84	100.40
1995	0.0	0.00	0.01	0.22	0.65	1.62	3.54	6.86	11.87	18.32	28.00	37.87	108.96
2000	0.0	0.00	0.03	0.28	0.77	1.92	4.05	7.72	13.21	20.22	31.08	41.39	120.67
2010	0.0	0.00	0.08	0.43	1.08	2.62	5.29	9.69	16.08	24.33	37.70	47.99	145.29

TABLE F-11

SLEEP DISRUPTION IMPACT - TRANSIT BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	39.25	39.25	39.25	39.25	39.25	39.25	39.25	39.25	39.25	39.25
1985	56.72	56.54	54.53	54.65	54.53	54.70	56.72	54.53	54.53	27.47
1990	68.37	68.15	55.83	55.61	49.52	49.67	53.64	46.91	49.52	10.50
1995	77.81	77.69	56.08	55.61	41.95	42.02	44.60	34.93	41.95	1.23
2000	87.00	87.00	59.87	59.06	40.30	40.30	40.98	29.89	40.30	0.03
2010	107.0	107.0	73.37	72.36	48.71	48.71	48.71	35.16	48.71	0.02

TABLE F-12

SLEEP DISRUPTION IMPACT - INTERCITY BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48
1985	11.48	9.14	8.91	10.76	8.91	10.76	11.48	8.91	8.91	5.53
1990	13.92	9.26	7.83	9.33	7.30	8.78	10.21	7.14	7.29	2.04
1995	16.29	10.03	7.48	8.12	6.24	6.87	7.79	5.85	6.24	0.23
2000	18.78	11.47	8.21	8.25	6.45	6.50	6.73	5.86	6.45	0.01
2010	24.33	14.88	10.63	10.63	8.30	8.30	8.30	7.51	8.30	0.01

TABLE F-13

SLEEP DISRUPTION IMPACT - SCHOOL BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
1985	1.18	1.18	1.14	1.13	1.14	1.14	1.18	1.14	1.14	0.61
1990	1.31	1.31	1.03	1.01	0.89	0.89	0.98	0.84	1.02	0.22
1995	1.39	1.39	0.92	0.90	0.62	0.62	0.68	0.50	0.92	0.02
2000	1.48	1.48	0.91	0.89	0.52	0.52	0.51	0.35	0.91	<0.01
2010	1.66	1.66	1.02	1.00	0.57	0.57	0.57	0.37	1.02	<0.01

TABLE F-14
SLEEP DISRUPTION IMPACT - TRANSIT BUSES

OPTION	1985 LWP (Millions)	1985 RCI	1985 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	56.72	-44.51	0.00	68.37	-74.19	0.00	107.00	-172.61	0.00
1	56.54	-44.05	0.32	68.15	-73.63	0.32	107.00	-172.61	0.00
2	54.53	-38.93	3.86	55.83	-42.24	18.34	73.37	-86.93	31.43
2A	54.65	-39.24	3.65	55.61	-41.68	18.66	72.36	-84.36	32.37
3	54.53	-38.93	3.86	49.52	-26.17	27.57	48.71	-24.10	54.48
3A	54.70	-39.36	3.56	49.67	-26.55	27.35	48.71	-24.10	54.48
3B	56.72	-44.51	0.00	53.64	-36.66	21.54	48.71	-24.10	54.48
4	54.53	-38.93	3.86	46.91	-19.52	31.39	35.16	10.42	67.14
5	54.53	-38.93	3.86	49.52	-26.17	27.57	48.71	-24.10	54.48
Q	27.47	30.01	51.36	10.50	73.24	84.64	0.02	-99.94	99.98

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact relative in the year-of-interest (with regulation) relative to the same year, without regulation.

TABLE F-15
SLEEP DISRUPTION IMPACT - INTERCITY BUSES

OPTION	1985 LWP (Millions)	1985 RCI	1985 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	11.48	-35.36	0.00	13.92	-64.13	0.00	24.33	-186.88	0.00
1	9.14	-7.76	20.39	9.27	-9.24	33.44	14.88	-75.45	38.84
2	8.91	-5.03	22.40	7.83	7.63	43.72	10.63	-25.34	56.31
2A	10.76	-26.87	6.27	9.33	-10.01	32.96	10.63	2.16	65.89
3	8.91	-5.03	22.40	7.29	14.09	447.65	8.30	2.16	65.89
3A	10.76	-26.87	6.27	8.78	-3.57	36.90	8.30	2.16	65.89
3B	11.48	-35.36	0.00	10.21	-20.39	26.65	8.30	2.16	65.89
4	8.91	-5.03	22.40	7.14	15.76	48.68	7.51	11.50	69.15
5	8.91	-5.58	22.40	7.29	14.08	47.65	8.30	2.16	65.89
Q	5.53	34.78	51.82	2.04	75.95	85.34	0.006	99.93	99.98

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

TABLE F-16
SLEEP DISRUPTION IMPACT - SCHOOL BUSES

OPTION	1985 LWP (Millions)	1985 RCI	1985 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	1.18	-30.71	0.00	1.31	-44.40	0.00	1.66	-83.82	0.00
1	1.18	-30.71	0.00	1.31	-44.40	0.00	1.66	-83.82	0.00
2	1.14	-25.52	3.97	1.03	-13.38	21.48	1.02	-13.05	38.50
2A	1.14	-25.63	3.89	1.01	-12.06	22.40	1.00	-10.25	40.02
3	1.14	-25.52	3.97	0.89	1.85	32.03	0.57	37.61	66.06
3A	1.14	-25.63	3.89	0.89	1.79	31.99	0.57	37.61	66.06
3B	1.18	-30.71	0.00	0.98	-8.09	25.15	0.57	37.61	66.06
4	1.14	-25.52	3.97	0.84	6.86	35.50	0.37	59.56	78.00
5	1.14	-25.52	3.97	1.03	-13.38	21.48	1.02	-13.05	38.50
Q	0.61	32.65	48.47	0.22	75.71	83.18	.000004	99.99	99.99

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

TABLE F-17

SLEEP AWAKENING IMPACTS - TRANSIT BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	20.75	20.75	20.75	20.75	20.75	20.75	20.75	20.75	20.75	20.75
1985	30.07	30.01	28.93	28.96	28.93	28.99	30.07	28.93	28.93	14.52
1990	36.29	36.24	29.44	29.30	26.04	26.09	28.24	24.66	26.04	5.55
1995	41.31	41.28	29.37	29.07	21.73	21.76	23.16	18.01	21.73	0.65
2000	46.15	46.15	31.24	30.82	20.65	20.66	21.02	15.16	20.65	0.01
2010	56.63	56.63	38.27	37.75	24.91	24.91	24.91	17.81	24.91	0.01

TABLE F-18

SLEEP AWAKENING IMPACTS - SCHOOL BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)								
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
1985	0.61	0.61	0.58	0.58	0.58	0.58	0.61	0.58	0.58	0.31
1990	0.67	0.67	0.52	0.52	0.45	0.45	0.50	0.43	0.52	0.11
1995	0.72	0.72	0.47	0.46	0.31	0.31	0.34	0.25	0.47	0.01
2000	0.76	0.76	0.46	0.45	0.24	0.26	0.26	0.17	0.46	<0.01
2010	0.86	0.86	0.52	0.50	0.28	0.28	0.28	0.18	0.52	<0.01

TABLE F-19

SLEEP AWAKENING IMPACTS - INTERCITY BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	4.43	4.43	4.43	4.43	4.43	4.43	4.43	4.43	4.43	4.43
1985	5.99	4.73	4.61	5.60	4.61	5.60	5.99	4.61	4.61	2.89
1990	7.26	4.75	4.01	4.81	3.73	4.53	5.29	3.66	3.73	1.06
1995	8.49	5.13	3.80	4.14	3.16	3.50	3.99	2.97	3.16	0.12
2000	9.79	5.87	4.16	4.19	3.26	3.28	3.41	2.96	3.26	<0.01
2010	12.69	7.61	5.40	5.40	4.19	4.19	4.19	3.79	4.19	<0.01

TABLE F-20
SLEEP AWAKENING IMPACT - TRANSIT BUSES

OPTION	1985 LWP (Millions)	1985 RCI	1985 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	30.07	-44.92	0.00	36.29	-74.89	0.00	56.63	-172.92	0.00
1	30.01	-44.63	0.20	36.24	-74.65	0.14	56.63	-172.92	0.00
2	28.93	-39.42	3.79	29.44	-41.88	18.88	38.27	-84.43	32.42
2A	28.96	-39.56	3.69	29.30	-41.20	19.26	37.75	-81.92	33.33
3	28.93	-39.42	3.79	26.04	-25.49	28.24	24.91	-20.05	56.01
3A	28.99	-39.71	3.59	26.09	-25.73	28.11	24.91	-20.05	56.01
3B	30.07	-44.92	0.00	28.24	-36.10	22.18	24.91	-20.05	56.01
4	28.93	-39.42	3.79	24.66	-18.84	32.05	17.81	14.17	68.55
5	28.93	-39.42	3.79	26.04	-25.49	28.24	24.91	-20.05	56.01
Q	14.52	30.02	51.71	5.55	73.25	84.70	0.01	4.82	99.98

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation relative to the same year, without regulation.

TABLE F-21
SLEEP AWAKENING IMPACT - INTERCITY BUSES

OPTION	1985 LWP (Millions)	1985 RCI	1985 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	5.99	-35.59	0.00	7.26	-63.98	0.00	12.69	-186.78	0.00
1	4.73	-6.80	21.06	4.76	-7.50	34.44	7.61	-72.00	40.02
2	4.61	-4.09	23.07	4.01	9.29	44.68	5.40	-21.94	57.48
2A	5.60	-26.60	6.43	4.81	-8.77	33.67	5.40	-21.94	57.48
3	4.61	-4.09	23.07	3.73	15.64	48.55	4.19	5.22	66.95
3A	5.60	-26.60	6.43	4.53	-2.42	37.54	4.19	5.22	66.95
3B	5.99	-35.30	0.00	5.29	-19.59	27.07	4.19	5.22	66.95
4	4.61	-4.09	23.07	3.66	17.29	49.56	3.79	14.26	70.10
5	4.61	-4.09	23.07	3.73	15.64	48.55	4.19	5.22	66.95
Q	2.89	34.67	51.71	1.06	75.95	85.34	0.003	99.93	99.98

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation relative to the same year, without regulation.

TABLE F-22
SLEEP AWAKENING IMPACTS - SCHOOL BUSES

OPTION	1985 LWP (Millions)	1985 RCI	1985 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	0.61	-30.70	0.00	0.67	-44.41	0.00	0.86	-83.80	0.00
1	0.61	-30.57	0.10	0.67	-44.28	0.09	0.86	-83.80	0.00
2	0.58	-25.30	4.14	0.52	-12.23	22.28	0.52	-10.66	39.79
2A	0.58	-24.43	4.79	0.51	-9.41	24.23	0.50	-7.27	41.63
3	0.58	-25.30	4.14	0.45	2.94	32.79	0.28	39.88	67.29
3A	0.58	-25.42	4.04	0.45	2.85	32.73	0.28	39.88	67.29
3B	0.61	-30.70	0.00	0.50	-7.40	25.63	0.28	39.88	67.29
4	0.58	-25.30	4.14	0.43	7.81	36.16	0.18	61.25	78.92
5	0.58	-25.30	4.14	0.52	-12.23	22.28	0.52	-10.66	39.79
Q	0.31	33.49	49.11	0.12	75.31	82.90	0.000002	99.99	99.99

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation relative to the same year, without regulation.

TABLE F-23

INDOOR SPEECH INTERFERENCE IMPACTS - TRANSIT BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)								
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option
1980	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87
1985	2.72	2.72	2.60	2.61	2.60	2.61	2.72	2.60	2.60	1.32
1990	3.29	3.28	2.55	2.55	2.24	2.25	2.48	2.15	2.25	0.51
1995	3.75	3.74	2.46	2.45	1.76	1.77	1.92	1.50	1.76	0.07
2000	4.20	4.20	2.57	2.57	1.61	1.61	1.65	1.22	1.61	0.01
2010	5.17	5.17	3.16	3.14	1.94	1.94	1.94	1.43	1.94	0.01

TABLE F-24

INDOOR SPEECH INTERFERENCE IMPACTS - INTERCITY BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1985	0.20	0.16	0.15	0.19	0.15	0.19	0.20	0.15	0.15	0.10
1990	0.24	0.16	0.13	0.16	0.13	0.15	0.18	0.12	0.13	0.04
1995	0.28	0.17	0.13	0.14	0.11	0.12	0.14	0.11	0.11	0.01
2000	0.33	0.19	0.14	0.14	0.12	0.12	0.12	0.11	0.12	<0.01
2010	0.43	0.25	0.18	0.18	0.15	0.15	0.15	0.14	0.15	<0.01

TABLE F-25

INDOOR SPEECH INTERFERENCE IMPACT - SCHOOL BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
1985	0.17	0.17	0.16	0.16	0.16	0.16	0.17	0.16	0.16	0.09
1990	0.19	0.19	0.14	0.14	0.12	0.12	0.14	0.12	0.14	0.03
1995	0.20	0.20	0.12	0.12	0.08	0.08	0.09	0.07	0.12	<0.01
2000	0.21	0.21	0.11	0.11	0.07	0.07	0.07	0.05	0.11	<0.01
2010	0.24	0.24	0.13	0.13	0.07	0.07	0.07	0.05	0.13	<0.01

TABLE F-26

OUTDOOR SPEECH INTERFERENCE IMPACTS - TRANSIT BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)								
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
1985	1.75	1.75	1.68	1.68	1.68	1.68	1.75	1.68	1.68	0.86
1990	2.12	2.12	1.70	1.70	1.51	1.51	1.64	1.44	1.51	0.36
1995	2.43	2.42	1.69	1.67	1.25	1.25	1.34	1.08	1.25	0.08
2000	2.72	2.72	1.80	1.80	1.19	1.19	1.21	9.35	1.19	0.05
2010	3.36	3.36	2.23	2.22	1.45	1.45	1.45	1.12	1.45	0.07

TABLE F-27

OUTDOOR SPEECH INTERFERENCE IMPACTS - INTERCITY BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
1985	0.12	0.09	0.09	0.11	0.09	0.11	0.12	0.09	0.09	0.06
1990	0.14	0.09	0.08	0.10	0.08	0.09	0.11	0.08	0.08	0.02
1995	0.17	0.10	0.08	0.09	0.07	0.08	0.08	0.07	0.07	<0.01
2000	0.19	0.12	0.09	0.09	0.07	0.07	0.08	0.07	0.07	<0.01
2010	0.25	0.15	0.12	0.12	0.10	0.10	0.10	0.10	0.10	<0.01

TABLE F-28

OUTDOOR SPEECH INTERFERENCE IMPACTS - SCHOOL BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)								
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
1985	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.04
1990	0.09	0.09	0.07	0.07	0.07	0.07	0.07	0.06	0.07	0.02
1995	0.10	0.10	0.06	0.06	0.05	0.05	0.05	0.04	0.06	<0.01
2000	0.11	0.11	0.06	0.06	0.04	0.04	0.04	0.03	0.06	<0.01
2010	0.12	0.12	0.07	0.07	0.05	0.05	0.05	0.04	0.07	<0.01

TABLE F-29

PEDESTRIAN SPEECH INTERFERENCE IMPACTS - TRANSIT BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	3.24	3.24	3.24	3.24	3.24	3.24	3.24	3.24	3.24	3.24
1985	4.71	4.71	4.62	4.61	4.62	4.62	4.71	4.62	4.62	2.38
1990	5.71	5.71	5.11	5.08	4.70	4.70	4.89	4.47	4.70	1.08
1995	6.52	6.52	5.47	5.42	4.93	4.53	4.66	3.93	4.93	0.37
2000	7.32	7.32	5.99	5.93	4.69	4.69	4.72	3.80	4.69	0.31
2010	9.06	9.06	7.40	6.60	5.75	5.75	5.75	4.59	5.75	0.38

Table F-30

PEDESTRIAN SPEECH INTERFERENCE IMPACTS - INTERCITY BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
1985	0.40	0.34	0.33	0.38	0.33	0.38	0.40	0.34	0.34	0.20
1990	0.49	0.37	0.33	0.37	0.31	0.35	0.39	0.31	0.31	0.09
1995	0.58	0.41	0.34	0.36	0.30	0.32	0.35	0.29	0.31	0.03
2000	0.67	0.48	0.38	0.38	0.33	0.33	0.34	0.31	0.33	0.03
2010	0.89	0.63	0.50	0.54	0.44	0.44	0.44	0.41	0.44	0.04

TABLE F-31

PEDESTRIAN SPEECH INTERFERENCE IMPACTS - SCHOOL BUSES

YEARS	REGULATORY OPTIONS, LEVEL WEIGHTED POPULATION (LWP in Millions)									
	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5	Option Q
1980	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
1985	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.21
1990	0.45	0.45	0.38	0.40	0.35	0.35	0.37	0.34	0.38	0.09
1995	0.48	0.48	0.37	0.37	0.30	0.30	0.32	0.27	0.37	0.02
2000	0.52	0.52	0.38	0.38	0.29	0.29	0.30	0.25	0.38	0.02
2010	0.60	0.60	0.45	0.44	0.34	0.34	0.34	0.28	0.45	0.02

TABLE F-32
INDOOR SPEECH INTERFERENCE IMPACT - TRANSIT BUSES

OPTION	1985 LWP (Millions)	RCI	RCI*	1990 LWP (Millions)	RCI	RCI*	2010 LWP (Millions)	RCI	RCI*
Baseline	2.72	-45.23	0.00	3.29	-75.31	0.00	5.17	-175.63	0.00
1	2.72	-45.07	0.11	3.28	-74.99	0.18	5.17	-175.63	0.00
2	2.60	-38.93	4.33	2.55	-36.11	22.36	3.16	-68.48	38.87
2A	2.60	-39.04	4.26	2.54	-35.84	22.51	3.14	-67.36	39.28
3	2.60	-38.93	4.33	2.24	-19.73	31.70	1.94	-3.52	62.44
3A	2.42	-29.28	10.98	2.24	-19.89	31.61	1.94	-3.52	62.44
3B	2.72	-45.23	0.00	2.48	-32.32	24.52	1.94	-3.52	62.44
4	2.60	-38.93	4.33	2.15	-14.56	34.65	1.43	23.52	72.25
5	2.60	-38.93	4.33	2.24	-19.73	31.70	1.94	-3.52	62.44
Q	1.32	29.65	51.56	0.51	72.80	84.48	0.01	99.47	99.81

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

TABLE F-33
INDOOR SPEECH INTERFERENCE IMPACT - INTERCITY BUSES

OPTION	1885 LWP (Millions)	1885 RCI	1885 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	0.20	-35.37	0.00	0.24	-64.60	0.00	0.43	-189.79	0.00
1	0.16	-6.12	21.61	0.16	-5.44	35.95	0.25	-68.02	42.02
2	0.15	-3.40	23.62	0.13	9.52	44.04	0.18	-23.81	57.28
2A	0.19	-26.53	6.53	0.16	-9.52	33.47	0.18	-23.31	57.28
3	0.15	-3.40	23.62	0.13	14.29	47.93	0.15	-1.36	65.03
3A	0.19	-26.53	6.53	0.15	-4.76	36.36	0.15	-1.36	65.03
3B	0.20	-35.37	0.00	0.18	-21.09	26.45	0.15	-1.36	65.03
4	0.15	-3.40	23.62	0.12	-15.65	48.76	0.14	5.44	67.37
5	0.15	-3.40	23.62	0.13	14.29	47.93	0.15	-1.36	65.03
Q	0.10	34.69	51.76	0.04	75.51	85.12	0.002	-98.64	99.53

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

TABLE F-34
INDOOR SPEECH INTERFERENCE IMPACT - SCHOOL BUSES

OPTION	1985 LWP (Millions)	1985 RCI	1985 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	0.17	-30.88	0.00	0.18	-44.75	0.00	0.24	-85.11	0.00
1	0.17	-30.80	0.06	0.18	-44.67	0.05	0.24	-85.11	0.00
2	0.16	-24.69	4.73	0.14	-7.37	25.83	0.13	0.24	46.10
2A	0.16	-24.22	4.79	0.14	-6.25	26.49	0.13	1.56	46.61
3	0.16	-24.69	4.73	0.12	5.33	34.60	0.07	43.03	69.22
3A	0.16	-24.76	4.67	0.12	5.33	34.60	0.07	43.03	69.22
3B	0.17	-30.88	0.00	0.14	-6.58	26.37	0.07	43.03	69.22
4	0.16	-24.69	4.73	0.12	9.33	37.36	0.05	60.67	78.76
5	0.16	-24.69	4.73	0.13	-7.37	25.83	0.13	0.24	46.10
Q	0.09	32.81	48.50	0.03	24.22	83.24	.0001	84.38	99.96

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

TABLE F-35
OUTDOOR SPEECH INTERFERENCE IMPACT - TRANSIT BUSES

OPTION	1985 LWP (Millions)	1985 RCI	1985 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	1.75	-45.71	0.00	2.12	-76.60	0.00	3.36	-180.18	0.00
1	1.74	-45.30	0.29	2.12	-76.27	0.19	3.36	-180.18	0.00
2	1.68	-39.80	4.06	1.70	-41.63	19.80	2.23	-85.60	33.76
2A	1.68	-39.88	4.00	1.70	-41.54	19.84	2.22	-122.38	34.02
3	1.68	-39.80	4.06	1.50	-25.31	29.04	1.45	-20.65	56.94
3A	1.68	-40.13	3.83	1.51	-25.65	28.85	1.45	-20.65	56.94
3B	1.75	-45.71	0.00	1.64	-36.64	22.63	1.45	-20.65	56.94
4	1.68	-39.80	4.06	1.44	-19.98	32.06	1.12	7.08	66.84
5	1.68	-39.80	4.06	1.50	-25.31	29.04	1.45	-20.65	56.94
Q	0.86	28.39	50.85	0.36	70.02	83.02	0.06	95.00	98.21

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation relative to the same year, without regulation.

TABLE F-36
OUTDOOR SPEECH INTERFERENCE IMPACT - INTERCITY BUSES

OPTION	1985 LWP (Millions)	1985 RCI	1985 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	0.11	-36.90	0.00	0.14	-66.67	0.00	0.25	-197.62	0.00
1	0.09	-8.33	20.87	0.09	-9.52	34.29	0.15	-79.76	39.60
2	0.09	-6.59	21.83	0.08	4.76	42.86	0.12	-37.20	53.66
2A	0.12	-28.57	6.09	0.10	-14.28	31.43	0.11	-38.09	54.00
3	0.09	-5.95	22.61	0.08	9.52	45.71	0.10	-14.29	61.60
3A	0.11	-28.57	6.09	0.09	-8.33	35.00	0.10	-14.29	61.20
3B	0.11	-36.90	0.00	0.10	-25.00	25.00	0.10	-14.29	61.60
4	0.09	-5.95	22.61	0.07	10.71	46.43	0.09	-7.14	61.60
5	0.09	-5.95	22.61	0.08	9.52	45.71	0.10	-14.29	64.00
Q	0.06	32.14	50.43	0.02	72.61	83.57	0.01	92.85	97.60

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

TABLE F-37
OUTDOOR SPEECH INTERFERENCE IMPACT - SCHOOL BUSES

OPTION	1985 LWP (Millions)	1985 RCI	1985 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	0.09	-31.22	0.00	0.09	-45.57	0.00	0.12	-88.03	0.00
1	0.08	-31.04	0.14	0.09	-45.39	0.13	0.12	-88.03	0.00
2	0.08	-25.62	4.27	0.07	-12.51	22.71	0.07	-12.16	40.35
2A	0.08	-26.15	3.52	0.07	-7.69	26.31	0.07	-10.76	40.98
3	0.08	-25.62	4.27	0.07	-1.32	30.40	0.05	25.77	60.52
3A	0.08	-25.79	4.14	0.07	-1.47	30.29	0.05	25.77	60.52
3B	0.09	-31.22	0.00	0.07	-11.99	23.07	0.05	25.77	60.52
4	0.08	-25.62	4.27	0.06	2.38	32.94	0.04	42.06	69.18
5	0.08	-25.62	4.27	0.07	-12.51	22.71	0.07	-12.16	40.35
Q	0.04	32.30	48.23	0.02	73.84	82.10	0.00	98.46	99.18

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation relative to the same year, without regulation.

TABLE F-38
PEDESTRIAN SPEECH INTERFERENCE IMPACT - TRANSIT BUSES

OPTION	1985 LWP (Millions)	1985 RCI	1985 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	4.71	-45.52	0.00	5.71	-76.31	0.00	9.06	-179.68	0.00
1	4.71	-45.46	0.04	5.71	-76.25	0.04	9.06	-179.68	0.00
2	4.62	-42.59	2.02	5.11	-57.75	10.53	7.40	-128.63	18.25
2A	4.61	-42.50	2.08	5.08	-56.92	11.00	6.60	-103.83	27.12
3	4.62	-42.59	2.02	4.70	-45.03	17.74	5.75	-77.61	36.50
3A	4.62	-42.62	1.99	4.70	-45.06	17.73	5.75	-77.61	36.50
3B	4.71	-45.52	0.00	4.89	-50.90	14.42	5.75	-77.61	36.50
4	4.62	-42.59	2.02	4.48	-38.23	21.60	4.59	-41.63	49.36
5	4.62	-42.59	2.02	4.70	-45.03	17.74	5.75	-77.61	36.50
Q	2.38	26.50	49.49	1.08	66.74	81.14	0.38	88.26	95.80

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

TABLE F-39
PEDESTRIAN SPEECH INTERFERENCE IMPACT - INTERCITY BUSES

OPTION	1985 LWP (Millions)	1985 RCI	1985 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	0.40	-36.77	0.00	0.49	-67.37	0.00	0.89	-200.81	0.00
1	0.34	-15.59	15.38	0.37	-25.08	25.15	0.63	-112.20	29.42
2	0.34	-13.56	16.87	0.33	-11.19	33.47	0.50	-69.15	43.74
2A	0.38	-30.17	5.94	0.37	-24.41	25.56	0.54	-82.37	39.35
3	0.34	-13.56	16.87	0.31	-6.44	36.31	0.44	-48.14	50.73
3A	0.38	-30.17	4.71	0.35	-19.66	28.40	0.44	-48.14	50.73
3B	0.40	-36.61	0.00	0.39	-32.88	20.49	0.44	-48.14	50.73
4	0.34	-13.56	16.87	0.31	-4.75	37.32	0.41	-38.64	53.89
5	0.34	-13.56	16.87	0.31	-6.44	36.31	0.44	-48.14	50.73
Q	0.20	31.19	49.63	0.09	69.83	81.95	0.04	87.80	95.94

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

TABLE F-40
PEDESTRIAN SPEECH INTERFERENCE IMPACT - SCHOOL BUSES

OPTION	1985 LWP (Millions)	1985 RCI	1985 RCI*	1990 LWP (Millions)	1990 RCI	1990 RCI*	2010 LWP (Millions)	2010 RCI	2010 RCI*
Baseline	0.40	-33.24	0.00	0.45	49.93	0.00	0.60	-102.07	0.00
1	0.40	-33.24	0.00	0.45	-49.90	0.02	0.60	-102.07	0.00
2	0.39	-29.57	2.76	0.38	-27.26	15.12	0.45	-49.30	26.12
2A	0.38	-29.43	2.76	0.38	-33.44	10.94	0.44	-48.16	26.66
3	0.39	-29.57	2.76	0.35	-16.99	21.97	0.34	-13.38	43.89
3A	0.39	-29.57	2.76	0.35	-16.99	21.97	0.34	-13.38	43.89
3B	0.40	-33.24	0.00	0.37	-24.18	17.18	0.34	-13.38	43.89
4	0.39	-29.57	2.76	0.34	-12.84	24.74	0.28	17.79	59.32
5	0.39	-29.57	2.76	0.38	-27.26	15.12	0.45	-49.30	26.12
Q	0.21	29.10	46.73	0.09	70.23	80.01	0.02	92.64	26.16

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year, without regulation.

Table F-41

HEARING LOSS IMPACT: PASSENGERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 60 - LWPH (thousands)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	302.3	302.3	302.3	302.3	302.3	302.3	302.3	302.3	302.3
1985	410.0	198.2	198.2	322.8	198.2	366.2	410.2	198.2	198.2
1990	464.3	71.1	71.1	161.3	71.1	198.9	282.0	71.1	71.1
1995	500.6	7.8	7.8	40.1	7.8	58.9	110.0	7.8	7.8
2000	531.2	0.1	0.1	1.4	0.1	3.9	16.4	0.1	0.1
2008	581.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table F-42

HEARING LOSS IMPACT: PASSENGERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 60 - RCI

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-35.63	34.44	34.44	-6.78	34.44	-21.14	-35.63	34.44	34.44
1990	-53.59	76.48	76.48	46.64	76.48	34.20	6.72	76.48	76.48
1995	-65.60	97.42	97.42	86.74	97.42	80.52	63.61	97.42	97.42
2000	-75.72	99.97	99.97	99.54	99.97	98.71	94.57	99.97	99.97
2008	-92.49	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-43

HEARING LOSS IMPACT: PASSENGERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 60 - RCI*

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	51.7	51.7	21.3	51.7	10.7	0.0	51.7	51.7
1990	0.0	84.7	84.7	65.3	84.7	57.2	39.3	84.7	84.7
1995	0.0	98.4	98.4	92.0	98.4	88.2	78.0	98.4	98.4
2000	0.0	100.0	100.0	99.7	100.0	99.3	96.9	100.0	100.0
2008	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-44

HEARING LOSS IMPACT: PASSENGERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	1977.1	1977.1	1977.1	1977.1	1977.1	1977.1	1977.1	1977.1	1977.1
1985	2681.5	1644.1	1590.1	2147.2	1590.1	2413.1	2681.5	1590.1	1590.1
1990	3037.1	1111.0	784.0	1179.6	719.8	1345.7	1855.1	713.1	719.8
1995	3274.3	860.4	316.3	451.5	178.8	429.2	742.0	161.6	178.8
2000	3474.6	872.7	223.0	226.4	41.8	60.6	137.2	17.6	41.8
2008	3806.3	955.7	238.8	238.8	33.9	33.9	33.9	6.0	33.9

Table F-45

HEARING LOSS IMPACT: PASSENGERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-35.63	16.84	19.57	-8.60	19.57	-22.05	-35.63	19.57	19.57
1990	-53.61	43.81	60.35	40.34	63.59	31.94	6.17	63.93	63.59
1995	-65.61	56.48	84.00	77.16	90.96	78.29	62.47	91.83	90.96
2000	-75.74	55.86	88.72	88.55	97.89	96.93	93.06	99.11	97.89
2008	92.52	51.66	87.92	87.92	98.29	98.29	98.29	99.70	98.29

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-46

HEARING LOSS IMPACT: PASSENGERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	38.7	40.7	19.9	40.7	10.0	0.0	40.7	40.7
1990	0.0	63.4	74.2	61.2	76.3	55.7	38.9	76.5	76.3
1995	0.0	73.7	90.3	86.2	94.5	86.9	77.3	95.1	94.5
2000	0.0	74.9	93.6	93.5	98.8	98.3	96.1	99.5	98.8
2008	0.0	74.9	93.7	93.7	99.1	99.1	99.1	99.8	99.1

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-47

HEARING LOSS IMPACT: PASSENGERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - LWPH (thousands)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	49919.3	49919.3	49919.3	49919.3	49919.3	49919.3	49919.3	49919.3	49919.3
1985	67703.2	66888.3	66809.0	66809.0	67455.4	67566.4	67703.2	66809.0	66809.0
1990	76680.6	75167.7	74687.2	74966.3	74487.7	74979.4	75449.5	74431.4	74487.7
1995	82670.8	80774.8	79975.3	80065.6	79547.8	79744.4	80033.2	79401.7	79547.8
2000	87728.6	85684.8	84730.3	84730.8	84166.8	84181.6	84252.2	83961.6	84166.8
2008	96102.2	93863.1	92809.6	92809.6	92172.8	92172.8	92172.8	91935.6	92172.8

Table F-48

HEARING LOSS IMPACT: PASSENGERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-35.63	-33.99	-33.83	-34.64	-33.83	-35.13	-35.63	-33.83	-33.83
1990	-53.61	-50.58	-49.62	-50.17	-49.22	-50.20	-51.14	-49.10	-49.22
1995	-65.61	-61.81	-60.21	-60.39	-59.35	-59.75	-60.33	-59.06	-59.35
2000	-75.54	-71.65	-69.73	-69.74	-68.61	-68.64	-68.78	-68.19	-68.61
2008	-92.52	-88.03	-85.92	-85.92	-84.64	-84.64	-84.64	-84.17	-84.64

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-49

HEARING LOSS IMPACT: PASSENGERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	1.2	1.3	0.7	1.3	0.4	0.0	1.3	1.3
1990	0.0	2.0	2.6	2.2	2.9	2.2	1.6	2.9	2.9
1995	0.0	2.3	3.3	3.2	3.8	3.5	3.2	4.0	3.8
2000	0.0	2.3	3.4	3.4	4.1	4.0	4.0	4.3	4.1
2008	0.0	2.3	3.4	3.4	4.1	4.1	4.1	4.3	4.1

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-50

HEARING LOSS IMPACT: DRIVERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 60 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1985	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1990	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1995	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table F-51

HEARING LOSS IMPACT: DRIVERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
1985	9.6	9.6	8.9	8.2	8.9	8.9	9.6	8.9	8.9
1990	11.0	11.0	6.8	6.2	5.5	5.5	6.8	5.4	5.5
1995	11.9	11.9	4.9	4.6	2.1	2.1	3.0	1.9	2.1
2000	12.7	12.7	4.3	4.3	0.6	0.6	0.8	0.2	0.6
2008	14.0	14.0	4.7	4.7	0.5	0.5	0.5	0.1	0.5

Table F-52

HEARING LOSS IMPACT: DRIVERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-37.14	-37.14	-27.14	-17.14	-27.14	-27.14	-37.14	-27.14	-27.14
1990	-57.14	-57.14	2.86	11.43	21.43	21.43	2.86	22.86	21.43
1995	-70.00	-70.00	30.00	34.29	70.00	70.00	57.14	72.86	70.00
2000	-81.43	-81.43	38.57	38.57	91.43	91.43	88.57	97.14	91.43
2008	-100.0	-100.0	32.86	32.86	92.86	92.86	92.86	98.57	92.86

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-53

HEARING LOSS IMPACT: DRIVERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	7.1	14.1	7.1	7.1	0.0	7.1	7.1
1990	0.0	0.0	37.9	43.3	49.7	49.7	37.9	50.7	49.7
1995	0.0	0.0	58.6	61.1	82.0	82.0	75.2	84.3	82.0
2000	0.0	0.0	65.9	66.2	95.0	95.0	93.4	98.0	95.0
2008	0.0	0.0	66.4	66.4	96.4	96.4	96.4	99.6	96.4

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-54

HEARING LOSS IMPACT: DRIVERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	329.9	329.9	329.9	329.9	329.9	329.9	329.9	329.9	329.9
1985	453.4	453.4	452.6	451.7	452.6	452.6	453.4	452.6	452.6
1990	520.5	520.5	515.3	514.6	512.3	512.3	513.9	511.4	515.3
1995	564.9	564.9	556.3	555.9	549.7	549.7	550.7	547.5	556.3
2000	603.6	603.6	593.2	593.2	584.5	584.5	584.5	581.3	593.2
2008	665.8	665.8	654.3	654.3	644.3	644.3	644.3	640.6	654.3

Table F-55

HEARING LOSS IMPACT: DRIVERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-37.44	-37.44	-37.19	-36.92	-37.19	-37.19	-37.44	-37.19	-37.19
1990	-57.78	-57.78	-56.20	-55.99	-55.29	-55.29	-55.77	-55.02	-55.29
1995	-71.23	-71.23	-68.63	-68.63	-66.63	-66.63	-66.63	-65.96	-66.63
2000	-82.96	-82.96	-79.81	-79.81	-77.17	-77.17	-77.24	-76.20	-77.17
2008	-101.82	-101.82	-98.33	-98.33	-95.30	-95.30	-95.30	-94.18	-95.30

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-56

HEARING LOSS IMPACT: DRIVERS FOR TRANSIT BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.2	0.4	0.2	0.2	0.0	0.2	0.2
1990	0.0	0.0	1.0	1.1	1.6	1.6	1.3	1.7	1.6
1995	0.0	0.0	1.5	1.6	2.7	2.7	2.5	3.1	2.7
2000	0.0	0.0	1.7	1.7	3.2	3.2	3.1	3.7	3.2
2008	0.0	0.0	1.7	1.7	3.2	3.2	3.2	3.8	3.2

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-57

HEARING LOSS IMPACT: PASSENGERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 60 - LWPH (thousands)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table F-58

HEARING LOSS IMPACT: PASSENGERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
1985	1.4	1.4	1.3	1.2	1.3	1.3	1.4	1.3	1.3
1990	1.9	1.9	1.3	1.3	1.2	1.2	1.4	1.1	1.2
1995	2.4	2.4	1.3	1.3	1.0	1.0	1.1	0.6	1.0
2000	3.0	3.0	1.5	1.5	1.0	1.0	1.0	0.3	1.0
2008	4.2	4.2	2.1	2.1	1.3	1.3	1.3	0.3	1.3

Table F-59

HEARING LOSS IMPACT: PASSENGERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-55.56	-55.56	-44.44	-33.33	-44.44	-44.44	-55.56	-44.44	-44.44
1990	-111.11	-111.11	-44.44	-44.44	-33.33	-33.33	-55.56	-22.22	-33.33
1995	-166.67	-166.67	-44.44	-44.44	-11.11	-11.11	-22.22	-33.33	-11.11
2000	-233.33	-233.33	-66.67	-66.67	-11.11	-11.11	-11.11	66.67	-11.11
2008	-366.67	-366.67	-133.33	-133.33	-44.44	-44.44	-44.44	66.67	-44.44

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-60

HEARING LOSS IMPACT: PASSENGERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	5.4	10.9	5.4	5.4	0.0	5.4	5.4
1990	0.0	0.0	29.0	33.1	36.3	36.3	27.4	43.7	36.3
1995	0.0	0.0	44.3	46.1	58.7	58.7	53.8	76.3	58.7
2000	0.0	0.0	49.6	49.8	67.4	67.4	66.3	90.4	67.4
2008	0.0	0.0	49.9	49.9	68.2	68.2	68.2	92.5	68.2

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-61

HEARING LOSS IMPACT: PASSENGERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - LWPH (thousands)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	92877.9	92877.9	92877.9	92877.9	92877.9	92877.9	92877.9	92877.9	92877.9
1985	146608.1	146608.2	146605.6	146603.2	146605.6	146605.6	146608.1	146605.6	146605.6
1990	200740.1	200740.0	200722.1	200719.6	200711.3	200711.3	200717.0	200701.2	200711.3
1995	259625.8	259625.6	259589.8	259588.1	259562.4	259562.4	259566.4	259531.5	259562.4
2000	325408.2	325408.2	325357.9	325357.9	325357.5	325315.4	325315.5	325264.8	325315.4
2008	448084.3	448084.3	448014.3	448014.3	447954.0	447954.0	447954.0	447880.9	447954.0

Table F-62

HEARING LOSS IMPACT: PASSENGERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-57.85	-57.85	-57.85	-57.85	-57.85	-57.85	-57.85	-57.85	-57.85
1990	-116.13	-116.13	-116.11	-116.11	-116.10	-116.10	-116.11	-116.09	-116.10
1995	-179.53	-179.53	-179.49	-179.49	-179.47	-179.47	-179.47	-179.43	-179.47
2000	-250.36	-250.36	-250.31	-250.31	-250.26	-250.26	-250.26	-250.26	-250.26
2008	-382.44	-382.44	-382.37	-382.37	-382.30	-382.30	-382.30	-382.23	-382.30

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-63

HEARING LOSS IMPACT: PASSENGERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-64

HEARING LOSS IMPACT: DRIVERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 60 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table F-65

HEARING LOSS IMPACT: DRIVERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
1985	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
1990	1.1	1.1	1.1	1.1	1.1	1.1	1.1	0.9	1.1
1995	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.6	1.2
2000	1.4	1.4	1.4	1.4	1.4	1.4	1.4	0.4	1.4
2008	1.6	1.6	1.6	1.6	1.6	1.6	1.6	0.4	1.6

Table F-66

HEARING LOSS IMPACT: DRIVERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-28.57	-28.57	-28.57	-28.57	-28.57	-28.57	-28.57	-28.57	-28.57
1990	-57.14	-57.14	-57.14	-57.14	-57.14	-57.14	-57.14	-28.57	-57.14
1995	-71.43	-71.43	-71.43	-71.43	-71.43	-71.43	-71.43	14.29	-71.43
2000	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	42.86	-100.0
2008	-128.57	-128.57	-128.57	-128.57	-128.57	-128.57	-128.57	42.86	-128.57

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-67

HEARING LOSS IMPACT: DRIVERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.9	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.2	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	68.6	0.0
2008	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.1	0.0

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-68

HEARING LOSS IMPACT: DRIVERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	54.5	54.5	54.5	54.5	54.5	54.5	54.5	54.5	54.5
1985	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3
1990	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.0	81.4
1995	91.2	91.2	91.2	91.2	91.2	91.2	91.2	90.2	91.2
2000	100.8	100.8	100.8	100.8	100.8	100.8	100.8	90.2	91.2
2008	116.7	116.7	116.7	116.7	116.7	116.7	116.7	114.9	116.7

Table F-69

HEARING LOSS IMPACT: DRIVERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-28.99	-28.99	-28.99	-28.99	-28.99	-28.99	-28.99	-28.99	-28.99
1990	-49.36	-49.36	-49.36	-49.36	-49.36	-49.36	-49.36	-48.62	-49.36
1995	-67.34	-67.34	-67.34	-67.34	-67.34	-67.34	-67.34	-65.50	-67.34
2000	-84.95	-84.95	-84.95	-84.95	-84.95	-84.95	-84.95	-82.20	-84.95
2008	-114.13	-114.13	-114.13	-114.13	-114.13	-114.13	-114.13	-110.83	-114.13

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-70

HEARING LOSS IMPACT: DRIVERS FOR INTERCITY BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0
2008	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-71

HEARING LOSS IMPACT: PASSENGERS FOR SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 60 - LWPH (thousands)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1985	0.3	0.1	0.1	0.2	0.1	0.3	0.3	0.1	0.1
1990	0.3	0.0	0.0	0.1	0.0	0.1	0.2	0.0	0.0
1995	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
2000	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table F-72

HEARING LOSS IMPACT: PASSENGERS FOR SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	1105.1	1105.1	1105.1	1105.1	1105.1	1105.1	1105.1	1105.1	1105.1
1985	1361.8	887.3	856.7	1107.1	856.7	1234.1	1361.8	856.7	856.7
1990	1418.5	572.8	394.7	568.0	369.3	650.4	868.3	367.1	394.7
1995	1424.7	417.8	134.7	191.7	82.5	191.7	332.4	76.9	134.7
2000	1452.8	408.0	81.1	82.3	14.4	22.5	56.5	6.8	81.1
2008	1510.7	424.2	81.5	81.5	9.8	9.8	9.8	1.5	81.5

Table F-73

HEARING LOSS IMPACT: PASSENGERS FOR SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-23.23	19.71	22.48	-.18	22.48	-11.67	-23.23	22.48	22.48
1990	-28.36	48.17	64.28	48.60	66.58	41.15	19.80	66.78	64.28
1995	-28.92	62.19	87.81	82.68	92.53	82.65	69.92	93.04	87.81
2000	-31.46	63.08	92.66	92.55	98.70	97.96	94.89	99.38	92.66
2008	36.70	61.61	92.63	92.63	99.11	99.11	99.11	99.86	92.63

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-74

HEARING LOSS IMPACT: PASSENGERS FOR SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	34.8	37.1	18.7	37.1	9.4	0.0	37.1	37.1
1990	0.0	59.6	72.2	60.0	74.0	54.2	37.5	74.1	72.2
1995	0.0	70.7	90.5	86.6	94.2	86.5	76.7	94.6	90.5
2000	0.0	71.9	94.4	94.3	99.0	98.4	96.1	99.5	94.4
2008	0.0	71.9	94.6	94.6	99.3	99.3	99.3	99.9	94.6

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-75

HEARING LOSS IMPACT: PASSENGERS FOR SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - LWPH (thousands)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	68192.3	68192.3	68192.3	68192.3	68192.3	68192.3	68192.3	68912.3	68192.3
1985	84031.3	83413.5	83346.8	83646.0	83346.0	83838.0	84031.3	83346.8	83346.8
1990	87529.4	86428.4	86040.3	86243.1	85910.0	86275.9	86632.7	85872.9	86040.3
1995	87909.8	86598.9	85981.8	86044.6	85714.4	85856.6	86069.4	85622.0	85981.8
2000	89647.8	88287.6	87574.9	87574.9	87233.3	87243.8	87295.2	87107.1	87574.9
2008	93218.0	91803.5	91056.6	91056.6	90689.3	90689.3	90689.3	90550.5	91656.6

Table F-76

HEARING LOSS IMPACT: PASSENGERS FOR SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-23.23	-22.32	-22.22	-22.66	-22.22	-22.94	-23.23	-22.22	-22.22
1990	-28.36	-26.74	-26.17	-26.47	-25.98	-26.52	-27.04	-25.93	-26.17
1995	-28.92	-26.99	-26.09	-26.18	-25.70	-25.90	-26.22	-25.56	-26.09
2000	-31.46	-29.47	-28.42	-28.42	-27.92	-27.94	-28.01	-27.74	-28.42
2008	-36.70	-34.62	-33.53	-33.53	-32.99	-32.99	-32.99	-32.79	-33.53

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-77

HEARING LOSS IMPACT: PASSENGERS FOR SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.7	0.8	0.5	0.8	0.2	0.0	0.8	0.8
1990	0.0	1.3	1.7	1.5	1.9	1.4	1.0	1.9	1.7
1995	0.0	1.5	2.2	2.1	2.5	2.3	2.1	2.6	2.2
2000	0.0	1.5	2.3	2.3	2.7	2.7	2.6	2.8	2.3
2008	0.0	1.5	2.3	2.3	2.7	2.7	2.7	2.9	2.3

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-78

HEARING LOSS IMPACT: DRIVERS FOR ALL SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 60 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table F-79

HEARING LOSS IMPACT: DRIVERS FOR SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2
1985	28.1	15.7	15.4	22.6	15.4	25.3	28.1	15.4	15.4
1990	30.2	7.4	6.1	11.3	6.0	13.6	18.8	6.0	6.1
1995	31.4	3.3	1.1	3.0	0.9	3.9	7.2	0.9	1.1
2000	32.7	2.9	0.4	0.4	0.1	0.3	1.1	0.0	0.4
2008	34.6	3.0	0.4	0.4	0.0	0.0	0.0	0.0	0.4

Table F-80

HEARING LOSS IMPACT: DRIVERS FOR SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-27.73	28.64	30.00	-2.73	30.00	-15.00	-27.73	30.00	30.00
1990	-37.27	66.36	72.27	48.64	72.73	38.18	14.55	72.73	72.27
1995	-42.73	85.00	95.00	86.36	95.91	82.27	67.27	95.91	95.00
2000	-48.64	86.82	98.18	98.18	99.55	98.64	95.00	100.00	98.18
2008	-57.27	86.36	98.18	98.18	100.00	100.00	100.00	100.00	98.18

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-81

HEARING LOSS IMPACT: DRIVERS FOR SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 70 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	44.2	44.9	19.6	44.9	9.8	0.0	44.9	44.9
1990	0.0	75.6	79.9	62.7	80.3	55.1	37.7	80.3	79.9
1995	0.0	89.6	96.4	90.5	97.2	87.5	77.1	97.2	96.4
2000	0.0	91.2	98.8	98.6	99.8	99.1	96.7	99.9	98.8
2008	0.0	91.2	98.9	98.9	99.9	99.9	99.9	100.0	98.9

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-82

HEARING LOSS IMPACT: DRIVERS FOR SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - LWPH (thousands)

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	1102.8	1102.8	1102.8	1102.8	1102.8	1102.8	1102.8	1102.8	1102.8
1985	1407.2	1387.9	1387.1	1395.9	1387.1	1400.1	1404.2	1387.1	1387.1
1990	1513.1	1483.0	1478.2	1484.6	1476.7	1486.7	1494.6	1476.2	1478.2
1995	1573.9	1536.8	1528.9	1531.2	1525.7	1529.7	1534.6	1524.5	1528.9
2000	1634.2	1595.0	1585.8	1585.8	1581.5	1581.8	1583.0	1579.9	1585.8
2008	1730.8	1689.3	1679.4	1679.4	1679.7	1674.7	1674.7	1672.9	1679.4

Table F-83

HEARING LOSS IMPACT: DRIVERS FOR SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-27.33	-25.85	-25.78	-26.66	-25.78	-26.96	-27.33	-25.78	-25.78
1990	-37.21	-34.48	-34.04	-34.62	-33.90	-34.81	-35.53	-33.86	-34.04
1995	-42.27	-39.35	-38.64	-38.85	-38.35	-38.71	-39.15	-38.24	-38.64
2000	-48.19	-44.63	-43.80	-43.80	-43.41	-43.43	-43.54	-43.26	-43.80
2008	-56.95	-53.18	-52.29	-52.29	-51.86	-51.86	-51.86	-51.70	-52.29

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-84

HEARING LOSS IMPACT: DRIVERS FOR SCHOOL BUSES WITH NON-BUS NOISE EXPOSURE LEVEL OF 80 - RCI*

YEARS	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	1.2	1.2	0.6	1.2	0.3	0.0	1.2	1.2
1990	0.0	2.0	2.3	1.9	2.4	1.7	1.2	2.4	2.3
1995	0.0	2.4	2.9	2.7	3.1	2.8	2.5	3.1	2.9
2000	0.0	2.4	3.0	3.0	3.2	3.2	3.1	3.3	3.0
2008	0.0	2.4	3.0	3.0	3.2	3.2	3.2	3.3	3.0

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-85

YEAR: 1980
TRANSIT BUS (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	6901	6901	6901	6901	6901	6901	6901	6901	6901
25-50	3824	3824	3824	3824	3824	3824	6901	6901	3824
50-80	2434	2434	2434	2434	2434	2434	2434	2434	2434
80-100	3825	3825	3825	3825	3825	3825	2434	2434	3825
>100	3077	3077	3077	3077	3077	3077	2434	2434	3077

Table F-86

YEAR: 1985
TRANSIT BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	9360	11510	12418	12050	12418	10713	9360	12418	12418
25-50	7401	7401	6944	5189	6944	5189	5189	6944	6944
50-80	3302	3302	2952	2603	2952	2952	3302	2952	2952
80-100	5187	2975	2878	4085	2878	4633	5187	2878	2878
>100	4174	2025	2023	3287	2023	3728	4174	2023	2023

Table F-87

YEAR: 1990
TRANSIT BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	10602	14592	20090	19953	22398	21101	18537	22402	19953
25-50	9621	9996	7213	5878	4875	3576	3575	4906	5878
50-80	3741	3741	1612	1310	1606	1606	2272	1606	1310
80-100	5875	1768	1182	2041	1182	2517	3568	1182	2041
>100	4727	737	728	1642	728	2025	2872	748	1642

Table F-88

YEAR: 1995
TRANSIT BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	11430	16431	25579	25641	29211	30006	28431	30537	29211
25-50	6338	11485	6872	5172	1939	1405	1405	1927	1939
50-80	4034	4034	489	339	477	477	886	477	477
80-100	6334	1187	212	508	212	746	1391	212	212
>100	5097	96	81	409	81	600	1120	81	81

Table F-89

YEAR: 2000
TRANSIT BUS (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	12130	17521	17471	28482	34962	34924	34538	34979	34962
25-50	6727	12275	6768	6727	265	180	224	248	265
50-80	4281	4281	49	29	32	32	132	32	32
80-100	6721	1173	9	18	9	49	207	9	9
>100	5409	18	1	14	1	40	167	1	1

Table F-90

YEAR: 2008
TRANSIT BUS (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	13288	19194	31248	31248	38618	38618	38618	38637	38618
25-50	7371	13449	7371	7371	19	19	19	0	19
50-80	4691	4691	19	19	0	0	0	0	0
80-100	7363	1285	0	0	0	0	0	0	0
>100	5925	19	0	0	0	0	0	0	0

Table F-91

YEAR: 1980
INTERCITY BUS (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	1181	1181	1181	1181	1181	1181	1181	1181	1181
25-50	21	21	21	21	21	21	21	21	21
50-80	2	2	2	2	2	2	2	2	2
80-100	0	0	0	0	0	0	0	0	0
>100	0	0	0	0	0	0	0	0	0

Table F-92

YEAR: 1985
INTERCITY BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	1818	1818	1818	1818	1818	1818	1818	1818	1818
25-50	26	26	26	26	26	26	26	26	26
50-80	4	4	4	4	4	4	4	4	4
80-100	0	0	0	0	0	0	0	0	0
>100	0	0	0	0	0	0	0	0	0

Table F-93

YEAR: 1990
INTERCITY BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	2570	2570	2570	2570	2570	2570	2570	2572	2570
25-50	32	32	32	32	32	32	32	27	32
50-80	4	4	4	4	4	4	4	3	4
80-100	0	0	0	0	0	0	0	0	0
>100	0	0	0	0	0	0	0	0	0

Table F-94

YEAR: 1995
INTERCITY BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	3329	3329	3329	3329	3329	3329	3329	3342	3329
25-50	36	36	36	36	36	36	36	25	36
50-80	5	5	5	5	5	5	5	3	5
80-100	0	0	0	0	0	0	0	0	0
>100	0	0	0	0	0	0	0	0	0

Table F-95

YEAR: 2000
INTERCITY BUS (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	4212	4212	4212	4212	4212	4212	4212	4230	4212
25-50	39	39	39	39	39	39	39	25	39
50-80	6	6	6	6	6	6	6	2	6
80-100	0	0	0	0	0	0	0	0	0
>100	0	0	0	0	0	0	0	0	0

Table F-96

YEAR: 2008
INTERCITY BUS (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	5849	5849	5849	5849	5849	5849	5849	5869	5849
25-50	46	46	46	46	46	46	46	30	46
50-80	6	6	6	6	6	6	6	2	6
80-100	0	0	0	0	0	0	0	0	0
>100	0	0	0	0	0	0	0	0	0

Table F-97

YEAR: 1980
SCHOOL BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	8468	8468	8468	8468	8468	8468	8468	8468	8468
25-50	14005	14005	14005	14005	14005	14005	14005	14005	14005
50-80	4408	4408	4408	4408	4408	4408	4408	4408	4408
80-100	947	947	947	947	947	947	947	947	947
>100	31	31	31	31	31	31	31	31	31

Table F-98

YEAR: 1985
SCHOOL BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	10440	19038	19540	14951	19540	12704	10440	19540	19540
25-50	17266	11356	10963	14068	10963	15662	17266	10963	10963
50-80	5435	3333	3224	4361	3224	4897	5435	3224	3224
80-100	1168	602	602	937	602	1053	1168	602	602
>100	39	20	20	31	20	35	39	20	20

Table F-99

YEAR: 1990
SCHOOL BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	10881	26215	29138	29550	29568	24472	20291	29568	29138
25-50	17992	7454	5163	7311	4733	8235	11197	4733	5163
50-80	5667	1915	1284	2076	1284	2531	3527	1284	1284
80-100	1218	209	209	446	209	538	758	209	209
>100	40	7	7	15	7	18	25	7	7

Table F-100

YEAR: 1995
SCHOOL BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	10935	29205	33853	32782	34736	32754	30259	34737	33853
25-50	18074	5525	1882	2585	998	2360	4128	998	1882
50-80	5697	1223	220	484	220	706	1301	220	220
80-100	1225	22	22	104	22	280	280	22	22
>100	40	1	1	3	1	9	9	1	1

Table F-101

YEAR: 2000
SCHOOL BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	11155	30120	35187	35463	36616	36469	35865	36616	35187
25-50	18742	5412	1203	1216	73	174	602	73	1203
50-80	5812	1168	10	17	10	45	190	10	10
80-100	1250	0	0	3	0	10	40	0	0
>100	41	0	0	0	0	0	1	0	0

Table F-102

YEAR: 2008
SCHOOL BUSES (THOUSANDS OF PEOPLE)
DISTRIBUTION OF RIDERS BY PERCENT OF YEARLY ALLOWABLE EXPOSURE CONSUMED

%	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
0-25	11603	31334	36960	36960	38173	38173	38173	38173	36960
25-50	19180	5626	1214	1214	0	0	0	0	1214
50-80	6047	1214	0	0	0	0	0	0	0
80-100	1300	0	0	0	0	0	0	0	0
>100	43	0	0	0	0	0	0	0	0

Table F-103

SPEECH INTERFERENCE: PASSENGERS FOR TRANSIT BUSES

LWPH (THOUSANDS)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	6093.7	6093.7	6093.7	6093.7	6093.7	6093.7	6093.7	6093.7	6093.7
1985	8264.5	5993.5	5773.0	6891.3	5773.0	7574.5	8264.5	5773.0	5773.0
1990	9360.4	5144.0	3807.5	4585.8	3544.3	4914.6	6224.1	3460.3	3544.3
1995	10091.6	4807.5	2583.5	2835.4	2019.6	2567.7	3371.9	1801.5	2019.6
2000	10709.0	5013.1	2357.8	2359.4	1614.6	1656.0	1852.7	1308.3	1614.6
2008	11731.2	5491.0	2560.7	2560.7	1720.7	1720.7	1720.6	1366.7	1720.7

Table F-104

SPEECH INTERFERENCE: PASSENGERS FOR TRANSIT BUSES

RCI

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0	0	0	0	0	0	0	0	0
1985	-36.52	1.64	5.26	-13.09	5.26	-24.30	-35.62	5.26	5.26
1990	-53.61	15.50	37.52	24.75	41.84	19.35	-2.14	43.22	41.84
1995	-65.61	21.11	57.60	53.47	66.86	57.86	44.67	70.44	66.86
2000	-75.74	17.73	61.03	61.05	73.50	72.82	69.60	78.53	73.50
2008	-92.51	9.89	57.98	57.98	71.76	71.76	71.76	77.57	71.76

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-105

SPEECH INTERFERENCE: PASSENGERS FOR TRANSIT BUSES

RCI*

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	27.5	30.1	16.6	30.1	8.3	0.0	30.1	30.1
1990	0.0	45.0	59.3	51.0	62.1	47.5	33.5	63.0	62.1
1995	0.0	52.4	74.4	71.9	80.0	74.6	66.6	82.1	80.0
2000	0.0	53.2	78.0	78.0	84.9	84.5	82.7	87.8	84.9
2008	0.0	53.2	78.2	78.2	85.3	85.3	85.3	88.4	85.33

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-106

SPEECH INTERFERENCE: DRIVERS FOR TRANSIT BUSES

LWPH (THOUSANDS)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
1985	16.4	16.4	15.8	15.3	15.8	15.8	16.4	15.8	15.8
1990	18.8	18.8	15.4	14.9	13.9	13.9	15.0	13.3	13.9
1995	20.4	20.4	14.7	14.4	11.5	11.5	12.2	10.0	11.5
2000	21.8	21.8	14.9	14.9	10.8	10.8	10.9	8.6	10.8
2008	24.0	24.0	16.4	16.4	11.7	11.7	11.7	9.2	11.7

Table F-107

SPEECH INTERFERENCE: DRIVERS FOR TRANSIT BUSES

RCI

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0	0	0	0	0	0	0	0	0
1985	-37.82	-37.82	-32.77	-28.57	-32.77	-32.77	-37.82	-32.77	-32.77
1990	-57.98	-57.98	-29.41	-25.21	-16.81	-16.81	-26.05	-11.76	-16.81
1995	-71.43	-71.43	-23.53	-21.01	3.36	3.36	-2.52	15.97	3.36
2000	-83.19	-83.19	-25.21	-25.21	9.24	9.24	8.40	27.73	9.24
2008	-101.68	-101.68	-37.82	-37.82	1.68	1.68	1.68	22.69	1.68

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-108

SPEECH INTERFERENCE: DRIVERS FOR TRANSIT BUSES

RCI*

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	3.4	6.8	3.4	3.4	0.0	3.4	3.4
1990	0.0	0.0	18.2	20.8	25.9	25.9	20.2	29.0	25.9
1995	0.0	0.0	28.1	29.3	43.3	43.3	40.1	50.9	43.3
2000	0.0	0.0	31.6	31.7	50.5	50.5	49.8	60.5	50.5
2008	0.0	0.0	31.8	31.8	51.4	51.4	51.4	61.9	51.4

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-109

SPEECH INTERFERENCE: PASSENGERS FOR INTERCITY BUSES

LWPH (THOUSANDS)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	2649.0	2649.0	2649.0	2649.0	2649.0	2649.0	2649.0	2649.0	2649.0
1985	4181.5	4181.5	4103.3	4025.3	4103.3	4103.3	4181.5	4103.3	4103.3
1990	5725.5	5725.5	5154.0	5072.9	4901.3	4901.3	5078.1	4618.5	4901.3
1995	7405.0	7405.0	6275.8	6228.6	5633.6	5633.6	5755.8	4760.7	5633.6
2000	9281.2	9281.2	7696.9	7689.6	6704.9	6704.9	6704.2	5268.8	6704.9
2008	12780.1	12780.1	10583.2	10583.2	9176.5	9176.5	9176.5	7096.1	9176.5

Table F-110

SPEECH INTERFERENCE: PASSENGERS FOR INTERCITY BUSES

RCI

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0	0	0	0	0	0	0	0	0
1985	-57.85	-57.85	-54.90	-51.96	-54.90	-54.90	-57.85	-54.90	-54.90
1990	-116.14	-116.14	-94.56	-91.50	-85.02	-85.02	-91.70	-74.35	-85.02
1995	-179.54	-179.54	-136.91	-135.13	-113.80	-113.80	-117.43	-79.72	-113.80
2000	-250.36	-250.36	-190.56	-190.28	-153.11	-153.11	-154.44	-98.90	-153.11
2008	-382.45	-382.45	-299.52	-299.52	-246.41	-246.41	-246.41	-167.88	-246.41

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-111

SPEECH INTERFERENCE: PASSENGERS FOR INTERCITY BUSES

RCI*

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	1.9	3.7	1.9	1.9	0.0	1.9	1.9
1990	0.0	0.0	10.0	11.4	14.4	14.4	11.3	19.3	14.4
1995	0.0	0.0	15.2	15.9	23.9	23.9	22.2	35.7	23.9
2000	0.0	0.0	17.1	17.1	27.8	27.8	27.8	43.8	27.8
2008	0.0	0.0	17.2	17.2	28.2	28.2	28.2	44.5	28.2

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-112

SPEECH INTERFERENCE: DRIVERS FOR INTERCITY BUSES

LWPH (THOUSANDS)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
1985	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1990	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.1	2.3
1995	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.1	2.5
2000	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.2	2.8
2008	3.3	3.3	3.3	3.3	3.3	3.3	3.3	2.5	3.3

Table F-113

SPEECH INTERFERENCE: DRIVERS FOR INTERCITY BUSES

RCI

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0	0	0	0	0	0	0	0	0
1985	-33.33	-33.33	-33.33	-33.33	-33.33	-33.33	-33.33	-33.33	-33.33
1990	-53.33	-53.33	-53.33	-53.33	-53.33	-53.33	-53.33	-40.00	-53.33
1995	-66.67	-66.67	-66.67	-66.67	-66.67	-66.67	-66.67	-40.00	-66.67
2000	-86.67	-86.67	-86.67	-86.67	-86.67	-86.67	-86.67	-46.67	-86.67
2008	-120.00	-120.00	-120.00	-120.00	-120.00	-120.00	-120.00	-66.67	-120.00

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-114

SPEECH INTERFERENCE: DRIVERS FOR INTERCITY BUSES

RCI*

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.9	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.4	0.0
2008	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.2	0.0

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-115

SPEECH INTERFERENCE: PASSENGERS FOR SCHOOL BUSES

LWPH (THOUSANDS)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	7152.5	7152.5	7152.5	7152.5	7152.5	7152.5	7152.5	7152.5	7152.5
1985	8813.8	6338.0	6158.7	7446.1	6158.7	8127.8	8813.8	6158.7	6158.7
1990	9180.8	4768.0	3725.9	4613.8	3491.3	4957.9	6224.7	3406.4	3725.9
1995	9220.6	3966.9	2310.0	2598.2	1828.5	2398.2	3154.2	1617.0	2310.0
2000	9402.9	3951.5	2038.2	2043.1	1422.6	1465.0	1647.6	1134.0	2038.2
2008	9777.4	4108.3	2103.0	2103.0	1441.3	1441.3	1441.3	1123.7	2103.0

Table F-116

SPEECH INTERFERENCE: PASSENGERS FOR SCHOOL BUSES

RCI

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-23.23	11.39	13.89	-4.10	13.89	-13.64	-23.23	13.89	13.89
1990	-28.36	33.34	47.91	35.49	51.19	30.68	12.97	52.37	47.91
1995	-28.91	44.54	67.70	63.67	74.44	66.47	55.90	77.39	67.70
2000	-31.46	44.75	71.50	71.44	80.11	79.52	76.96	84.15	71.50
2008	-36.70	42.56	70.60	70.60	79.85	79.85	79.85	84.29	70.60

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-117

SPEECH INTERFERENCE: PASSENGERS FOR SCHOOL BUSES

RCI*

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	28.1	30.1	15.5	30.1	7.8	0.0	30.1	30.1
1990	0.0	48.1	59.4	49.7	62.0	46.0	32.2	62.9	59.4
1995	0.0	57.0	74.9	71.8	80.2	74.0	65.8	82.5	74.9
2000	0.0	58.0	78.3	78.3	84.9	84.4	82.5	87.9	78.3
2008	0.0	58.0	78.5	78.5	85.3	85.3	85.3	88.5	78.5

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

Table F-118

SPEECH INTERFERENCE: DRIVERS FOR SCHOOL BUSES

LWPH (THOUSANDS)

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8
1985	170.4	107.0	105.6	141.8	105.6	156.0	170.4	105.6	105.6
1990	183.6	66.7	58.5	84.8	55.5	94.3	121.7	54.1	58.5
1995	191.0	46.9	33.3	42.6	26.9	42.5	59.4	23.4	33.3
2000	198.3	46.0	30.1	30.4	21.7	22.9	27.1	16.9	30.1
2008	210.0	48.7	31.7	31.7	22.6	22.6	22.6	17.2	31.7

Table F-119

SPEECH INTERFERENCE: DRIVERS FOR SCHOOL BUSES

RCI

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	-27.35	19.81	21.08	-5.98	21.08	-16.59	-27.35	21.08	21.08
1990	-37.22	50.15	56.28	36.62	58.52	29.52	9.04	59.57	56.28
1995	-42.75	64.95	75.11	68.16	29.90	68.24	55.61	82.51	75.11
2000	-48.21	65.62	77.50	77.28	83.78	82.88	79.75	87.37	77.50
2008	-56.95	63.60	76.31	76.31	83.11	83.11	83.11	87.14	76.31

RCI = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the impact in 1980 with no regulation.

Table F-120

SPEECH INTERFERENCE: DRIVERS FOR SCHOOL BUSES

RCI*

Years	Baseline	Option 1	Option 2	Option 2A	Option 3	Option 3A	Option 3B	Option 4	Option 5
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	37.2	38.0	16.8	38.0	8.4	0.0	38.0	38.0
1990	0.0	63.7	68.1	53.8	69.8	48.6	33.7	70.5	68.1
1995	0.0	75.5	82.6	77.7	85.9	77.7	68.9	87.7	82.6
2000	0.0	76.8	84.8	84.6	89.0	88.4	86.3	91.5	84.8
2008	0.0	76.8	84.9	84.9	89.2	89.2	89.2	91.8	84.9

RCI* = Benefit in percent reduction of impact in the year-of-interest (with regulation) relative to the same year without regulation.

APPENDIX G

BUS NOISE ABATEMENT COSTS

Presented in this appendix are the estimated cost increases (decreases) required to manufacture buses quieter than those currently produced, for the various technology levels discussed in Section 5. This appendix is organized as follows:

I. Introduction

- Methodology
- Bus Classification

II. Manufacturing Process

- Gasoline Powered Conventional School Bus
- Diesel Powered Conventional School Bus
- Diesel Powered Integral Mid-Engine School Bus
- Diesel Powered Integral Rear Engine School Bus
- Diesel Powered Integral Intercity Bus

III. Estimating Equipment, Operating & Maintenance Costs, and Fuel Costs

- Equipment Costs
- Maintenance Costs
- Fuel Costs

IV. Enforcement Costs

- Introduction
- Methodology
- Estimating Costs

I-INTRODUCTION

METHODOLOGY

Using information developed by Booz-Allen Applied Research under EPA contract number 68-01-3509, technology packages were developed and distributed to bus manufacturers and bus component suppliers. These packages described study levels of bus noise abatement and recommended approaches to achieve those study levels.

Bus manufacturers were asked to provide, on a level-by-level basis, cost estimates to achieve the technology levels of bus noise abatement. In addition to the technology packages each manufacturer received:

- Cost estimating forms
- Lead time estimating forms, and
- Enforcement scenarios necessary for assessing costs attributable to compliance testing by manufacturers

Telephone contacts were made with all manufacturers receiving the technology packages. In addition, visits were made by EPA personnel and EPA consultants to various manufacturers in order to gain a better understanding of the different manufacturing processes used throughout the bus industry.

Component manufacturers were contacted and supplied with a copy of the technology packages that pertained to their product. These manufacturers were asked to furnish cost information for their products based on the recommendations in the technology package.

Cost information requested from the manufacturers was based on a manufacturing tolerance of 2 1/2 - 3 dB. For example, if the study level was 83 dB, the design level for manufacturing would be 80 - 80.5 dB.

When submitting cost estimates, the manufacturers were asked to break the costs into:

- Product cost
- Channel cost
- End-user cost

For each bus category, manufacturers were asked to identify each type of cost. The different types of costs were used to determine the impact on labor, material, quality control, investment and burden cost. No manufacturer supplied this information totally. A.M. General was the only manufacturer that provided some information on end-user costs, channel costs and product costs for transit buses.

Quality control and testing procedure costs were not broken out by any responding manufacturer. These costs were included in their responses. For the automotive-truck industry, costs related to quality control and testing normally represent 5%-8% of product cost. The estimated costs in this report include quality control and testing procedure costs.

A.M. General was the only responding company to indicate the additional investment required to meet the study levels of noise. On a level-by-level basis the investment required 3%-21% of total estimated cost. For the automotive-truck industry, every dollar of investment typically generates three dollars of revenue, on an annual basis. The estimated costs in this report include investment cost.

School bus body builders have equipment and tooling that are highly flexible. Many operations on different part configurations are possible. Wayne Corp., by using roll forming equipment, have, to some extent, limited their flexiblity.

Integral bus builders (intercity, transit, and school) have flexibility in their assembly process. No information was supplied by any integral bus manufacturers on the impact of engine encapsulation on bus design.

Estimated operating and maintenance costs were based on interviews with end-users, industry supplied information and components vendors.

Estimated costs in this report are associated with levels of bus noise abatement. By initiating the actions outlined in the technology study, the corresponding level of noise was assumed to be achieved. The first study level for each bus type is designated as Level 1, the second study level is Level 2, etc. Levels do not correspond to years.

The development of the EPA estimated costs was based, as much as possible, on manufacturers' knowledge of the industry, cost structure and technology. Components costs received from vendors were used to cross-check manufacturers' data and to provide a basis for estimating costs when required.

Guidelines followed in the construction of EPA cost estimates were:

- Manufacturers' data was used as much as possible.
- An hourly rate of $18 per hour was used to cover direct labor and all burdens charges.
- Labor hour changes were estimates.

Response to requests for cost estimates were slow with varying levels of participation by the companies. Firms that chose not to respond at all were:

- Chrysler Corporation
  Detroit, Michigan
- Blue Bird Body Company
  Fort Valley, Georgia
- Thomas Built Buses, Inc.
  High Point, North Carolina
- Gillig Brothers
  Hayward, California
- Ward School Bus Manufacturing, Inc.
  Conway, Arkansas

All other companies provided some information.

BUS CLASSIFICATION

Buses are normally classified into three major categories:

- School Buses
- Transit Buses
- Intercity Buses

Within each category various configurations of buses are possible. To estimate the cost impact of bus noise abatement, buses were classified as follows:

- Gasoline Powered Conventional School Buses
- Diesel Powered Conventional School Buses
- Forward Engine Forward Control School Buses
- Diesel Powered Integral Urban Transit Buses
- Diesel Powered Integral Mid-Engine School Buses
- Diesel Powered Integral Rear-Engine School Buses
- Diesel Powered Integral Intercity Buses

The definition of a bus used in this study is an engine-powered vehicle with an enclosed passenger compartment designed for the transportation of passengers on a street or a highway and having a Gross Vehicle Weight Rating (GVWR) in excess of 10,000 lbs. The vehicle's primary design is to transport passengers, not material, driver, etc.

II - MANUFACTURING PROCESS

Gasoline Powered Conventional School Bus

A completed conventional school bus is assembled by mounting a body onto a chassis. The chassis and the body are produced by two separate manufacturers. The school bus chassis is equipped with an engine located forward of the driver and passengers, a completed drive train, a completed steering mechanism and an engine cowl. The chassis itself is not a completed vehicle, per Federal specifications, that can be driven on a street or highway.

A conventional school bus chassis is similar to a medium duty truck chassis. As a result, school bus and truck chassis are/can be manufactured on the same assembly line utilizing many of the same components and manufacturing equipment. The primary differences between conventional school bus and truck chassis are the locations of the fuel and air tanks, the chassis rail configurations, the brake systems and the vehicle operator enclosures.

A typical assembly sequence for a bus chassis is:

- assemble frame and braces
- install front and rear axles
- mount engine and transmission
- locate chassis wire
- locate fluid lines
- bleed and test hydraulic system and air check
- paint frame
- install exhaust system
- mount tires
- hook up chassis wiring to lights and engine
- connect all chassis lines
- mount and hook cowls
- install radiator
- mount front end and bumper
- mount temporary driver seat
- install steering wheel
- add coolant to radiator
- add gas
- inspect
- deliver to shipping lot

Normally the front and rear axles, engine and transmission, tires, cab trim, and front end are off line assemblies. Conveyor systems move these subassemblies to the main line to match the chassis used.

This assembly sequence is the same as truck assembly. An individual not familiar with the two chasssis configurations or standing away from the assembly line cannot differentiate between the two.

After assembly the chassis is shipped to a body builder. Each chassis is accompanied by an incomplete vehicle document which states the Federal Standards to which the vehicles comply as built by the chassis builder.

The body builder mounts the body shell to the chassis and completes the interior of the shell. Body builders do not alter or change the chassis as received. Chassis builders maintain service representatives at the body builder's location to inspect the chassis after the body is mounted and to make repairs if required.

A typical assembly sequence for body builders is:

- fabricate, build and mate
  - floor
  - backend
  - side frames
  - roof
  - interior side panels
  - exterior side panels
  - ceiling
- undercoat
- mount exterior trim
- paint exterior and interior
- install floor coverings
- mount shell to chassis
- install
  - seats
  - windows

- lights
- heater, etc.

. letter

. inspect

. road test

. deliver to shipping lot

Normally subassembly operations are: seats, lights, flooring, and frames. Subassembly operations are as close to the assembly line as practical.

High flexibility is present due to the variation in bus lengths, in chassis designs between manufacturers and in specifications from each buyer. Normally no two buses are identical on the assembly line.

Federal Certification tags are placed on the completed bus by the body builder. Chassis builders furnish tags and specification sheets listing what standards the chassis will meet as long as components are not changed.

Both chassis and body manufacturers have a high degree of flexibility in their assembly sequence primarily due to the various requirements for a bus. Federal, State aand local governments plus each school district and school have individual standards that a school bus must meet. These standards can and do vary from state to state, local government to local government and school district to school district.

Diesel Powered Conventional School Bus

Diesel powered conventional school buses are basically the same as gasoline powered conventional school buses except for the engine. The same definitions of conventional school bus, chassis and body assembly methods can be used for the diesel bus. For the descriptions, refer to gasoline powered conventional school buses.

Diesel and gasoline engine chassis are mixed on the chassis assembly line. Differences between the two engines normally impact the subassembly area of engine and transmission. Work content may vary on the assembly line but production lines are balanced to account for these variations.

Body builders, as in gasoline powered buses, mount the body to the chassis. The type of engine does not impact their work methods.

Vehicle certification procedures are the same as for gasoline powered buses.

Forward Engine Forward Control School Bus

Diesel powered forward engine forward control school buses, gasoline powered forward engine forward control school buses and forward control buses, gasoline and diesel, are being combined for cost estimating purposes. These types of buses have many of the same characteristics, construction methods and technology packages for noise abatement. A primary difference between these buses is the interior layout of the bus. The layout changes with the use, such as a transit coach, school bus, luxury bus, etc.

These types of buses are not of integral construction. A body shell is mounted onto a chassis with two manufacturers involved. The buses are produced by companies that manufacture school buses. For descriptions of the assembly sequence, refer to the gasoline powered conventional school bus.

This type of bus is normally built on the same body assembly line as the conventional school bus. Extra work required is performed off the assembly line. Flexibility is present in the assembly process.

Federal Certification procedures are the same as for the conventional school bus.

Manufacturers must meet not only Federal requirements but also State and local governments and school district requirements. State and local governments and school district requirements can and often do vary among themselves.

Diesel Powered Integral Urban Transit Bus

Transit buses differ from conventional school buses in their manufacture. While conventional school buses are manufactured in a two-stage process (body on chassis) by two separate manufacturers, transit buses are manufactured by a single manufacturer who performs the entire assembly. For transit buses the floor, sides, ends and roof are joined into a one-piece construction to form the bus shell. The advantage to this type of construction is more efficient use of materials and space. Intercity buses and rear and mid-engine diesel school buses also employ this type of construction.

A typical assembly sequence for an integral transit bus is:

- fabricate and assemble
  - understructure
  - right and left sides
  - front and back end
  - roof
- join sections together
- assemble exterior skin
- assemble interior floor base and rubber covering
- install interior wires, controls, etc.
- mount undercarriage items
- paint interior and exterior
- mount wheels
- install windows and doors
- test for water leaks
- complete interior
  - seats
  - lights
  - controls
  - flooring
  - trim, etc.

- install engine, transmission and drive train
  - heating and cooling system
  - gas lines
  - air and hydraulic lines, etc.
- inspect bus
- road test
- deliver to shipping lot

Typical subassembly operations are: seats, windows, engine and transmission, front and rear axles, lights and air conditioners. The assembly sequence can overlap and many components not listed above are installed throughout the process. These procedures apply to the "New look" buses which are no longer produced in the United States. With the introduction of Advanced Design Buses both manufacturers have introduced some new manufacturing techniques. In general, though, the procedure mentioned above still applies.

High flexibility is present in the assembly process. Every bus order represents the specifications of that purchaser. As with the school buses, transit buses must meet Federal, State and local government standards. These standards can and do vary from state to state and local government to local government.

Diesel Powered Integral Mid-Engine School Buses

Diesel powered integral mid-engine school buses are constructed under the same principles as the urban transit bus. The entire bus supports the bus weight and provides strength.

A typical assembly sequence for this type of bus is:

- Chassis assembly
  - drill side rails
  - weld cross bars to the side rails
  - mount front end and front axle

- mount rear axle and rear suspension
- install engine, transmission, exhaust, controls, cooling system, electrical system, etc.

. Body assembly
  - build roof, both exterior and interior
  - build left side
  - build right side
  - build rear end

. mate body and chassis

. weld outriggers

. assemble exterior skin on all sides

. run engine

. paint

. complete interior
  - skin
  - seats
  - floors
  - windows
  - steering
  - lights, etc.

. complete mechanical hookup

. final inspect

. road test

. deliver to shipping lot

Typical subassemblies are: seats, windows, engine and transmission, axles, and lights.

Flexibility is present in the assembly process. Each bus order is built to the individual state and/or local school district specifications. In all cases Federal specifications must be met.

Diesel Powered Integral Rear Engine School Buses

Diesel powered integral rear engine school buses have the same type of construction as urban transit buses. The floor, sides, ends and roof are joined together into a one piece construction.

As with the urban transit bus, the advantage to this type of construction is more efficient use of material and space.

A typical assembly sequence for this type of bus is:

- assemble side rails and cross members
- assemble to frame assembly
  - front and rear axles
  - suspension
  - side rails
  - fire wall
  - air piping
  - engine and transmission
  - radiator and fan
- mount front platform for driver
- install long half sections across frame
- install flooring
- mount side posts
- assemble roof
- assemble side panels
- hook up connections
  - from engine
  - electrical
  - gauges
- undercoat
- remove temporary tires and mount permanent
- paint bus
- install

- windows
- finished floors
- seats
- final trim, etc.

. final inspection

. road test

. delivery to shipping lot

Typical subassemblies are: seats, windows, engine and transmissions, roof exterior and interior, axles and lights.

Flexibility is present in the assembly process. Each bus order is built to the Federal, State and local government specifications. The specifications can and do vary from state to state and locality to locality. In addition, each school district can and does have their own additional specifications.

Diesel Powered Integral Intercity Bus

Diesel powered integral intercity buses utilize the same type of construction as the diesel powered integral urban transit buses. The complete structure is load bearing and is a more efficient use of material and space compared to a conventional school bus.

A typical assembly sequence for integral intercity buses is:

. fabricate component parts

. assemble floor structure

. assemble front and back ends

. assemble sides

. assemble roof

. joint floor, ends, sides and roof

. install air lines, electrical interior

. install insulation

- paint
- letter
- complete interior of bus
  - lavatory
  - inside side panels
  - inside roof panels
- install front and rear axles
- install air conditioning
- install cooling system
- complete steering
- complete instrumentation
- install engine and transmission
- install seats
  - install windows
- complete air and electrical hookups
- inspect
- road test
- delivery to shipping lot

Typical subassemblies are: seats, windows, engine and transmission, roof exterior and interior, axles and lights.

Quality control checks are maintained throughout the manufacturing process. Before a bus is moved to the next work station, the production foreman and inspector must sign a check list.

Flexibility is present in the assembly process. Each bus is individually ordered and unique to that purchaser. The types of assembly lines employed lend themselves to variety in production and changes in mid-production.

III - ESTIMATED EQUIPMENT, OPERATING & MAINTENANCE COSTS

EQUIPMENT COSTS

The following series of tables present cost estimates for achieving various technology study levels. The tables are paired into sections, with each section representing one noise level. Within each section, the first table (suffix A) summarizes the cost estimates for each bus type, while the second table (suffix B) presents detailed material and labor cost estimates. Costs estimates for each individual noise abatement feature are presented in 1976 dollars. These costs estimates are aggregated in a later section of this appendix to form the basis of representative costs for the various technology levels. Those costs are presented in 1978 dollars.

The costs presented here were developed from information supplied by chassis manufacturers, body builders, and component vendors as described in the introduction.

Refinements of these costs were developed from the comments presented at the Public Hearings, recent technological changes, and revised estimates reflecting sound engineering judgment.

The costs presented are average costs. Since there are variations among the manufacturers and assemblers in types of equipment used (engine, transmission, etc.) and also on the techniques of manufacturing, i.e., roll forming versus press brake, welding versus riveting, etc., the cost differential cannot be pegged to one manufacturer or assembly method.

Noise levels examined are as follows:

Tables 1A, 1B	83	dB	exterior,	86	dB	interior
2A, 2B	80	"	"	83	"	"
3A, 3B	77	"	"	80	"	"
4A, 3B	75	"	"	78	"	"

School buses are divided into five categories, one gasoline and four diesel. The costs for diesel buses in Section 7 are a weighted average of the four costs, with the weights equal to each diesel's share of total diesel sales. These weights are .485 for diesel, .386 for front engine forward control, .099 for mid engine, and .030 for rear engine.

TABLE G-1A

COST OF NOISE ABATEMENT EQUIPMENT

(1976 dollars)

Exterior 83 dB

Interior 86 dB

School Buses	
Gasoline	$ 52*
Diesel	316*
Front Engine Forward Control	290
Mid Engine	227
Rear Engine	**
Urban Transit Bus	354
Intercity Bus	526
ADB	**

Source: Table G-1B

Notes: *If thermostatically controlled fans are not installed, the costs to reach an 83/86 level would be $25 and $290 respectively.

**Buses meet this regulatory level.

TABLE G-1B

BUS TYPE	NOISE CONTROL FEATURES 83E/86I (added to Current Buses)(1976 dollars)	COST Labor	4 Mat'l	Source
Conventional Gasoline Powered School Bus 14,000-30,200 lb. GVWR	. Best available mufflers	-	-	
	. Install thermostatically controlled fan drive	-	$ 52	
	. Improve fan shroud	-	25	Shroud estimate
	. Reduce fan speed	-	-	
Conventional Diesel-Powered School Bus 20,000-27,250 lb. GVWR	. Block and oil pan covers, valve cover or intake manifold isolation, cross-overs, damping on covers	$ 10	176	Estimated room catalog information
	. Line engine	5	25	Letter - labor estimate
	. Advanced double wrapped muffler and maybe resonator	3	45	Est. mat'l & comments/hearing
	. Install thermostatically controlled fan drive	-	52	
	. Improved fan shroud	1	25	Estimate
	. Reduce fan speed			
Front-Engine Forward Control	. Same as conventional gasoline and diesel-powered school buses	19	271	
Mid-Engine School Bus 20,000-27,000 lb. GVW	. Damped engine and oil pan covers, treated engine compartment (3)	12	137	Estimate
	. Advanced double wall muffler and resonator	3	75	Vendor estimate
	. Optimize cooling air flow			
	. Reduce fan speed			
Rear-Engine School Bus 20,000-27,000 lb. GVW	. Buses meet this design level			

TABLE G-15

BUS TYPE	NOISE CONTROL FEATURES 83E/86I (added to Current Buses)(1976 dollars)	COST Labor	4 Mat'l	Source
Urban Transit Bus 20,000-27,000 lb. GVWR	. Damped rocker arm covers	$2	$81	Estimated vendor info
	. Transmission loss treatment on interior	3	35	Estimated vendor discussion
	. Seal engine compartment			
	. Design radiator grill to prevent line of sight transmission to sound	1	35	Letter estimate
	. Advanced double wrapped mufflers (only for naturally aspirated engines)	2	20	Vendor info/labor est.
	. Reduce fan speed	3	125	Vendor info/mfg info
	. Best available air cleaner with careful sealing	2	45	Vendor info/labor est.
Intercity Bus 20,342-28,800 lb. GVWR	. Same as Urban Transit Bus except use turbocharger	13	341	
	. Exhaust with tail pipes rerouted to exist at roof line	5	75	Vendor est/labor est.
	. MCI buses may not need as extensive cooling system treatment	3	50	Estimate
	. Damping of bulkhead panels	4	35	Mat'l/labor estimates
ADB	. Buses meet this regulatory level			

<u>Cost references</u>
1. Motor-Parts & Time Guide, 1976, 1977, 1978.
2. Vendor information (vendor estimate).
3. Manufacturers price lists (manufacturer).
4. A.T. Kearney estimates (material and labor).

TABLE G-2A

COST OF NOISE ABATEMENT EQUIPMENT

(1976 dollars)

Exterior 80 dB

Interior 83 dB

School Buses	
Gasoline	$153*
Diesel	335*
Front Engine Forward Control	410
Mid-Engine	344
Rear Engine	378
Urban Transit Bus	849
Intercity Bus	1016
ADB	594

Source: Table G-2B

Note: *Gasoline school bus costs will be $215 and diesel school bus cost will be $410 if thermostatically controlled fans have not been installed.

TABLE G-2B

BUS TYPE	NOISE CONTROL FEATURES 80E/83I (added to Current Buses)(1976 dollars)	COST Labor	4 Mat'l	Source
Coventional Gasoline-Powered School Bus	. Line engine hood	$ 5	$ 35	Sound insulation, mastic, labor
	. Acoustical barrier between engine compartment and driver	5	25	Acoustical mat'l & labor
	. Seal firewall penetrations	10	5	Caulking mat'l & labor
	. Double muffler volume, optimize muffler location	5	45	$25 basic muffler, $20 double wrap
	. Vibration isolate exhaust system	3	15	3 vibrator mounts @ $5 each
	. Increase radiator and fan size	5	57	Switzer-vendor info
Conventional Diesel-Powered School Bus	. Engine side shields (24 ft^2)	5	174	Letter & Vendor info - labor estimate
	. Engine underpan from radiator to bell housing	3	35	Vendor info & labor estimate
	. Turbocharge or experimental truck mufflers	2	95	Vendor estimate
	. Increase radiator and fan size	3	72	
	. Improve intake filter for silencing	1	20	Estimate
Front-Engine Forward Control School Bus	. Same as conventional gasoline and diesel-powered school buses	14	396	
Mid-Engine School Bus	. Engine compartment underpan	2	72	Vendor info and estimate
	. Add large resonator to non-turbocharged exhaust systems	5	140	Vendor info and estimate
	. Seal all exhaust leaks	3	50	Caulking, insulation, labor
	. Improve engine mounts	1	36	4 mounts at $9 each
	. Reduce fan speed		$ 35	Estimate

TABLE G-2B

BUS TYPE	NOISE CONTROL FEATURES 80E/83I (added to Current Buses)(1976 dollars)	COST Labor	COST 4 Mat'l	Source
Rear-Engine School Bus	. Turbocharging or large resonator	$ 3	$ 100	Vendor est./labor
	. Seal exhaust leaks	2	20	Caulking, flashing & labor
	. Optimize fan shroud and fan coverage, adjust fan to radiator distance	3	250	Vendor est., hearing & comments
	. Reduce fan speed			
Urban Transit Bus	. Complete engine underpan	5	455	Vendor, mfg, info & est
	. Damped rocker arm covers	2	81	Mgf information
	. Transmission loss treatment on interior of existing engine compartment	3	32	Vendor info & estimate
	. Seal engine compartment noise	2	-	Estimate
	. Substitute turbocharged six for V-eight or add resonator, double wall muffler and gas-tight joints	4	80	Vendor info & estimate
	. Contoured shroud with optimized clearance and coverage	5	130	Vendor and mfg info
	. Reduce fan speed		50	Estimate
Intercity Bus	. Same as Urban Transit Bus	21	828	
	. MCI will use acoustic treatment on ducts to radiator	3	82	Estimate
	. Damping of panels	4	78	Mat'l & labor est.
ADB	. Full engine underpan	5	455	Mgf estimate
	. Turbocharge	4	80	Mgf estimate
	. Reduce fan speed		50	

TABLE G-3A

COST OF NOISE ABATEMENT EQUIPMENT

(1976 dollars)

Exterior 77 dB

Interior 80 dB

School Buses	
Gasoline	$ 331*
Diesel	1,250*
Front Engine Forward Control	1,250
Mid Engine	1,587
Rear Engine	1,898
Urban Transit Bus	1,809
Intercity Bus	2,528
ADB	1,460

Source: Table G-3B

Note: *Gasoline school bus cost will $224 and diesel school bus cost will $1,040 if thermostatically controlled fans have been installed.

TABLE G-3B

BUS TYPE	NOISE CONTROL FEATURES 77E/80I (added to Current Buses)(1976 dollars)	COST Labor	4 Mat'l	Source
Conventional Gasoline-Powered School Bus	. Engine side shields (20 ft^2)	5	190	Mfg. estimate and labor
	. Dual exhaust with mufflers	4	80	Level 1 $60 plus $20 for 2 resonators ($10 each) Donaldson/Storm Co.
	. Increase radiator and fan size (50% fan speed reduction)	1	51	Vendor estimate
	. Improved fan shroud			Switzer
Conventional Diesel-Powered School Bus	. Side shields with underpan or flow-through engine enclosure with special mounts	3	664	Mgf estimate
	. Isolate engine or body from chassis	2	10	4 shock isolators at $2.50
	. Turbocharge or experimental truck mufflers	3	125	Mfg estimate
	. Wrap exhaust pipes	2	-	Estimate
	. Increase radiator and fan size			
	. Reduce fan speed			
	. Improved fan shroud	4	198	Vendor & mfg est.
	. Air intake silencer	2	30	Estimate
	. Careful body design to minimize radiation from body panels including damping and stiffening	-	-	
	. Isolate body from chassis	3	64	4 shock isolators at $16
	. Double flooring	5	125	Estimate
	. Interior treatments if necessary: carpeting, roof, padding	10	-	Labor est.-mat'l include above

TABLE G-3B

BUS TYPE	NOISE CONTROL FEATURES 77E/80I (added to Current Buses)(1976 dollars)	COST Labor	Mat'l	Source
Front-Engine Forward Control School Bus	. Same as conventional gasoline and diesel-powered school bus	34	1,216	
Mid-Engine School Bus	. Add turbocharger and resonator	5	520	Mfg / vendor estimate
	. Enlarge radiator 10% and use contoured shroud		25	Estimate
	. Reduce fan speed		152	Estimate
	. Careful body design as above			
	. Possibly double flooring	25	860	Mfg / vendor estimate
Rear-Engine School Bus	. Add turbocharger and resonator or manifold muffler	5	330	Vendor / mfg estimate
	. Muffler with stack silencer	1	35	Vendor estimate
	. Sealed belly pan with acoustically treated exit duct	2	450	Estimate-vendor & mfg info
	. Line-of-sight shield between engine and fan	3		
	. Enlarge radiator by 10% and use contoured shield	3	420	Vendor estimate
	. Replace fan to deliver greater total head	2	175	Mfg estimate
	. Improved engine mounts	3		
	. Careful body design	15	450	Vendor estimate
	. Absorption treatment on inside of body	4	-	
Urban Transit Bus	. Complete engine underpans	10	455	Mfg / vendor estimate
	. Line-of-sight shielding between engine and radiator	2	155	Mfg / vendor estimate

TABLE G-3B

BUS TYPE	NOISE CONTROL FEATURES 77E/80I (added to Current Buses)(1976 dollars)	COST Labor	COST 4 Mat'l	Source
Urban Transit Bus (cont'd)	. Acoustically treated duct exit or louvers	4	125	Mfg and vendor estimate
	. Seal drive shaft opening and other openings	2	15	Mat'l & labor estimate
	. Auxiliary engine compartment ventilation	2	89	Additional fan labor
	. Substitute turbocharged six for V-eight or add double-wall muffler, resonator, and gas-tight joints	3	380	Vendor estimate
	. Larger fan and radiator or replace fan to increase pressure rise	2	530	Mfg & vendor estimate
	. Transmission loss treatment of engine compartment	3	32	Mat'l & labor estimate
Intercity Bus	. Same as Urban Transit Bus	28	1781	
	. Eagle buses will need shield between engine and air-conditioner condenser opening	3	40	Vendor estimate
	. Damping of bulkhead	2	30	Labor & mat'l estimate
	. Redesign engine mounts	2	35	Est engine mount cost
	. Damping of body panels	4	70	Labor & mat'l master spring
	. Sandwich construction flooring	3	190	Vendor estimate
	. Isolation of rear body	5	58	Labor & material
	. Sound absorbing lining on inside	5	272	Vendor estimate
ADB	. Complete engine enclosure	5	540	
	. Substitute turbocharge six for V-8	3	380	
	. Remote radiator with increase cooling capacity	2	530	

TABLE G-4A

COST OF NOISE ABATEMENT EQUIPMENT

(1976 dollars)

Exterior 75 dB

Interior 78 dB

School Buses	
Gasoline	$ 789
Diesel	1,697
Front Engine Forward Control	1,697
Mid-Engine	6,390
Rear-Engine	6,390
Urban Transit	3,327
Intercity Bus	3,654
ADB	2,315

Source: Table G-4B

TABLE G-4B

BUS TYPE	NOISE CONTROL FEATURES 75E/78I (added to Current Buses)(1976 dollars)	COST Labor	 4 Mat'l	Source
Conventional Gasoline-Powered School Bus	. Engine side shields and underpan between radiator and bell housing (flow restriction may require increase in fan speed)	$10	$ 375	355 (shroud) plus 20 (Switzer fan est)
	. Dual exhaust with mufflers and resonators	3	125	Donaldson (105) & Stam Co. (20)
	. Increase cooling capacity	2	34	GM
	. Isolate engine or body	5	20	4 stock isolators $20
	. Stiffen or damp body panels	15	35	Spray coating
	. Double flooring	5	150	Carpenter
	. Interior sound absorption	10		
Conventional Diesel-Powered School Bus	. Turbocharge engine			
	. Sealed tunnel-type flow-through engine enclosure	5	752	Estimate[4]
	. Manifold mufflers or advanced double-walled dual mufflers, double-wall exhaust piping, and pipe joint seals	5	185	[1] [4]
	. Optimize cooling system increase capacity and redesign layout	3	225	Estimate[4]
	. Isolate engine or body	5	20	Estimate[2] [4]
	. Stiffen or damp body panels			
	. Sandwich construction flooring	22	475	Vendor & ATK est.
	. Interior sound absorption	-	-	
Front-Engine Forward Control School Bus	Same as conventional gasoline and diesel-powered school buses			

TABLE G-4B

BUS TYPE	NOISE CONTROL FEATURES 75E/78I (added to Current Buses)(1976 dollars)	COST Labor	4 Mat'l	Source
Mid-Engine School Bus	• Sealed tunnel-type flow-through engine enclosure	5	1,505	1 2 4
	• Advanced exhaust system or turbocharging	3	770	2 4
	• Increase cooling capacity; water cooling exhaust manifolds may be required	10	1,490	1 2 4
	• Low noise transmission gears	2	235	3 4
	• Isolate engine and body	4	860	2 4
	• Interior sound absorption	10	861	2 4
	• Sandwich construction flooring	5	250	2 4
	• Stiffen or damp body panels	5	375	2 4
Rear-Engine School Bus	• Same as Mid-Engine School Bus			
Urban Transit Bus	• Sealed tunnel-type flow-through engine enclosure	10	900	2 4
	• Turbocharge engine or double-wall-muffler, resonator and gas-tight joints	3	330	2 4
	• Water-cooled manifolds	1	275	2 4
	• Optimize air flow, may require centrifugal fans	4	823	2 4
	• Engine and body isolation	5	362	2 4
	• Stiffen or damp body panels	5	609	2 4
	• Interior sound absorption			

TABLE G-4B

BUS TYPE	NOISE CONTROL FEATURES 75E/78I (added to Current Buses)(1976 dollars)	COST Labor	& Mat'l	Source
Intercity Bus	. Sealed tunnel-type flow-through engine enclosure	5	900	2 4
	. Transmission enclosure	3	600	2 4
	. Enclosures may need fans to circulate air	9	823	2 4
	. Turbocharge engine or double-wall muffler, resonator and gas-tight joints	5	350	2 4
	. Water cooled manifolds	2	250	2
	. Optimize air flow, may require centrifugal fans	2		4
	. Engine and body isolation	5		4
	. Stiffen or damp body panels	5	362	4
	. Interior sound absorption	5		
ADB	. Complete engine enclosure	10	900	
	. Turbocharged engine	3	330	
	. Remote radiator with increase cooling capacity	2	530	
	. Water cooled manifolds	1	275	
	. Acoustical louvers	4	125	
	. Enclosed cooling system	5	130	

Cost References

1 Motor-Parts & Time Guide, 1976, 1977, 1978.

2 Vendor Information (vendor estimate)

3 Manufacturers price lists (manufacturer)

4 A.T. Kearney estimates (material and labor)

Maintenance Costs

Changes in maintenance costs will undoubtedly occur with the addition of the noise abatement requirements previously discussed for school buses.

The complexity of maintenance will increase with each level of noise abatement, where additional shielding, pan covers, shrouds, sealing, and such are required. Routine maintenance which requires removal of the noise control features to allow access, adds an additional labor element to this function.

School Buses

The dollar amount of bus maintenance costs is determined both by the type of maintenance program and bus usage. It is difficult to predict even an average figure since each bus system's cost varies from others. The following costs, in Table G-5 are based primarily on user, manufacturer, and interviews.

TABLE G-5

ESTIMATED COST OF MAINTENANCE FOR SCHOOL BUSES DUE TO NOISE ABATEMENT REQUIREMENTS

(1976 Dollars per Bus)

	EPA Estimated Cost Per Year ($)				
Level	A*	B*	C	D	E
1	$ 12	$ 0	$ 20	$100	$100
2	$ 26	$ 30	$155	$305	$305
3	$183	$ 46	$215	$520	$520
4	$195	$515	$450	$830	$830

* Maintenance costs are given in 1978 dollars and reflect maintenance expenditure from medium and heavy truck (chassis) background document.

A. Gasoline Powered Conventional School Bus

B. Diesel Powered Conventional School Bus

C. Forward Engine Forward Control School Bus

D. Diesel Powered Integral Mid-Engine School Bus

E. Diesel Powered Integral Rear-Engine School Bus

Urban Transit Buses

Impact on maintenance costs will result from changes proposed for the technology study levels. These changes include increased labor and some additional parts. The transit bus, because of its unitized construction, will be more affected by a lack of accessibility for maintenance. The result will be more labor costs for maintenance, compared to the conventional school bus.

As previously stated, the cost of maintenance will vary between transit companies. Maintenance functions, and their related costs, will also vary among the bus designs of each manufacturer. The techniques and approaches undertaken by each manufacturer will be sufficiently different to prevent a standard, across the board, cost estimate from being applicable. The costs presented are averages for bus maintenance impacts due to noise abatement requirements.

TABLE G-6

AVERAGE MAINTENANCE COST FOR DIESEL POWERED INTEGRAL URBAN TRANSIT BUSES

(1976 Dollars per Bus)

Level	Exterior dB	Interior dB	Estimated Costs
1	83	86	$ 140
2	80	83	$ 305
3	77	80	$ 520
4	75	78	$ 830

Intercity Buses

It has been estimated that maintenance costs due to noise abatement requirements will be similar to those developed for the diesel powered integral urban transit buses.

ADB's

The types of designs presently being developed, may limit accessibility for maintenance. Adding the impact of the noise abatement requirements, there may be additional constraints imposed on maintenance. Within the engine compartment, additional ventilation may be required. Since sound deadening acoustic material prevents natural heat withdrawal, exhaust fans may be needed.

TABLE G-7

AVERAGE MAINTENANCE COST
FOR ADB BUSES DUE TO
NOISE ABATEMENT REQUIREMENTS

(1976 Dollars per Bus)

Level	Exterior dB	Interior dB	Estimated Costs
1	83	86	*
2	80	83	$255
3	77	80	$475
4	75	78	$785

* Buses met this design level.

Estimation of Impacts on Fuel Economy Costs

Each noise abatement feature recommended by Booz-Allen and Hamilton was summarized in Tables 1 through 5 in their report, "The Impact of Bus Noise Emission Reduction on Fuel Consumption." dated April 28, 1978. (Ref. 2) This report, prepared under EPA Contract No. 68-01-3509, evaluated each of the noise abatement features in terms of weight penalty, increased cooling requirements, and fuel economy improvements that might be produced.

Methodology

Since the major impact imposed by the noise abatement regulations on buses is the additional weight added by these features, the effect of the added weight on fuel consumption must be determined.

In some cases noise abatement techniques are also energy-efficient. The range of fuel economy improvement is also determined. General Motors suggested, in their Docket Presentation, ONAC Docket #74-2, April 10, 1974, that increased fuel consumption could be evaluated by the formulas:

$$\text{Diesel Fuel Consumption} = \frac{4.9 \text{ Gallons}}{100 \text{ lb. weight}} \text{ per 10,000 vehicle miles}$$

$$\text{Gasoline Fuel Consumption} = \frac{7.6 \text{ Gallons}}{100 \text{ lb. weight}} \text{ per 10,000 vehicle miles}$$

The average vehicle miles used in the calculation are presented below. (Ref. 1)

Bus Industry	Annual Vehicle Miles
Transit Bus	37,608
Intercity Bus	55,858
School Bus	8,939

With the mix within each industry segment of diesel and gasoline fuel engines, an average of the two formulas was taken to calculate fuel economy impacts. The final formula used was:

Fuel Consumption = $\frac{\text{6.25 Gallons}}{\text{100 lb. weight}}$ per 10,000 vehicle miles,

at 60 cents per Gallon fuel cost.

= Dollar cost per vehicle miles.

The sixty cents per gallon of fuel cost was an average figure of both the diesel fuel and gasoline fuel prices at fleet cost standards. The majority of bus companies negotiate fleet rates with their fuel suppliers thus enabling a lower rate than the consumer incurs. Due to constantly rising fuel costs, the discussion here concentrates on percent increases.

Estimation of Fuel Cost Impact

Based upon the weight penalties developed by Booz-Allen (Ref. 2), the bus industry data and the formulas presented in the previous section, Methodology, the cost impact estimates are presented in the following figures rounded to the nearest 5 dollars.

The tables on the following pages present the range of fuel cost impact imposed by the additional weight resulting from the noise abatement requirements. The figures do not present what the net additional cost may be due to the noise abatement features. Certain types of noise abatement equipment, such as thermostatically controlled fans, turbochargers or modified mufflers may affects buses' fuel economy due to a change in engine performance in addition to the weight change. These performance benefits are also presented.

(1) Conventional and Forward Control Gasoline-Powered School Buses

83 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
Negligible	0-5 percent	$ 0

The fuel economy improvement of up to five percent will result from improvements in cooling system optimization or the substitution of a fan clutch.

80 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
50 lbs.	0-5 percent	$ 0

Overall, the penalty is insignificant. Cooling system optimization will contribute to performance benefits. Compared to the bus meeting the 83 dB regulated level, this benefit may not be realized as the cooling system will already be optimized.

77 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
230 lbs.	2-5 percent	$10

Buses will benefit from use of larger fans operating at lower speeds or the use of fan clutches. The weight penalty will reduce fuel economy about one percent for the smaller buses (14,000 GVWR) and one-half of one percent for the larger buses.

75 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
925 lbs.	4-7 percent	$30

The flow through engine enclosure could offset all benefit gained from optimizing cooling system flow. However, the viscous fan drive will still increase performance. The large weight penalty, due to extensive acoustic treatmont, will reduce fuel economy by three to seven percent. At this level, a larger cooling system capacity might be needed to handle extra heat load due to enclosure.

(2) <u>Conventional and Front-Engine Forward Control Diesel-Powered School Buses</u>

<u>83 dB Exterior Noise Level</u>

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
75 lbs.	3-7 percent	$5

Principal weight gain is from larger double-wrapped muffler and engine covers. Since diesel powered school buses range from 20,200 to 27,250 lbs. in gross weight, the effect on fuel economy will not be measurable. The performance benefits are from reduced fan horsepower and reduced fan-on time.

<u>80 dB Exterior Noise Level</u>

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
200 lbs.	0-6 percent	$5

The use of turbocharged engine is optional at this noise level. The benefits from turbocharging alone, if used, would be of the order of five percent. The weight penalty will reduce the performance benefits by about one percent.

<u>77 dB Exterior Noise Level</u>

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
900 lbs.	0-6 percent	$30

Turbocharging is likely to be utilized because of emissions requirements. The large weight penalty is due to the use of double flooring and interior acoustic treatments. Reduction in fuel economy due to this weight could be about 4.5 percent for local operation.

<u>75 dB Exterior Noise Level</u>

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
925 lbs.	4-6 percent	$30

The principal benefits will be derived from use of a viscous fan drive and turbocharging. The large weight penalty, due to the extensive acoustic treatment, will reduce fuel economy by three to five percent. Even with a variable fan speed, a larger radiator and fan will probably be needed.

(3) Mid-Engine School Buses

83 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
75 lbs.	2-4 percent	$5

Mid-engine school buses will benefit from cooling system optimization, but the optimization will be more difficult due to space restrictions. The weight penalty is insignificant.

80 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
100 lbs.	2-4 percent	$5

The weight penalty is from the engine compartment belly pan and larger exhaust system. Performance benefits with respect to the 83 dB bus are not significant.

77 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
500 lbs.	0-5 percent	$15

Weight penalty is from double flooring and strengthening the body. This will reduce fuel economy by an estimated two percent in local and short-haul service. Principal performance benefit is from adding a turbocharger and increasing radiator size. Because of space restrictions and increased engine compartment cooling demands, the benefit might be difficult to realize.

75 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
975 lbs.	4-7 percent	$35

For all buses at this level, the principal benefits will be derived from viscous or variable speed fan drive and turbocharging. All buses at this level will also have a large weight penalty due to the extensive acoustic treatment. Fuel economy for this bus may be reduced three to four percent. Even with variable fan speed, larger radiator and fans might be needed.

(4) Rear-Engine School Buses

83 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
0	0	0

The buses already meet this level.

80 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
75 lbs.	3-6 percent	$5

Optional turbocharger will produce about five percent benefit. There is room for cooling system optimization and with a viscous clutch fan, a minimum three percent benefit is expected over current fuel economy.

77 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
550 lbs.	3-6 percent	$20

Weight penalty is due to belly pan, strengthening of body and absorptive treatment inside the bus. Turbocharging will help fuel economy.

75 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
975 lbs.	4-7 percent	$35

The principal benefits will be derived from viscous fan drives and turbocharging. Buses meeting this level will also have a large weight penalty due to extensive acoustic treatment. Fuel economy for this bus will be reduced three to four percent. Even with variable fan speed, larger radiator and fans might be needed.

(5) Urban Transit Bus ("New Look" Design)

83 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
300 lbs.	0-2 percent	$40

Fuel economy should improve if the cooling system is redesigned. The weight penalty is from the engine compartment lining and larger mufflers. Fuel economy will be reduced less than one percent from this added weight.

80 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
250 lbs.	0-5 percent	$35

Turbocharged engine, if utilized, will produce a benefit of close to five percent (5). The larger weight penalty will result if the turbocharged engine option is not utilized, neutralizing all benefits from cooling system improvement.

77 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
500 lbs.	0-5 percent	$70

Weight penalty is due to the complete engine enclosure, larger radiator which will probably be remote from the engine, and double-walled muffler. This will result in reduced fuel economy of the order of 1.6 percent.

75 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
775 lbs.	0-5 percent	$110

The additional weight penalty at this level, three to four percent, is due to body damping, and interior sound absorbing treatments. The turbocharger option and variable speed fan contribute to increased fuel economy. The complete engine enclosure may offset benefits gained from optimizing cooling system flow.

(6) Advance Design Bus (ADB)

83 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
0	0	0

The buses will meet this level without additional noise abatement features.

80 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
320 lbs.	None	$45

The engine may need to be enclosed. Fuel economy will suffer by one percent.

77 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
560 lbs.	None	$80

The increased weight from larger mufflers body strengthening and damping will lower fuel economy by one and one-half percent.

75 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
900 lbs.	None	$125

The increased weight due to the extensive acoustic treatment will lower fuel economy by approximately three and one-half percent.

(7) Intercity Buses

83 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
335 lbs.	0-5 percent	$70

The noise control features are similar to those for urban transit buses. Turbocharging would be favored. This will result in somewhat better performance improvement than in the case of urban transit buses.

80 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
365 lbs.	0-5 percent	$75

The requirement for damping of bulkhead results in higher weight penalties compared to urban transit buses. Loss of fuel economy due to weight will be less than one-half percent because of the long haul mode of operation of intercity buses.

77 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
650 lbs.	0-2 percent	$135

The larger weight increase comes from double thickness flooring and additional sound absorption treatment inside the bus. Fuel economy could be reduced by one and one-half to two and one-half percent.

75 dB Exterior Noise Level

Weight Penalty:	Performance Benefit:	Average Cost Per Bus Per Year (1978 dollars)
900 lbs.	0-2 percent	$190

The weight penalty is three to four percent. The performance benefit is derived from the turbocharger option and variable speed fan drive. Even with variable fan speed, larger radiator and fans might be needed.

IV - ENFORCEMENT COSTS

INTRODUCTION

Estimated costs for enforcement are included in the cost estimates presented in the preceding sections. Manufacturers contacted would not provide detailed information concerning enforcement costs, other than to say they are included in their overall cost estimates.

To understand the potential cost/impact of enforcement requirements, the bus industry was divided into four segments:

- Non-integral school buses with engines enclosed by the body manufacturer (These buses are to be tested for exterior noise by the body manufacturer.)
- School bus chassis with engine enclosed by the chassis manufacturer (These buses are to be tested for exterior noise by the chassis manufacturer.)
- Transit buses (These buses are to be tested for interior and exterior noise by the integral manufacturer.)
- Intercity buses and integrally constructed school buses (These buses are to be tested for interior and exterior noise by the integral manufacturer.)

An estimated cost per bus was developed for each segment. Since some companies produce buses in more than one segment, each segment has been treated separately.

METHODOLOGY

The estimated costs have been based on the following points:

Test requirements are based on an Enforcement Scenario developed by EPA, summarized in Table G-8. Each manufacturer is normally subject to one Selective Enforcement Audit comprising of an average of 13 tests.

Tests are conducted for compliance testing only, and not for gathering engineering data.

Construction of a test facility is not required.

Cost per test for Product Verification or Selective Enforcement Auditing is $350 (Table G-9).

- Equipment cost per year is $600 (Table G-9).

- Interior and exterior measurements can be taken simultaneously.

- Manufacturers will generally be required to test only their loudest configurations during Selective Enforcement Auditing.

- Product Verification tests must be performed for each category and configuration. Manufacturers may vary from the range of PV tests estimated by EPA to be typical for that type of manufacturer.

TABLE G-8

EPA ENFORCEMENT TEST REQUIREMENTS PER MANUFACTURER

	Integral Manufacturer			Chassis Manufacturer			Body Manufacturer		
	PV Tests		SEA(1)	PV Tests		SEA(1)	PV Tests		SEA(1)
	Low	High	Tests	Low	High	Tests	Low	High	Tests
Non-integral School Bus with engine enclosed by chassis manufacturer	-	-	-	10	25	13	-	-	-
Non-integral School Bus with engine enclosed by manufacturer	-	-	-	-	-	-	10	25	13
Transit Bus	8	20	13	-	-	-	-	-	-
Intercity Bus or Integrally Constructed School Bus	8	20	13	-	-	-	-	-	-

(1) This is the average number of tests required assuming one Selective Enforcement Audit per year per manufacturer.

TABLE G-9

ESTIMATE COST PER TEST (EXTERIOR OR INTERIOR)
1978 DOLLARS

I. Manpower:

- 2 Technicians @ $150/day each	$300
- 1 Engineer @ $300/day each	300
	$600

II. Time required to set up, run, record and file necessary data:
4 hours 2 tests per day

III. Average miles driven: 20 @ cost of $2.50/mile, which includes:

- Driver
- Gas and oil
- Other expenses related to a test, e.g., test site, etc.

IV. Cost per test:

($600 - 2) plus 50 = $350

V. Equipment cost $6,000 with a useful life of 10 years or a cost per year of $600.

Source: Conversations with:

Riverbank Acoustical Lab
U.S. Testing Company
Bendix Automotive Proving Grounds

Based on the above points, a weighted average for each segment of the bus industry was made to develop an estimated cost per bus for enforcement purposes.

ESTIMATED COSTS

Tables G-12, G-14, G-16, and G-18 show estimates of production (and market share) for school bus chassis, school bus bodies, transit buses, and intercity and integral school buses, respectively. The estimated costs per bus for enforcement for each of these bus types are shown in Tables G-13, G-15, G-17, and G-19, respectively. These costs should be considered as typical for a bus of that type. Production and market share data are combined with enforcement cost data to provide estimates of enforcement costs incurred by manufacturers.

Table G-10 summarizes the estimated costs for non-integral school buses.

TABLE G-10

ESTIMATED ENFORCEMENT COSTS
FOR DIFFERENT BUS TYPES

Bus Type	Test	EPA Estimated Cost
Non-Integral School Buses with Engines Enclosed by Chassis Manufacturer--all study levels	Exterior	$ 1.59
Non-Integral School Buses with Engines Enclosed by Body Manufacturer--all study levels	Exterior	$16.11
Transit Buses--all study levels	Exterior and Interior	$14.41
Intercity and Integrally Constructed School Buses--all study levels	Exterior and Interior	$30.72

Source:

1. Tables G-11 and G-12.
2. Tables G-13 and G-14.
3. Tables G-15 and G-16.
4. Tables G-17 and G-18.

TABLE G-11

SCHOOL BUSES - CHASSIS

Manufacturer	1977 Market Share	Domestic Units[1] Produced
Chevrolet	11.0%	3,335
Ford	24.4%	7,364
GMC	8.2%	2,482
International Harvester	50.5%	15,262
Others	5.9%	1,778
Total	100.0%	30,221

(1) Includes Chassis with engines enclosed by body manufacturers. Chassis manufacturer will not test these.

Source: Section 3
Section 7

TABLE G-12

ENFORCEMENT TEST COSTS
SCHOOL BUS CHASSIS
1976 DOLLARS

Company	Units Sold	Equipment Cost Per Year/Bus	SEA at High	PV Test			PV Cost Per Bus			SEA	Total Estimated Cost (1)		
				Low	Mid	High	Low	Mid	High	Cost/Bus	Low	Mid	High
Chevrolet	3,335	$.18	$4,550	$3,500	$6,125	$8,750	$1.05	$1.84	$2.62	$1.36	$2.59	$3.38	$4.16
G.M.C.	2,482	.24	4,550	3,500	6,125	8,750	1.41	2.47	3.53	1.83	3.72	4.54	5.60
Ford	7,364	.08	4,550	3,500	6,125	8,750	.48	.83	1.19	.62	1.18	1.53	1.89
International Harvester	15,262	.04	4,550	3,500	6,125	8,750	.23	.40	.57	.30	.57	.74	.91
Average Based on Market Share											$1.09	$1.59	$1.95

(1) Includes equipment cost, PV and SEA Tests

Source: Tables G-8, G-9, and G-11

TABLE G-13

SCHOOL BUSES - BODY

Company	Units[1]
Blue Bird	800[2]
Superior	800
Thomas	600
Carpenter	600

(1) Estimates based upon interviews with manufacturers. These vehicles include large forward control and pusher models as well as smaller parcel delivery models. In some cases, the body manufacturer also manufactures the chassis.

(2) Data not available. EPA estimate.

TABLE G-14

ENFORCEMENT TEST COSTS
SCHOOL BUS BODIES
1976 DOLLARS

Non-integral School Buses with Engines Enclosed by Body Manufacturer

ompany	Units Sold	Equipment Cost Per Year/Bus	SEA at High	PV Test			PV Cost Per Bus			SEA	Total Estimated Cost (1)		
				Low	Mid	High	Low	Mid	High	Cost/Bus	Low	Mid	High
lue Bird	800	$ .75	$4,550	$3,500	$6,125	$8,750	$4.44	$ 7.66	$10.94	$5.69	$10.88	$14.10	$17.38
uperior	800	.75	4,550	3,500	6,125	8,750	4.44	7.66	10.94	5.69	10.88	14.10	17.38
homas	600	1.00	4,550	3,500	6,125	8,750	5.83	10.21	14.58	7.58	14.41	18.79	23.16
arpenter	600	1.00	4,550	3,500	6,125	8,750	5.83	10.21	14.58	7.58	14.41	18.79	23.16
verage Based on Market Share											$ 12.36	$ 16.11	$19.86

(1) Includes equipment costs, PV and SEA test

Source: Tables G-8, G-9, and G-13

TABLE G-15

TRANSIT BUSES

Company	Units[1]
General Motors	1,600
Gillig	150
Flxible	800[2]
Transportation Manufacturing Corporation	240

(1) EPA estimates based upon interviewing with manufacturers.

(2) projected.

TABLE G-16

ENFORCEMENT TEST COSTS
TRANSIT BUSES
1976 DOLLARS

Company	Units Sold	Equipment Cost Per Year/Bus	SEA at High	PV Test			PV Cost Per Bus			SEA	Total Estimated Cost (1)		
				Low	Mid	High	Low	Mid	High	Cost/Bus	Low	Mid	High
General Motors	1,600	$ .38	$4,550	$2,800	$4,900	$7,000	$ 1.75	$ 3.06	$ 4.38	$ 2.84	$ 4.97	$ 6.28	$7.60
Gillig	150	4.00	4,550	2,800	4,490	7,000	18.67	32.67	46.67	30.33	53.00	66.93	81.00
Flxible	800	.75	4,550	2,800	4,900	7,000	3.50	6.13	8.75	5.69	9.94	12.57	15.19
Transportation Manufacturing Corporation	130	2.50	4,550	2,800	4,900	7,000	11.67	20.42	29.17	18.96	33.13	41.88	50.63
Average Based on Market Share											$11.38	$14.41	$17.42

(1) Includes Equipment Cost, PV and SEA Tests

Source: Tables G-8, G-9, G-15.

TABLE G-17

INTERCITY BUSES AND INTEGRAL SCHOOL BUSES

Company	Units(1)
Crown Coach	500
Eagle International	200
General Motors	300
Gillig	250
Motor Coach Industires	540
Prevost	100
Transportation Manufacturing Corporation	400

(1) These figures are estimates based upon interviews with manufacturers. Some of these may be built for Canadian market.

TABLE G-18

ENFORCEMENT TEST COSTS
INTERCITY BUSES
1976 DOLLARS

Intercity Buses and Integrally Constructed School Buses

Company	Units Sold	Equipment Cost Per Year/Bus	SEA at High	PV Test Low	PV Test Mid	PV Test High	PV Cost Per Bus Low	PV Cost Per Bus Mid	PV Cost Per Bus High	SEA Cost/Bus	Total Estimated Cost (1) Low	Total Estimated Cost (1) Mid	Total Estimated Cost (1) High
Crown	500	$1.2	$4,550	$2,800	$4,900	$7,000	$ 5.6	$ 9.8	$14.0	$ 9.1	$15.9	$20.1	$24.3
Eagle Int'l	200	3.0	4,550	2,800	4,900	7,000	14.0	24.5	35.0	22.75	39.75	50.25	60.75
General Motors	300	2.0	4,450	2,800	4,900	7,000	9.33	16.33	23.33	15.17	26.50	33.50	40.50
Gillig	250	2.4	4,550	2,800	4,900	7,000	11.2	19.6	28.0	18.2	31.8	40.20	48.60
Motor Coach Industries	540	1.11	4,550	2,800	4,900	7,000	5.19	9.07	12.96	8.43	14.73	18.61	22.50
Prevost	100	6.0	4,550	2,800	4,900	7,000	28.0	49.00	70.00	45.50	79.50	100.50	121.50
Transportation Manufacturing Corporation	400	1.5	4,550	2,800	4,900	7,000	7.0	12.25	17.5	11.38	19.88	25.13	30.38
Average Based on Market Share											24.30	30.72	37.14

(1) Includes Equipment Costs, PV and SEA Tests

Source: Tables G-8, G-9 and G-14

REFERENCES

APPENDIX G

1. "Costs of Noise Abatement to Meet Noise Emissions Standards in the Bus Manufacturing Industry" Preliminary Draft Update submitted by A.T. Kearney, Inc., under EPA contract #68-01-3512, September, 1978.

2. "The Impact of Bus Noise Emission Reduction on Fuel Consumption" Report submitted by Booz-Allen and Hamilton, under EPA contract #68-01-3509, April 28, 1978.

3. Correspondence from George McLennan, Booz-Allen and Hamilton to Francine Ely, EPA, April 29, 1980.

APPENDIX H

ESTIMATES OF DEMAND ELASTICITIES FOR URBAN BUS TRANSIT AND INTERCITY BUS TRANSPORTATION

This appendix reviews some of the pertinent econometric literature and reports estimates made of the fare-elasticity of demand for both intra-city and intercity bus transit. The estimating model is based on one developed by Nelson (Ref. 1). The cross-sectional test of intra-urban transit demand in a sample of U.S. metropolitan areas used in Nelson's model is repeated for the year 1974. Results are compared with Nelson's estimates for the years 1960 and 1968, and some tentative explanations for the observed lower fare elasticity in 1974 are offered.

For intercity bus travel demand, the same model is applied to time series of annual aggregate U.S. data. The fits are generally quite satisfactory, subject to the caveat that the time series sample may overstate the significance of the results when substantial autocorrelation is present.

Both time series and cross-section estimates reveal fare-elasticities of demand that are of the same order of magnitude, ranging from -0.20 to -0.80. This range is somewhat above the industry rule-of-thumb of -0.30, but is by no means contradictory, given the nature of the approximations and data involved. The data also exhibit positive cross-elasticities with respect to completing mode (auto and rail), though the precision of the estimates is not adequate for predictive purposes.

Part 1 of Appendix H reviews the econometric model and describes the notation. Parts 2 and 3 record the results of the statistical tests for urban transit demand and intercity bus travel demand, respectively. These results are applied in Parts 7-A and 7-B of the Economic Impact Analysis (Section 7).

H - I ECONOMETRIC MODEL OF TRANSIT DEMAND

Consider a given geographical area, such as an urban center or the United States intercity highway network. Bus service B, defined as vehicle miles of service provided per year, may be thought of as a factor input in the production of transportation services to the population of the given region. Since passengers are to some extent flexible as to trip schedules and destination points, but not perfectly so, bus service B encounters diminishing returns in the production of transportation services as saturation of the potential market increases.

Demand D for bus service, defined as revenue passenger miles of service obtained per year, depends both upon the quantity B of service provided and upon other demand characteristics of the market served: the age and income of the population, the availability of auto, rail, and other competing modes of transportation, the fare per mile F charged to revenue passengers (and fares on competing modes), and other exogenous factors which may differentiate one urbanized area from another or which reflect changes in the demand for bus transit over time.

EQUILIBRIUM IN THE TRANSIT MARKET

Transit firms experience total revenue equal to FD and total costs equal to CB, where C is the average cost per mile of vehicle operation. Nelson's paper (Ref. 1) provides evidence that there are no scale economies in the operations of bus transit firms, hence that a linear approximation of the cost function does not misrepresent the empirical evidence.

Since transit firms operate in a regulated environment, equilibrium is not necessarily determined by the "competitive" condition that total revenues less total costs (FD-CB) yield profits just sufficient to give the firm a competitive return on its total invested capital. Rather, the regulatory authority imposes on the transit firm a constraint, such as a rate of return criterion or a set ratio of revenues to costs, and the firm responds accordingly. Nelson summarizes the action of the regulatory authority in terms of a target cost-revenue ratio k:

$$k = CB / FD.$$

If k is treated as an exogenous, predetermined component of the model, then equilibrium is determined by the condition CB = kFD.

The full model may be written:

Supply: B = B (POP, AREA, D,C,k) + u
Demand: D = D (B, POP, F,F', Area, Auto, Hway, GNI) + v
Equilibrium: CB = kFD

Here POP is the population of the given geographical region, AREA its area, HWAY its highway capacity per capita, F' the fare per passenger mile on competing modes of transportation, and GNI the level of real per capita income. B (bus service supplied), D (ridership demanded), and F (fare per passenger mile) are endogenous, jointly determined variables, while the remaining quantities, including C (cost per vehicle mile) and k (cost/revenue criterion), are exogenous (predetermined). The symbols u and v represent random, independent error terms.

DETERMINANTS OF THE COST/REVENUE RATIO K

Urban bus transit systems have undergone a significant revolution in ownership and profitability during the post World War II period, and a general perspective is useful to understanding the nature of the regulatory constraint, k. Tables H-1 and H-2 record some pertinent statistics. As indicated in Table H-1, there has been a persistent decline in the operational profitability of bus transit operations, both at a local level and in terms of national aggregates. The assumption that k is exogenous to the transit sytem is at best a crude approximation, since other regulatory constraints on service B and the fare F certainly come into play.

Nelson finds that for the 1960 and 1968 cross-section samples of urban bus transit systems, the variable k is better "explained" in terms of regulatory variables such as private-versus-public ownership and the locality of regulatory control than by the various operating characteristics such as costs of operation, highway capacity, etc. His finding justifies treatment of k as exogenous, but it also suggests that conclusions of the empirical tests may be affected by the rapid increase in public ownership of transit systems that has occurred during the past two decades (Table H-2).

ESTIMATION OF THE ECONOMETRIC MODEL

The above model is an example of an (over-) identified simultaneous equations model with endogenous variables B, D, and F, and exogenous variables POP, HWAY, C, k, AUTO, F', and GNI. The standard technique for estimating such models is two-stage least squares (2SLS), an adaptation of ordinary least squares (OLS) wherein correlations between jointly determined

TABLE H-1

TREND OF TRANSIT OPERATIONS, 1940-1977

Calendar Year	Operating Revenue (millions)	Operating Expense (millions)	Cost-Revenue Ratio
1940	$ 737.0	$ 660.7	0.896
1945	1,380.4	1,231.7	0.892
1950	1,452.1	1,385.7	0.954
1955	1,426.4	1,370.7	0.961
1960	1,407.2	1,376.5	0.978
1965	1,443.8	1,454.4	1.007
1966	1,478.5	1,515.6	1.025
1967	1,556.0	1,622.6	1.043
1968	1,562.7	1,723.8	1.103
1969	1,625.6	1,846.1	1.136
1970	1,707.4	1,995.6	1.169
1971	1,740.7	2,152.1	1.236
1972	1,728.5	2,241.6	1.297
1973	1,797.6	2,536.1	1.411
1974	1,939.7	3,239.4	1.670
1975	2,002.4	3,705.9	1.851
1976	2,161.1	4,020.9	1.86
1977	2,280.0	4,304.8	1.89

Note: Table H-1 shows operating revenue and expense for all public transit systems (railway, trolley and bus). Estimates for transit bus operations alone are approximately 70% of the figures shown.

Soure: American Public Transit Association, Transit Fact Book '77-'78 Table 4.

TABLE H-2

PUBLIC OWNERSHIP OF U.S. MASS TRANSIT SYSTEMS, SELECTED STATISTICS, 1967-77

Statistics	1967	1969	1971	1973	1975	1977
Number of Systems	98 (9%)	131 (12%)	151 (14%)	185 (18%)	333 (35%)	455 (45%)
Operating Revenue (mil)	930 (60%)	1,219 (75%)	1,445 (83%)	1,581 (88%)	1,729 (86%)	2,044 (90%)
Vehicle Miles Operated (mil)	1,027 (51%)	1,239 (63%)	1,292 (70%)	1,431 (78%)	1,706 (86%)	1,790 (89%)
No. of Employees (thous)	87 (60%)	108 (77%)	118 (85%)	126 (90%)	138 (86%)	N.A.
Total Transit Vehicles Owned and Leased	30,026 (48%)	38,590 (63%)	41,301 (68%)	47,508 (79%)	51,964 (83%)	54,662 (86%)
Motor Buses	19,527 (39%)	27,110 (55%)	29,982 (61%)	35,732 (74%)	40,583 (80%)	43,422 (84%)
Subway & Elevated	1,794 (95%)	9,343 (100%)	9,325 (100%)	9,276 (100%)	9,608 (100%)	-
Surface Railway	734 (59%)	1,190 (90%)	1,176 (96%)	1,037 (96%)	982 (93%)	-
Trolley Coaches	971 (78%)	947 (88%)	913 (88%)	1,013 (100%)	703 (100%)	-
						11,240 (99%)*

* All Electric Transit Vehicles Owned and Leased (Subway, Railway and Trolley)

Note: Percentages are with respect to estimated industry total.

Source: American Public Transit Association, Transit Fact Book, various issues.

endogenous variables and the error terms u and v are eliminated prior to estimation of the structural relationships.

It should be noted, however, that the 2SLS technique is not necessarily preferable to OLS, particularly where specification error is involved (Ref. 2). For this reason both methods of estimation are reported below.

REVIEW OF RECENT STUDIES OF URBAN TRANSIT DEMAND

Two significant studies have examined urban bus transit demand within a given locale instead of for aggregate cross-section or time-series data. Kraft and Domencich (Ref. 3) use an origin-and-destination survey from the Boston area to estimate travel demand elasticities with respect to both service (time) and fare. What small effects they determine fall mainly on the service variable, and their estimates of the fare elasticity are low, between -0.09 and -0.33. Notably, cross elasticities with respect to automobile operating costs are neglible.

A more recent study by Schmenner (Ref. 4) analyzes patronage data on a route-by-route basis for the cities of Hartford, New Haven, and Stamford, Connecticut. Time series regressions for data provided by a local bus company indicate an elasticity of demand with respect to fare per mile of between -0.80 and -1.03. Schmenner attributes his higher estimates of fare elasticity to reduced error due to aggregation in his sample. His data also exhibit a positive cross-elasticity with respect to automobile operating costs.

The Nelson study (1972) is subject to Schmenner's criticism that the estimates are probably biased towards zero due to aggregation, since the unit of observation is the transit system for an entire urbanized area.

Information on a cross-section of transit systems (e.g., Table H-3) is published annually by the American Public Transit Association in its Transit Operating Report. The sample each year consists of member firms whose transit operations are devoted solely to bus transportation, without competition from rail or trolley. While the total sample size (number of firms) has stayed relatively constant over the years, it is subject to relatively high turnover from one year to the next, so that cross-sectional comparisons for different years are not strictly equivalent. The 1974 sample for the present study contains 19 (of 52) firms that were not present in either the 1960 or 1968 (Nelson) samples.

H-II CROSS SECTION ESTIMATES OF URBAN BUS TRANSIT MODEL

Nelson's results for 1960 and 1968 are presented in Tables H-4 and H-5, along with parallel regression results for 1974. Data sources for the 1974 regressions are reviewed in Tables H-6 and H-7 for the Urban Trban Transit Bus model.

SUPPLY EQUATION ESTIMATES

The supply equations for 1974 conform well to Nelson's previous estimates, with the significant exception of variables C and k, both related to the cost of operations. As indicated in Table H-2, the last decade has witnessed a significant increase in the number of publicly owned and subsidized urban mass transit systems, particularly in connection with the Urban Mass Transporation Act of 1964, which subsidized both purchases of new equipment and conversion of private transit firms to private ownership.

TABLE H-3

1974 Sample of Bus Firms and Urbanized Areas

Location	Company Name
Akron, OH	Metro Regional Transit Authority
Albany, NY	Capital District Transportation Authority
Albuquerque, NM	Albuquerque Transit System
Amarillo, TX	Amarillo Transit System
Atlanta, GA	Metropolitan Atlanta Rapid Transit Authority
Baltimore, MD	Maryland Department of Transportation Mass Transit District
Binghamton, NY	Broome County Transit
Charleston, SC	South Caroline Electric and Gas Company
Charleston, WV	Karawha Valley Regional Transportation Authority
Charlotte, NC	Charlotte City Coach Lines, Inc.
Chattanooga, TN	Chattanooga Area Regional Transportation Authority
Cincinnati, OH	Southwest Ohio Regional Transit Authority
Columbia, SC	South Carolina Electric and Gas Company
Columbia, OH	Central Ohio Transit Authority
Corpus Christi, TX	Corpus Christi Transit System
Dallas, TX	Dallas Transit System
Duluth, MN	Duluth Transit Authority
El Paso, TX	Country Club Bus Lines, Inc.
Fort Worth, TX	McDonald Transit, Inc. dba CITRAN
Greenville, SC	Greenville City Coach Lines, Inc.
Harrisburg, PA	Cumberland-Dauphin-Harrisburg Transit Authority
Huntington, WV	Tri-State Transit Authority
Houston, TX	Houston Transit System/Rapid Transit Lines, Inc.
Jacksonville, FL	Jacksonville Transportation Authority
Kansas City, MO	Kansas City Area Transportation Authority
Lewiston, ME	Hudson Bus Lines
Lincoln, NE	Lincoln Transportation System
Madison, WI	City of Madison Department of Transportation
Memphis, TN	Memphis Area Transit Authority
Miami, FL	Metropolitan Dade County Transit Agency
Milwaukee, WI	Milwaukee & Suburban Transport Corporation
Minneapolis-St. Paul, MN	Twin Cities Area Metropolitan Transit Commission
Monterey, CA	Monterey Peninsula Transit
Muskegon, MI	Muskegon Area Transit System
Nashville, TN	Metropolitan Transit Authority
Norfolk, VA	Tidewater Metro Transit
Omaha, NE	Transit Authority of the City of Omaha
Portland, OR	Tri-County Metropolitan Transportation District of Oregon
Raleigh, NC	Raleigh City Coach Lines, Inc.
Rochester, NY	Regional Transit Service, Inc.
St. Louis, MO	Bi-State Transit System
San Diego, CA	San Diego Transit Corporation
Savannah, GA	Savannah Transit Authority

TABLE H-3 (Continued)

Location	Company Name
Springfield, MO	City Utilities of Springfield
Stockton, CA	Stockton Metropolitan Transit District
Syracuse, NY	CNY Centro, Inc.
Toledo, OH	Toledo Area Regional Transit Authority
Tulsa, OK	Metropolitan Tulsa Transit Authority
Waco, TX	Waco Transit System
Wichita, KS	Wichita Metropolitan Transit Authority
Wilmington, DE	Delaware Authority for Regional Transportation
Winston-Salem, NC	Winston-Salem Transit Authority

TABLE H-4

Estimates of the Supply Equation For Urban Bus Transit Service

Statistic	1960[a] (2SLS)	1968[a] (2SLS)	1974 (OLS)	1974 (2SLS)
Dependent Variable	ln B	ln B	ln B	ln B
Independent Variable				
Constant	-1.05	1.42	.448	.359
(t-statistic)	(-1.75)	(1.41)	(1.68)	(1.00)
ln POP	.055	.248	.193	.406
	(0.42)	(1.75	(1.54)	(1.73)
ln AREA	.008	.055	.142	.151
	(0.13)	(0.76)	(1.36)	(1.14)
ln D	.927	.727	.648	-.007
	(7.08)	(7.08)	(14.13)	(-0.03)
ln C	-.446	-.601	-.043	.490
	(-2.70)	(-3.66)	(-0.26)	(3.64)
ln R	-.511	-.065	.230	.575
	(-2.09)	(-0.34)	(2.06)	(2.03)
R^2	.971	.982	.972	.958
Standard Error	.133	.170	.217	.268
Number of Observations	44	51	52	52

Note: [a]From Gary R. Nelson, "An Econometric Model of Urban Transit Operations." Table 4.5 of John D. Wells, et al, Economic Characteristics of the Urban Transportation Industry (Washington D.C.: U.S. Government Printing Office, 1972).

TABLE H-5

Estimates of the Demand Equation For Urban Bus Transit Service

Statistic	1960[a] (2SLS)	1968[a] (2SLS)	1974 (OLS)	1974 (2SLS)
Dependent Variable	ln D	ln D	ln D	ln D
Independent Variable				
Constant (t-statistic)	NR	NR	7.412 (6.94)	9.485 (3.31)
$-(B/POP)^{-0.3}$	6.54 (5.84)	8.81 (4.41)	6.81 (14.19)	9.458 (2.91)
F	-4.52 (-3.70)	-3.06 (-1.91)	-.669 (-1.25)	-0.183 (-0.20)
ln POP	1.11 (17.34)	1.10 (8.46)	1.037 (6.51)	0.974 (4.36)
ln AREA	.002 (0.03)	.0208 (0.19)	.0809 (0.52)	-.0069 (-0.03)
ln AUTOS	-.106 (-0.96)	-.175 (-0.44)	-.175 (-.51)	.0691 (0.13)
ln HWAY	--	.156 (0.98)	.784 (4.12)	1.022 (2.68)
POURTY[b]	-1.61 (-1.49)	-3.02 (02.93)	1.215 (0.65)	-.743 (-0.22)
INC 15[c]	-0.40 (-0.33)	-3.57 (-1.81)	.0798 (0.05)	2.393 (-0.63)
AGE 18[d]	-1.74 (-1.53	-5.95 (-2.44)	-4.149 (-2.02)	-1.029 (-0.22)
AGE 65[e]	(-0.87) (-0.54)	(-8.17) (-2.39)	(-3.607) (-1.33)	(-5.623) (-1.30)

TABLE H-5 (Continued)

Statistic	1960[a] (2SLS)	1968[a] (2SLS)	1974 (OLS)	1974 (2SLS)
R2	.986	.976	.974	.954
Standard Error	.113	.227	.270	.356
Number of Observations	44	51	52	52
Fare Elasticity Evaluated at Mean Fare	-0.81 (-3.70)	-0.67 (-1.91)	-0.20 (-1.25)	-0.05 (0.20)

Notes: [a]From Gary R. Nelson, "An Econometric Model of Urban Transit Operations." Table 4.6 of John D. Wells et al, Economic Characteristics of the Urban Transportation Industry (Washington, D.C.: U.S. Government Printing Office, 1972).

[b]Percent of households below poverty level ($3,000 for 1960 and 1968).

[c]Percent of households with income above $15,000 ($10,000 in 1960 and 1968).

[d]Percent of population under 18 years of age.

[e]Percent of population over 65 years of age.

TABLE H-6

TREND OF AVERAGE FARE, MOTOR BUS URBAN TRANSIT, 1940 - 77

Calendar Year	Average Fare	Consumer Price Index (1967=100)	Average Real Fare
1940	6.87	42.0	16.36
1945	7.07	53.9	13.12
1950	9.56	72.1	13.26
1955	14.41	80.2	17.97
1960	17.96	88.7	20.25
1965	20.55	94.5	21.75
1966	21.23	97.2	21.84
1967	22.39	100.0	22.39
1968	23.20	104.2	22.26
1969	25.71	109.8	23.42
1970	29.41	116.3	25.29
1971	32.23	121.3	26.57
1972	33.07	125.3	26.39
1973	32.40	133.1	24.34
1974	31.76	147.7	21.50
1975	31.99	161.2	19.84
1976	32.77	170.5	19.22
1977	34.90p	181.5	19.23

Source: American Public Transit Association, Transit Fact Book '77-78 Table 12. p: preliminary

TABLE H-7

Cross-Section Urban Transit Regressions:
Definition of Variables and Their Sources

Variable	Definition and Source
AGE 18	Fraction of Population Under Age 18 years in 1970. U.S. Census of Population (1970), Vol. 1 Part 1, Table 66 (Urbanized areas).
AGE 65	Fraction of Population over Age 65 years in 1970. U.S. Census of Ppulation (1970), Vol. I, Part 1, Table 66 (Urbanized Areas).
AREA	Land Area of Urbanized Area. U.S. Census of Population (1970), Vol. I, Part A, Section 1, Table 20.
AUTOS	Automobiles per Capita, by County, 1973. Rand McNally & Co., Commercial Atlas and Marketing Guide, 107th edition. (New York, 1976).
B	Line Service Bus Miles. American Public Transit Association, Transit Operating Report (1974): Section D, Operating Statistics, Item 3.
CPM	Operation Expense per Total Bus Mile. American Public Transit Association, Transit Operating Report (1974): Section D, Derived Statistics, Item 2.
D	Total Revenue Passengers. American Public Transit Association. Transit Operating Report (1974): Section D, Operating Statistics, Item 27.
F	Revenue per Revenue Passenger. American Public Transit Association, Transit Operating Report (1974): Section D, Operating Statistics, Item 27 and Operating Revenues and Operating Expenses, Item 1.
HWAY 68	Population Per Unit of Highway Capacity, 1968. Highway capacity estimated by the formula: $8720x + 2500y$, where x is miles of freeways and expressways and y is all other road miles. Federal Highway Administration, National Highway Needs Report, 1970 (91st Congress). Washington, D.C., U.S. Government Printing Office: 49-840-0.

TABLE H-7 (Continued)

Variable	Definition and Source
INC15	Fraction of Households with Income in Excess of $15,000 per year in 1970. U.S. Census of Population (1970), Vol. I, part 1, Table 183.
k	Ratio of Expenses to Revenues. American Public Transit Association, Transit Operating Report (1974): Section D, Income Statement, Items 1 and 2.
MPH	Bus Miles Per Hour (Line Service). American Public Transit Association, Transit Operating Report (1974): Section D, Derived Statistics, Item 4.
POP	Population of Urbanized Area. American Public Transit Association, Transit Operating Report (1974): Section D, Operating Statistics, Item 1.
POVRTY	Fraction of Households Below Poverty Level in 1970. U.S. Census of Population (1970), Vol. I, Part 1, Table 183.

Whereas the cost/revenue ratio k is negatively associated with supply of service in 1960, the reverse appears to be true in 1974: firms with greater service B, holding constant population, demand, etc., experience higher ratios of cost to revenue. This change highlights the importance of the shift from private to public ownership.

DEMAND EQUATION ESTIMATES

The same phenomenon may explain the relatively poor performance of the two-stage least squares fits for the demand equation in 1974. Apparently, Nelson's sophisticated model is misspecified as applied to the 1974 urban setting, and ordinary least squares estimation is probably preferable (that is, treating service B and average fare F as exogenous, predetermined variables).

The following results may be concluded from Table H-5:

1) Improved service levels B relative to population POP holding constant the fare per mile F and highway capacity per capita HWAY, attract greater ridership. This result has been found in virtually all empirical studies of urban transit.

2) Demand D is inelastic with respect to the fare F, and the fare elasticity has declined in absolute value since 1968. In part, this decline may be attributed to a fall in the real fare (Table H-6) relative to rising real wages (which measure the opportunity cost of travel time). In the economic impact analysis covering transit buses (Section 7, Part B) an average (-0.5) of the three 2SLS point estimates (1960, 1968, 1974) in Table H-7 was used for the demand (fare) elasticity estimate.

3) Bus patronage is unresponsive to measures of income dispersion (PVRTY and INC15), but is significantly increased in cities where the population in the 19 to 64 age group is greater. This result is consistent with Nelson's finding that bus transit demand is determined primarily by trips to and from people's places of employment.

4) The coefficients on per-capita automobile ownership are not significantly different from zero, but they are mostly negative, indicating a very slight positive cross elasticity with respect to the automobile mode of travel.

H-III TIME SERIES ESTIMATES OF INTERCITY BUS TRANSPORTATION DEMAND

Table H-8 records regression coefficients for the demand model as applied to time series of intercity bus transportation statistics. Data sources are reviewed in Table H-9 for the Intercity Bus Model.

The fits are generally satisfactory. Due to the presence of significant autocorrelation in the residuals of the log-log form of the regressions (Durbin-Watson statistic = 1.31), a first-difference formulation was tried with somewhat better results (Durbin-Watson statistic = 1.77).

The following results are concluded from Table H-8:

1) Intercity bus patronage D is responsive to service B, as with urban transit.

2) The fare elasticity of intercity bus travel demand is about -0.50, holding constant the availability and fare on competing modes (auto and rail). A one percent increase in bus fares relative to rail fares results in an additional 0.03 percent decrease in bus patronage.

3) The income elasticity of intercity bus demand is small but positive (around 0.20), indicating that distributional impacts of fare increases do not necessarily affect only lower income groups.

TABLE H-8

ESTIMATES OF THE DEMAND EQUATION
FOR INTERCITY BUS TRANSPORTATION,
1948 - 73

Statistic	OLS	2SLS	OLS[a]
Dependent Variable	ln D	ln D	ln D
Independent Variable			
Constant (t-statistic)	-16.14 (-3.25)	-16.03 (-2.99)	.044 (1.72)
ln B	.953 (10.95)	.959 (6.90)	1.003 (8.12)
ln POP	.493 (2.08)	.501 (1.78)	-.143 (-.13)
ln F	-.448 (-3.00)	-.446 (-3.00)	-17.47 (-3.30)
F/FRAIL	-.026 (-1.14)	-.026 (-1.13)	-.030 (-1.46)
ln AUTO	-.693 (-3.25)	-.685 (-2.61)	-2.283 (-2.37)
ln GNI	.207 (1.30)	.201 (1.03)	.332 (2.34)
lN HWAY	-.142	-.135	--
R	.985	.985	.919
Standard Error	.015	.015	.017
Durbin-Watson	1.31	1.31	1.77
Number of Observations	26	26	25

Note: The 2SLS estimates treat ln B as a jointly determined dependent variable, identified by the excluded variables ln C and ln K.

A first-difference form of the demand equation: the constant reflects a trend coefficient; ln F is replaced by the first difference in F; F/FRAIL is replaced by the first differences in F/FRAIL; all other variables are replaced by the first differences in natural logarithms. The coefficient F implies a fare elasticity of -0.497, evaluated at the mean fare.

TABLE H-9

INTERCITY BUS TRANSIT TIME SERIES REGRESSIONS: DEFINITION OF VARIABLES AND THEIR SOURCES

VARIABLE	DEFINITION AND SOURCE
AUTO	Passenger Car and Taxi Registrations, U.S., per capita. Department of Transportation, Summary of Transportation Statistics, Table 9.
B	Vehicle Miles Operated. Regular-Route Intercity Service, Class I Carriers. National Association of Motor Bus Owners, Fact Book, Table 4.
C	Cost per mile of bus service. Regular Route Intercity Service, Class I Carriers. Estimated as: C = CPMB = (E- (TR-R))/B, where TR is total operating revenues, R is passenger revenues on intercity regular routes, E is total operating expenses, and B is vehicle miles operated. National Association of Motor Bus Owners, Fact Book, Tables 3 and 4. Deflated by the Consumer Price Index (1967=1.00).
CPI	Consumer Price Index, 1967=1.00. U.S. Department of Commerce, Bureau of Economic Analysis.
D	Revenue Passenger Miles, Regular-Route Intercity Service, Class I Carriers. National Association of Motor Bus Owners, Fact Book, Table 4.
F	Revenue per Passenger Mile, Regular-Route Intercity Service, Class I Carriers. F=R/D, where R is passenger revenue on intercity routes and D is revenue passenger miles. National Association of Motor Bus Owners, Fact Book, Tables 3 and 4. Deflated by the Consumer Price Index (1967=1.00).
FRAIL=FPMR	Rail Per Passenger Mile. Class I rail, other than commutation. Department of Transportation, Summary of Transportation Statistics, Table I.
GNI	Real per Capita U.S. National Income. U.S. Department of Commerce, Bureau of Economic Analysis.

TABLE H-9 (Continued)

VARIABLE	DEFINITION AND SOURCE
HWAY	U.S. Intercity Highway Mileage per Capita. Department of transportation, Summary of Transportation Statistics, Table 8.
k	Cost/Revenue, Intercity Buses. Regular Route Intercity Service, Class I Carriers: k = CPMB/RPMB.
POP	U.S. Total Population. U.S. Department of Commerce, Bureau of the Census.
RPMB	Revenue per Mile, Buses. Regular-route intercity service: revenue from Table 3 of National Association of Motor Bus Owners, Fact Book, Miles Operated = B.

REFERENCES

APPENDIX H

1. Gary R. Nelson, "An Econometric Model of Urban Bus Transit Operations". Chapter IV of John D. Wells et al, Economic Characteristics of the Urban Public Transportation Industry (Washington, D.C.: U.S. Government Printing Office, 1972).

2. J. Johnston, Econometric Methods, Chapter 10 (New York, 1963).

3. G. Kraft and T. Domencich, Free Transit, Boston, Mass.: D. C. Heath and Company, 1971.

4. R. Schmenner, "The Demand for Urban Bus Transit", Journal of Transport Economics and Policy (January, 1976) 9:68-66.

5. "A Study to Determine the Economic Impact of Noise Emission Standards in the Bus Manufacturing Industry", Draft Final Report submitted by A. T. Kearney, Inc. under Contract No. 68-01-3512, prepared for the Office of Noise Abatement and Control, September, 1976.

APPENDIX I

UNIFORM ANNUALIZED COSTS

OF BUS NOISE ABATEMENT

Intercity Buses - Option 1

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1982

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.7107	0.7107	0.4239	0.2868
1982	1.4544	2.1651	0.8765	0.5779
1983	2.1915	4.3567	1.3348	0.8568
1984	2.9431	7.2998	1.8114	1.1317
1985	3.6796	10.9794	2.2892	1.3904
1986	4.4049	15.3842	2.7704	1.6345
1987	5.1437	20.5280	3.2699	1.8738
1988	5.8725	26.4004	3.7740	2.0984
1989	6.5987	32.9991	4.2873	2.3113
1990	7.3273	40.3264	4.8130	2.5143
1991	7.4986	47.8249	4.9273	2.5712
1992	7.6495	55.4744	5.0259	2.6236
1993	7.8116	63.2859	5.1320	2.6796
1994	7.9684	71.2543	5.2332	2.7351
1995	8.1435	79.3977	5.3474	2.7961
1996	8.3338	87.7315	5.4722	2.8615
1997	8.5196	96.2511	5.5932	2.9264
1998	8.7201	104.9712	5.7245	2.9956
1999	8.9296	113.9007	5.8620	3.0675
2000	9.1439	123.0446	6.0027	3.1412
2001	9.3631	132.4077	6.1466	3.2164
2002	9.5875	141.9951	6.2940	3.2935
2003	9.8175	151.8126	6.4450	3.3725
2004	10.0531	161.8657	6.5997	3.4534
2005	10.2943	172.1600	6.7580	3.5363
2006	10.5411	182.7011	6.9200	3.6211
2007	10.7942	193.4953	7.0861	3.7081
2008	11.0532	204.5485	7.2562	3.7970
2009	11.3185	215.8670	7.4303	3.8882
2010	11.5901	227.4571	7.6086	3.9815

PRESENT VALUE OF ANNUAL COSTS = 49.9041

EQUIVALENT ANNUAL COST = 5.2647 MILLION DOLLARS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					
BASELINE PRODUCTION--BLPOP							
1770.0	1850.0	1975.0	2000.0	2080.0	2085.0	2100.0	2180.0
2200.0	2240.0	2294.0	2349.0	2405.0	2463.0	2522.0	2583.0
2645.0	2708.0	2773.0	2840.0	2908.0	2977.0	3048.0	3122.0
3197.0	3274.0	3352.0	3433.0	3515.0	3600.0	3686.0	0.0
0.0	0.0	0.0					
REVISED BASELINE PRODUCTION--BLPOR							
0.0	1843.1	1967.7	1992.6	2072.3	2077.3	2092.2	2171.9
2191.8	2231.7	2285.5	2340.3	2396.1	2453.9	2512.6	2573.4
2635.2	2698.0	2762.7	2829.5	2897.2	2966.0	3036.7	3110.4
3185.1	3261.9	3339.6	3420.3	3502.0	3586.6	3672.3	0.0
0.0	0.0	0.0					
ATTRITION FACTOR--AF							
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					
INCREMENTAL FUEL COST--DFC							
0.0	70.00	70.00	70.00	70.00	70.00	70.00	70.00
70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
70.00	70.00	70.00	70.00	70.00	70.00	70.00	0.0
0.0	0.0	0.0					
INCREMENTAL MAINTENANCE COST--DMC							
0.0	160.00	160.00	160.00	160.00	160.00	160.00	160.00
160.00	160.00	160.00	160.00	160.00	160.00	160.00	160.00
160.00	160.00	160.00	160.00	160.00	160.00	160.00	160.00
160.00	160.00	160.00	160.00	160.00	160.00	160.00	0.0
0.0	0.0	0.0					
INCREMENTAL EQUIPMENT COST--DVP							
0.0	819.00	819.00	819.00	819.00	819.00	819.00	819.00
819.00	819.00	819.00	819.00	819.00	819.00	819.00	819.00
819.00	819.00	819.00	819.00	819.00	819.00	819.00	819.00
819.00	819.00	819.00	819.00	819.00	819.00	819.00	0.0
0.0	0.0	0.0					
PRICE ELASTICITY OF DEMAND--PED							
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					
ELASTICITY FACTOR--EF							
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP =110385.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Intercity Buses - Option 2

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1986

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.7107	0.7107	0.4239	0.2868
1982	1.4544	2.1651	0.8765	0.5779
1983	2.1915	4.3567	1.3348	0.8568
1984	2.9431	7.2998	1.8114	1.1317
1985	5.8917	13.1915	4.2171	1.6746
1986	7.2912	20.4826	5.1013	2.1899
1987	8.7154	29.1980	6.0192	2.6962
1988	10.1205	39.3184	6.9454	3.1750
1989	11.5203	50.8387	7.8886	3.6317
1990	12.9242	63.7629	8.8544	4.0698
1991	13.4149	77.1778	9.0619	4.3529
1992	13.8625	91.0402	9.2402	4.6222
1993	14.3182	105.3584	9.4324	4.8858
1994	14.7549	120.1133	9.6156	5.1393
1995	15.0792	135.1924	9.8253	5.2539
1996	15.4316	150.6239	10.0547	5.3768
1997	15.7758	166.3997	10.2770	5.4987
1998	16.1470	182.5467	10.5183	5.6287
1999	16.5348	199.0815	10.7709	5.7639
2000	16.9317	216.0132	11.0294	5.9023
2001	17.3375	233.3507	11.2938	6.0437
2002	17.7531	251.1038	11.5646	6.1885
2003	18.1790	269.2825	11.8420	6.3370
2004	18.6153	287.8975	12.1262	6.4891
2005	19.0620	306.9592	12.4171	6.6448
2006	19.5189	326.4780	12.7148	6.8041
2007	19.9876	346.4651	13.0201	6.9675
2008	20.4671	366.9319	13.3325	7.1347
2009	20.9585	387.8901	13.6525	7.3060
2010	21.4613	409.3513	13.9800	7.4813

PRESENT VALUE OF ANNUAL COSTS = 85.0434

EQUIVALENT ANNUAL COST = 8.9718 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

1770.0	1850.0	1975.0	2000.0	2080.0	2085.0	2100.0	2180.0
2200.0	2240.0	2294.0	2349.0	2405.0	2463.0	2522.0	2583.0
2645.0	2708.0	2773.0	2840.0	2908.0	2977.0	3048.0	3122.0
3197.0	3274.0	3352.0	3433.0	3515.0	3600.0	3686.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	1843.1	1967.7	1992.6	2072.3	2070.4	2085.3	2164.8
2184.6	2224.3	2278.0	2332.6	2388.2	2445.8	2504.4	2564.9
2626.5	2689.1	2753.6	2820.1	2887.7	2956.2	3026.7	3100.2
3174.6	3251.1	3328.6	3409.0	3490.4	3574.8	3660.2	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	70.00	70.00	70.00	70.00	75.00	75.00	75.00
75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
75.00	75.00	75.00	75.00	75.00	75.00	75.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	160.00	160.00	160.00	160.00	349.00	349.00	349.00
349.00	349.00	349.00	349.00	349.00	349.00	349.00	349.00
349.00	349.00	349.00	349.00	349.00	349.00	349.00	349.00
349.00	349.00	349.00	349.00	349.00	349.00	349.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	819.00	819.00	819.00	819.00	1544.00	1544.00	1544.00
1544.00	1544.00	1544.00	1544.00	1544.00	1544.00	1544.00	1544.00
1544.00	1544.00	1544.00	1544.00	1544.00	1544.00	1544.00	1544.00
1544.00	1544.00	1544.00	1544.00	1544.00	1544.00	1544.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10　　BASE VEHICLE PRICE--BASEP =110385.

RATE OF DISCOUNT--R = 0.10　　COST OF CAPITAL RATE --CCRATE = 0.10

Intercity Buses - Option 2A

1

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1985
AND ATTAINS STEADY STATE IN 1986

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	1.4852	1.4852	0.8779	0.6074
1986	2.9492	4.4344	1.7620	1.1872
1987	4.4379	8.8723	2.6799	1.7580
1988	5.9075	14.7798	3.6062	2.3013
1989	7.3718	22.1516	4.5493	2.8225
1990	8.8403	30.9919	5.5151	3.3251
1991	10.3127	41.3046	6.5041	3.8086
1992	11.7891	53.0937	7.5167	4.2723
1993	13.2698	66.3635	8.5537	4.7161
1994	14.7549	81.1184	9.6156	5.1393
1995	15.0792	96.1975	9.8253	5.2539
1996	15.4316	111.6290	10.0547	5.3768
1997	15.7758	127.4048	10.2770	5.4987
1998	16.1470	143.5518	10.5183	5.6287
1999	16.5348	160.0866	10.7709	5.7639
2000	16.9317	177.0183	11.0294	5.9023
2001	17.3375	194.3559	11.2938	6.0437
2002	17.7531	212.1089	11.5646	6.1885
2003	18.1790	230.2879	11.8420	6.3370
2004	18.6153	248.9032	12.1262	6.4891
2005	19.0620	267.9651	12.4171	6.6448
2006	19.5189	287.4836	12.7148	6.8041
2007	19.9876	307.4707	13.0201	6.9675
2008	20.4671	327.9375	13.3325	7.1347
2009	20.9585	348.8955	13.6525	7.3060
2010	21.4613	370.3569	13.9800	7.4813

PRESENT VALUE OF ANNUAL COSTS = 64.8056

EQUIVALENT ANNUAL COST = 6.8367 MILLION DOLLARS

1

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

1770.0	1850.0	1975.0	2000.0	2080.0	2085.0	2100.0	2180.0
2200.0	2240.0	2294.0	2349.0	2405.0	2463.0	2522.0	2583.0
2645.0	2708.0	2773.0	2840.0	2908.0	2977.0	3048.0	3122.0
3197.0	3274.0	3352.0	3433.0	3515.0	3600.0	3686.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	0.0	0.0	0.0	0.0	2070.4	2085.3	2164.8
2184.6	2224.3	2278.0	2332.6	2388.2	2445.8	2504.4	2564.9
2626.5	2689.1	2753.6	2820.1	2887.7	2956.2	3026.7	3100.2
3174.6	3251.1	3328.6	3409.0	3490.4	3574.8	3660.2	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	75.00	75.00	75.00
75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
75.00	75.00	75.00	75.00	75.00	75.00	75.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	349.00	349.00	349.00
349.00	349.00	349.00	349.00	349.00	349.00	349.00	349.00
349.00	349.00	349.00	349.00	349.00	349.00	349.00	349.00
349.00	349.00	349.00	349.00	349.00	349.00	349.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	0.0	0.0	0.0	0.0	1544.00	1544.00	1544.00
1544.00	1544.00	1544.00	1544.00	1544.00	1544.00	1544.00	1544.00
1544.00	1544.00	1544.00	1544.00	1544.00	1544.00	1544.00	1544.00
1544.00	1544.00	1544.00	1544.00	1544.00	1544.00	1544.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP =110385.
RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Intercity Buses - Option 3

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.7107	0.7107	0.4239	0.2868
1982	1.4544	2.1651	0.8765	0.5779
1983	2.1915	4.3567	1.3348	0.8568
1984	2.9431	7.2998	1.8114	1.1317
1985	5.8917	13.1915	4.2171	1.6746
1986	7.2912	20.4826	5.1013	2.1899
1987	13.9420	34.4246	10.3472	3.5949
1988	16.8589	51.2836	11.9258	4.9332
1989	19.7513	71.0349	13.5331	6.2182
1990	22.6374	93.6722	15.1791	7.4583
1991	24.0354	117.7077	15.5191	8.5163
1992	25.3410	143.0487	15.8084	9.5326
1993	26.6361	169.6848	16.1211	10.5150
1994	27.8761	197.5608	16.4180	11.4581
1995	28.9927	226.5535	16.7600	12.2327
1996	30.1208	256.6743	17.1356	12.9852
1997	30.7941	287.4683	17.5145	13.2796
1998	31.5192	318.9871	17.9257	13.5935
1999	32.2762	351.2632	18.3562	13.9200
2000	33.0509	384.3137	18.7968	14.2542
2001	33.8431	418.1567	19.2474	14.5958
2002	34.6542	452.8105	19.7088	14.9454
2003	35.4856	488.2961	20.1816	15.3040
2004	36.3372	524.6331	20.6660	15.6713
2005	37.2092	561.8420	21.1618	16.0474
2006	38.1012	599.9431	21.6691	16.4321
2007	39.0160	638.9590	22.1893	16.8267
2008	39.9522	678.9109	22.7217	17.2304
2009	40.9112	719.8218	23.2670	17.6442
2010	41.8930	761.7144	23.8253	18.0676

PRESENT VALUE OF ANNUAL COSTS = 146.2463

EQUIVALENT ANNUAL COST = 15.4284 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

1770.0	1850.0	1975.0	2000.0	2080.0	2085.0	2100.0	2180.0
2200.0	2240.0	2294.0	2349.0	2405.0	2463.0	2522.0	2583.0
2645.0	2708.0	2773.0	2840.0	2908.0	2977.0	3048.0	3122.0
3197.0	3274.0	3352.0	3433.0	3515.0	3600.0	3686.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	1843.1	1967.7	1992.6	2072.3	2070.4	2085.3	2142.8
2162.5	2201.8	2254.9	2308.9	2364.0	2421.0	2479.0	2538.9
2599.9	2661.8	2725.7	2791.5	2858.4	2926.2	2996.0	3068.7
3142.4	3218.1	3294.8	3374.4	3455.0	3538.6	3623.1	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	70.00	70.00	70.00	70.00	75.00	75.00	135.00
135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
135.00	135.00	135.00	135.00	135.00	135.00	135.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	160.00	160.00	160.00	160.00	349.00	349.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	819.00	819.00	819.00	819.00	1544.00	1544.00	3767.00
3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00
3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00
3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP =110385.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Intercity Buses - Option 3A

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1985
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	1.4852	1.4852	0.8779	0.6074
1986	2.9492	4.4344	1.7620	1.1872
1987	7.2546	11.6890	4.5979	2.6567
1988	10.2360	21.9250	6.1765	4.0595
1989	13.1929	35.1179	7.7838	5.4090
1990	16.1435	51.2614	9.4299	6.7136
1991	19.0873	70.3487	11.1154	7.9720
1992	22.0238	92.3725	12.8411	9.1827
1993	24.9536	117.3260	14.6084	10.3452
1994	27.8761	145.2021	16.4180	11.4581
1995	28.9927	174.1948	16.7600	12.2327
1996	30.1208	204.3157	17.1356	12.9852
1997	30.7941	235.1098	17.5145	13.2796
1998	31.5192	266.6289	17.9257	13.5935
1999	32.2762	298.9050	18.3562	13.9200
2000	33.0509	331.9556	18.7968	14.2542
2001	33.8431	365.7986	19.2474	14.5958
2002	34.6542	400.4524	19.7088	14.9454
2003	35.4856	435.9380	20.1816	15.3040
2004	36.3372	472.2749	20.6660	15.6713
2005	37.2092	509.4839	21.1618	16.0474
2006	38.1012	547.5850	21.6691	16.4321
2007	39.0160	586.6008	22.1893	16.8267
2008	39.9522	626.5527	22.7217	17.2304
2009	40.9112	667.4636	23.2670	17.6442
2010	41.8930	709.3562	23.8253	18.0676

PRESENT VALUE OF ANNUAL COSTS = 120.4693

EQUIVALENT ANNUAL COST = 12.7091 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

1770.0	1850.0	1975.0	2000.0	2080.0	2085.0	2100.0	2180.0
2200.0	2240.0	2294.0	2349.0	2405.0	2463.0	2522.0	2583.0
2645.0	2708.0	2773.0	2840.0	2908.0	2977.0	3048.0	3122.0
3197.0	3274.0	3352.0	3433.0	3515.0	3600.0	3686.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	0.0	0.0	0.0	0.0	2070.4	2085.3	2142.8
2162.5	2201.8	2254.9	2308.9	2364.0	2421.0	2479.0	2538.9
2599.9	2661.8	2725.7	2791.5	2858.4	2926.2	2996.0	3068.7
3142.4	3218.1	3294.8	3374.4	3455.0	3538.6	3623.1	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	75.00	75.00	135.00
135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
135.00	135.00	135.00	135.00	135.00	135.00	135.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	349.00	349.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	0.0	0.0	0.0	0.0	1544.00	1544.00	3767.00
3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00
3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00
3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP =110385.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Intercity Buses - Option 3B

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1987
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0
1986	0.0	0.0	0.0	0.0
1987	3.0979	3.0979	1.5642	1.5337
1988	6.1435	9.2414	3.1428	3.0007
1989	9.1645	18.4059	4.7501	4.4144
1990	12.1793	30.5852	6.3962	5.7831
1991	15.1873	45.7726	8.0817	7.1056
1992	18.1879	63.9605	9.8074	8.3806
1993	21.1819	85.1424	11.5747	9.6072
1994	24.1685	109.3109	13.3843	10.7842
1995	27.1485	136.4594	15.2378	11.9107
1996	30.1208	166.5802	17.1356	12.9852
1997	30.7941	197.3744	17.5145	13.2796
1998	31.5192	228.8936	17.9257	13.5935
1999	32.2762	261.1697	18.3562	13.9200
2000	33.0509	294.2205	18.7968	14.2542
2001	33.8431	328.0635	19.2474	14.5958
2002	34.6542	362.7173	19.7088	14.9454
2003	35.4856	398.2026	20.1816	15.3040
2004	36.3372	434.5396	20.6660	15.6713
2005	37.2092	471.7488	21.1618	16.0474
2006	38.1012	509.8499	21.6691	16.4321
2007	39.0160	548.8657	22.1893	16.8267
2008	39.9522	588.8176	22.7217	17.2304
2009	40.9112	629.7283	23.2670	17.6442
2010	41.8930	671.6211	23.8253	18.0676

PRESENT VALUE OF ANNUAL COSTS = 105.5038

EQUIVALENT ANNUAL COST = 11.1302 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

1770.0	1850.0	1975.0	2000.0	2080.0	2085.0	2100.0	2180.0
2200.0	2240.0	2294.0	2349.0	2405.0	2463.0	2522.0	2583.0
2645.0	2708.0	2773.0	2840.0	2908.0	2977.0	3048.0	3122.0
3197.0	3274.0	3352.0	3433.0	3515.0	3600.0	3686.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	0.0	0.0	0.0	0.0	0.0	0.0	2142.8
2162.5	2201.8	2254.9	2308.9	2364.0	2421.0	2479.0	2538.9
2599.9	2661.8	2725.7	2791.5	2858.4	2926.2	2996.0	3068.7
3142.4	3218.1	3294.8	3374.4	3455.0	3538.6	3623.1	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	135.00
135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
135.00	135.00	135.00	135.00	135.00	135.00	135.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	0.0	0.0	0.0	0.0	0.0	0.0	3767.00
3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00
3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00
3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	3767.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP =110385.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Intercity Buses - Option 4

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1989

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.7107	0.7107	0.4239	0.2868
1982	1.4544	2.1651	0.8765	0.5779
1983	2.1915	4.3567	1.3348	0.8568
1984	2.9431	7.2998	1.8114	1.1317
1985	5.8917	13.1915	4.2171	1.6746
1986	7.2912	20.4826	5.1013	2.1899
1987	13.9420	34.4246	10.3472	3.5949
1988	24.0169	58.4416	18.6104	5.4066
1989	28.2554	86.6970	21.1068	7.1487
1990	32.4954	119.1924	23.6633	8.8321
1991	34.4993	153.6917	24.1800	10.3192
1992	36.3673	190.0590	24.6172	11.7501
1993	38.2229	228.2819	25.0905	13.1324
1994	39.9989	268.2808	25.5388	14.4601
1995	41.6612	309.9417	26.0572	15.6040
1996	43.3375	353.2788	26.6277	16.7098
1997	44.5440	397.8225	27.2028	17.3411
1998	45.5925	443.4150	27.8414	17.7511
1999	46.6875	490.1021	28.5101	18.1774
2000	47.8081	537.9102	29.1944	18.6138
2001	48.9541	586.8640	29.8942	19.0599
2002	50.1273	636.9912	30.6108	19.5164
2003	51.3300	688.3208	31.3453	19.9847
2004	52.5618	740.8826	32.0975	20.4643
2005	53.8231	794.7056	32.8676	20.9554
2006	55.1134	849.8188	33.6555	21.4579
2007	56.4366	906.2551	34.4635	21.9731
2008	57.7908	964.0459	35.2905	22.5004
2009	59.1781	1023.2236	36.1375	23.0406
2010	60.5981	1083.8215	37.0045	23.5936

PRESENT VALUE OF ANNUAL COSTS = 201.5432

EQUIVALENT ANNUAL COST = 21.2620 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

1770.0	1850.0	1975.0	2000.0	2080.0	2085.0	2100.0	2180.0
2200.0	2240.0	2294.0	2349.0	2405.0	2463.0	2522.0	2583.0
2645.0	2708.0	2773.0	2840.0	2908.0	2977.0	3048.0	3122.0
3197.0	3274.0	3352.0	3433.0	3515.0	3600.0	3686.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	1843.1	1967.7	1992.6	2072.3	2070.4	2085.3	2142.8
2150.7	2189.8	2242.6	2296.4	2351.1	2407.8	2465.5	2525.1
2585.7	2647.3	2710.9	2776.4	2842.9	2910.3	2979.7	3052.1
3125.4	3200.7	3276.9	3356.1	3436.3	3519.3	3603.4	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	70.00	70.00	70.00	70.00	75.00	75.00	135.00
190.00	190.00	190.00	190.00	190.00	190.00	190.00	190.00
190.00	190.00	190.00	190.00	190.00	190.00	190.00	190.00
190.00	190.00	190.00	190.00	190.00	190.00	190.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	160.00	160.00	160.00	160.00	349.00	349.00	595.00
950.00	950.00	950.00	950.00	950.00	950.00	950.00	950.00
950.00	950.00	950.00	950.00	950.00	950.00	950.00	950.00
950.00	950.00	950.00	950.00	950.00	950.00	950.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	819.00	819.00	819.00	819.00	1544.00	1544.00	3767.00
4946.00	4946.00	4946.00	4946.00	4946.00	4946.00	4946.00	4946.00
4946.00	4946.00	4946.00	4946.00	4946.00	4946.00	4946.00	4946.00
4946.00	4946.00	4946.00	4946.00	4946.00	4946.00	4946.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP =110385.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE =.0.10

Transit Buses - Option 1

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1982

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	1.4515	1.4515	0.9570	0.4946
1982	2.8921	4.3436	1.9239	0.9682
1983	4.3215	8.6652	2.9008	1.4208
1984	5.7546	14.4198	3.8976	1.8570
1985	7.1757	21.5955	4.9044	2.2713
1986	8.5997	30.1952	5.9311	2.6685
1987	10.0108	40.2060	6.9679	3.0430
1988	11.4240	51.6300	8.0245	3.3995
1989	12.8387	64.4687	9.1011	3.7376
1990	14.2392	78.7079	10.1876	4.0516
1991	14.4341	93.1420	10.3272	4.1069
1992	14.6430	107.7850	10.4767	4.1663
1993	14.8581	122.6431	10.6312	4.2269
1994	15.0518	137.6948	10.7708	4.2810
1995	15.2594	152.9543	10.9203	4.3392
1996	15.4615	168.4158	11.0652	4.3963
1997	15.6705	184.0863	11.2156	4.4550
1998	15.8745	199.9608	11.3617	4.5129
1999	16.0736	216.0344	11.5036	4.5700
2000	16.2810	232.3154	11.6518	4.6292
2001	16.4966	248.8120	11.8063	4.6904
2002	16.7084	265.5203	11.9574	4.7510
2003	16.9228	282.4431	12.1103	4.8125
2004	17.1526	299.5955	12.2752	4.8775
2005	17.3791	316.9744	12.4373	4.9419
2006	17.6084	334.5828	12.6013	5.0071
2007	17.8407	352.4231	12.7676	5.0731
2008	18.0761	370.4990	12.9361	5.1400
2009	18.3148	388.8135	13.1069	5.2079
2010	18.5567	407.3696	13.2800	5.2767

PRESENT VALUE OF ANNUAL COSTS = 93.4397

EQUIVALENT ANNUAL COST = 9.8575 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					
BASELINE PRODUCTION--BLPOP							
4700.0	4800.0	4850.0	4900.0	5000.0	5050.0	5150.0	5200.0
5300.0	5400.0	5450.0	5500.0	5600.0	5675.0	5700.0	5800.0
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					
REVISED BASELINE PRODUCTION--BLFOR							
0.0	4784.8	4834.6	4884.5	4984.2	5034.0	5133.7	5183.5
5283.2	5382.9	5432.7	5482.6	5582.3	5657.0	5681.9	5781.6
5858.4	5935.1	6013.9	6092.6	6173.4	6255.1	6337.9	6421.6
6506.3	6592.0	6678.8	6766.5	6856.2	6946.9	7038.6	0.0
0.0	0.0	0.0					
ATTRITION FACTOR--AF							
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					
INCREMENTAL FUEL COST--DFC							
0.0	40.00	40.00	40.00	40.00	40.00	40.00	40.00
40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0
0.0	0.0	0.0					
INCREMENTAL MAINTENANCE COST--DMC							
0.0	160.00	160.00	160.00	160.00	160.00	160.00	160.00
160.00	160.00	160.00	160.00	160.00	160.00	160.00	160.00
160.00	160.00	160.00	160.00	160.00	160.00	160.00	160.00
160.00	160.00	160.00	160.00	160.00	160.00	160.00	0.0
0.0	0.0	0.0					
INCREMENTAL EQUIPMENT COST--DVP							
0.0	544.00	544.00	544.00	544.00	544.00	544.00	544.00
544.00	544.00	544.00	544.00	544.00	544.00	544.00	544.00
544.00	544.00	544.00	544.00	544.00	544.00	544.00	544.00
544.00	544.00	544.00	544.00	544.00	544.00	544.00	0.0
0.0	0.0	0.0					
PRICE ELASTICITY OF DEMAND--PED							
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					
ELASTICITY FACTOR--EF							
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP = 85855.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Transit Buses - Option 2

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1986

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	1.4515	1.4515	0.9570	0.4946
1982	2.8921	4.3436	1.9239	0.9682
1983	4.3215	8.6652	2.9008	1.4208
1984	5.7546	14.4198	3.8976	1.8570
1985	12.3726	26.7924	9.4082	2.9643
1986	15.4030	42.1953	11.3712	4.0318
1987	18.3993	60.5947	13.3531	5.0462
1988	21.3921	81.9867	15.3732	6.0188
1989	24.3799	106.3667	17.4314	6.9485
1990	27.3306	133.6972	19.5087	7.8219
1991	28.1717	161.8690	19.7677	8.4041
1992	29.0100	190.8789	20.0456	8.9643
1993	29.8287	220.7076	20.3330	9.4957
1994	30.5746	251.2823	20.5917	9.9830
1995	30.9961	282.2781	20.8775	10.1186
1996	31.4064	313.6843	21.1546	10.2518
1997	31.8307	345.5146	21.4420	10.3887
1998	32.2450	377.7595	21.7214	10.5237
1999	32.6497	410.4092	21.9928	10.6569
2000	33.0709	443.4797	22.2760	10.7950
2001	33.5090	476.9885	22.5714	10.9376
2002	33.9393	510.9275	22.8603	11.0790
2003	34.3751	545.3022	23.1526	11.2225
2004	34.8417	580.1438	23.4678	11.3739
2005	35.3017	615.4451	23.7777	11.5240
2006	35.7674	651.2124	24.0914	11.6761
2007	36.2393	687.4514	24.4093	11.8301
2008	36.7175	724.1689	24.7313	11.9862
2009	37.2024	761.3711	25.0580	12.1445
2010	37.6936	799.0645	25.3888	12.3048

PRESENT VALUE OF ANNUAL COSTS = 172.1281

EQUIVALENT ANNUAL COST = 18.1589 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					
BASELINE PRODUCTION--BLPOP							
4700.0	4800.0	4850.0	4900.0	5000.0	5050.0	5150.0	5200.0
5300.0	5400.0	5450.0	5500.0	5600.0	5675.0	5700.0	5800.0
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					
REVISED BASELINE PRODUCTION--BLFOR							
0.0	4784.8	4834.6	4884.5	4984.2	5012.5	5111.8	5161.4
5260.7	5359.9	5409.6	5459.2	5558.4	5632.9	5657.7	5757.0
5833.4	5909.8	5988.2	6066.6	6147.1	6228.4	6310.8	6394.2
6478.6	6563.9	6650.3	6737.6	6827.0	6917.3	7008.6	0.0
0.0	0.0	0.0					
ATTRITION FACTOR--AF							
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					
INCREMENTAL FUEL COST--DFC							
0.0	40.00	40.00	40.00	40.00	35.00	35.00	35.00
35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
35.00	35.00	35.00	35.00	35.00	35.00	35.00	0.0
0.0	0.0	0.0					
INCREMENTAL MAINTENANCE COST--DMC							
0.0	160.00	160.00	160.00	160.00	349.00	349.00	349.00
349.00	349.00	349.00	349.00	349.00	349.00	349.00	349.00
349.00	349.00	349.00	349.00	349.00	349.00	349.00	349.00
349.00	349.00	349.00	349.00	349.00	349.00	349.00	0.0
0.0	0.0	0.0					
INCREMENTAL EQUIPMENT COST--DVP							
0.0	544.00	544.00	544.00	544.00	1274.00	1274.00	1274.00
1274.00	1274.00	1274.00	1274.00	1274.00	1274.00	1274.00	1274.00
1274.00	1274.00	1274.00	1274.00	1274.00	1274.00	1274.00	1274.00
1274.00	1274.00	1274.00	1274.00	1274.00	1274.00	1274.00	0.0
0.0	0.0	0.0					
PRICE ELASTICITY OF DEMAND--PED							
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					
ELASTICITY FACTOR--EF							
1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP = 85855.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Transit Buses - Option 2A

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1985
AND ATTAINS STEADY STATE IN 1986

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	3.1381	3.1381	1.9248	1.2133
1986	6.2746	9.4127	3.8877	2.3868
1987	9.3769	18.7896	5.8697	3.5072
1988	12.4757	31.2653	7.8898	4.5859
1989	15.5696	46.8349	9.9480	5.6215
1990	18.6262	65.4611	12.0253	6.6009
1991	21.6451	87.1062	14.1216	7.5234
1992	24.6565	111.7626	16.2561	8.4004
1993	27.6436	139.4063	18.4191	9.2245
1994	30.5746	169.9809	20.5917	9.9830
1995	30.9961	200.9770	20.8775	10.1186
1996	31.4064	232.3834	21.1546	10.2518
1997	31.8307	264.2141	21.4420	10.3887
1998	32.2450	296.4590	21.7214	10.5237
1999	32.6497	329.1084	21.9928	10.6569
2000	33.0709	362.1790	22.2760	10.7950
2001	33.5090	395.6877	22.5714	10.9376
2002	33.9393	429.6267	22.8603	11.0790
2003	34.3751	464.0015	23.1526	11.2225
2004	34.8417	498.8430	23.4678	11.3739
2005	35.3017	534.1443	23.7777	11.5240
2006	35.7674	569.9116	24.0914	11.6761
2007	36.2393	606.1509	24.4093	11.8301
2008	36.7175	642.8682	24.7313	11.9862
2009	37.2024	680.0703	25.0580	12.1445
2010	37.6936	717.7637	25.3888	12.3048

PRESENT VALUE OF ANNUAL COSTS = 130.1647

EQUIVALENT ANNUAL COST = 13.7319 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

4700.0	4800.0	4850.0	4900.0	5000.0	5050.0	5150.0	5200.0
5300.0	5400.0	5450.0	5500.0	5600.0	5675.0	5700.0	5800.0
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	0.0	0.0	0.0	0.0	5012.5	5111.8	5161.4
5260.7	5359.9	5409.6	5459.2	5558.4	5632.9	5657.7	5757.0
5833.4	5909.8	5988.2	6066.6	6147.1	6228.4	6310.8	6394.2
6478.6	6563.9	6650.3	6737.6	6827.0	6917.3	7008.6	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	35.00	35.00	35.00
35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
35.00	35.00	35.00	35.00	35.00	35.00	35.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	349.00	349.00	349.00
349.00	349.00	349.00	349.00	349.00	349.00	349.00	349.00
349.00	349.00	349.00	349.00	349.00	349.00	349.00	349.00
349.00	349.00	349.00	349.00	349.00	349.00	349.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	0.0	0.0	0.0	0.0	1274.00	1274.00	1274.00
1274.00	1274.00	1274.00	1274.00	1274.00	1274.00	1274.00	1274.00
1274.00	1274.00	1274.00	1274.00	1274.00	1274.00	1274.00	1274.00
1274.00	1274.00	1274.00	1274.00	1274.00	1274.00	1274.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP = 85855.
RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Transit Buses - Option 3

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	1.4515	1.4515	0.9570	0.4946
1982	2.8921	4.3436	1.9239	0.9682
1983	4.3215	8.6652	2.9008	1.4208
1984	5.7546	14.4198	3.8976	1.8570
1985	12.3726	26.7924	9.4082	2.9643
1986	15.4030	42.1953	11.3712	4.0318
1987	29.5014	71.6968	23.0962	6.4053
1988	35.2572	106.9540	26.5657	8.6916
1989	40.9886	147.9426	30.1006	10.8881
1990	46.6353	194.5780	33.6682	12.9671
1991	48.7798	243.3578	34.0867	14.6931
1992	50.8851	294.2427	34.5375	16.3477
1993	52.9201	347.1626	35.0042	17.9158
1994	54.7895	401.9517	35.4211	19.3684
1995	56.3015	458.2529	35.8845	20.4170
1996	57.7360	515.9888	36.3323	21.4037
1997	58.5153	574.5042	36.8259	21.6894
1998	59.2769	633.7805	37.3057	21.9712
1999	60.0212	693.8015	37.7718	22.2494
2000	60.7958	754.5972	38.2582	22.5376
2001	61.6010	816.1978	38.7655	22.8354
2002	62.3924	878.5901	39.2617	23.1307
2003	63.1940	941.7839	39.7638	23.4302
2004	64.0514	1005.8352	40.3052	23.7462
2005	64.8971	1070.7319	40.8374	24.0598
2006	65.7533	1136.4851	41.3761	24.3772
2007	66.6208	1203.1057	41.9221	24.6987
2008	67.4998	1270.6052	42.4752	25.0246
2009	68.3913	1338.9963	43.0362	25.3551
2010	69.2942	1408.2903	43.6044	25.6898

PRESENT VALUE OF ANNUAL COSTS = 283.5173

EQUIVALENT ANNUAL COST = 29.9100 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

4700.0	4800.0	4850.0	4900.0	5000.0	5050.0	5150.0	5200.0
5300.0	5400.0	5450.0	5500.0	5600.0	5675.0	5700.0	5800.0
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	4784.8	4834.6	4884.5	4984.2	5012.5	5111.8	5118.8
5217.2	5315.7	5364.9	5414.1	5512.5	5586.4	5611.0	5709.4
5785.2	5861.0	5938.8	6016.5	6096.3	6177.0	6258.7	6341.4
6425.1	6509.7	6595.3	6682.0	6770.6	6860.1	6950.7	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	40.00	40.00	40.00	40.00	35.00	35.00	70.00
70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
70.00	70.00	70.00	70.00	70.00	70.00	70.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	160.00	160.00	160.00	160.00	349.00	349.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	544.00	544.00	544.00	544.00	1274.00	1274.00	2682.00
2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00
2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00
2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP = 85855.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Transit Buses - Option 3A

1

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1985
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	3.1381	3.1381	1.9248	1.2133
1986	6.2746	9.4127	3.8877	2.3868
1987	15.0029	24.4156	10.1367	4.8663
1988	20.8647	45.2803	13.6061	7.2586
1989	26.7021	71.9824	17.1410	9.5611
1990	32.4548	104.4373	20.7086	11.7462
1991	38.1215	142.5588	24.3090	13.8125
1992	43.7585	186.3173	27.9748	15.7837
1993	49.3345	235.6518	31.6898	17.6447
1994	54.7895	290.4409	35.4211	19.3684
1995	56.3015	346.7422	35.8845	20.4170
1996	57.7360	404.4780	36.3323	21.4037
1997	58.5153	462.9932	36.8259	21.6894
1998	59.2769	522.2698	37.3057	21.9712
1999	60.0212	582.2908	37.7718	22.2494
2000	60.7958	643.0864	38.2582	22.5376
2001	61.6010	704.6870	38.7655	22.8354
2002	62.3924	767.0793	39.2617	23.1307
2003	63.1940	830.2732	39.7638	23.4302
2004	64.0514	894.3245	40.3052	23.7462
2005	64.8971	959.2212	40.8374	24.0598
2006	65.7533	1024.9741	41.3761	24.3772
2007	66.6208	1091.5950	41.9221	24.6987
2008	67.4998	1159.0945	42.4752	25.0246
2009	68.3913	1227.4856	43.0362	25.3551
2010	69.2942	1296.7793	43.6044	25.6898

PRESENT VALUE OF ANNUAL COSTS = 229.0185

EQUIVALENT ANNUAL COST = 24.1606 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					
BASELINE PRODUCTION--BLPOP							
4700.0	4800.0	4850.0	4900.0	5000.0	5050.0	5150.0	5200.0
5300.0	5400.0	5450.0	5500.0	5600.0	5675.0	5700.0	5800.0
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					
REVISED BASELINE PRODUCTION--BLFOR							
0.0	0.0	0.0	0.0	0.0	5012.5	5111.8	5118.8
5217.2	5315.7	5364.9	5414.1	5512.5	5586.4	5611.0	5709.4
5785.2	5861.0	5938.8	6016.5	6096.3	6177.0	6258.7	6341.4
6425.1	6509.7	6595.3	6682.0	6770.6	6860.1	6950.7	0.0
0.0	0.0	0.0					
ATTRITION FACTOR--AF							
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					
INCREMENTAL FUEL COST--DFC							
0.0	0.0	0.0	0.0	0.0	35.00	35.00	70.00
70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
70.00	70.00	70.00	70.00	70.00	70.00	70.00	0.0
0.0	0.0	0.0					
INCREMENTAL MAINTENANCE COST--DMC							
0.0	0.0	0.0	0.0	0.0	349.00	349.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	0.0
0.0	0.0	0.0					
INCREMENTAL EQUIPMENT COST--DVP							
0.0	0.0	0.0	0.0	0.0	1274.00	1274.00	2682.00
2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00
2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00
2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	0.0
0.0	0.0	0.0					
PRICE ELASTICITY OF DEMAND--PED							
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					
ELASTICITY FACTOR--EF							
1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10   BASE VEHICLE PRICE--BASEP = 85855.

RATE OF DISCOUNT--R = 0.10   COST OF CAPITAL RATE --CCRATE = 0.10

Transit Buses - Option 3B

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1987
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0
1986	0.0	0.0	0.0	0.0
1987	6.0124	6.0124	3.4040	2.6084
1988	12.0032	18.0156	6.8734	5.1297
1989	17.9696	35.9851	10.4083	7.5613
1990	23.8513	59.8364	13.9760	9.8753
1991	29.6469	89.4833	17.5763	12.0706
1992	35.4129	124.8963	21.2422	14.1708
1993	41.1178	166.0141	24.9571	16.1607
1994	46.7018	212.7160	28.6884	18.0134
1995	52.2509	264.9668	32.4851	19.7658
1996	57.7360	322.7026	36.3323	21.4037
1997	58.5153	381.2180	36.8259	21.6894
1998	59.2769	440.4944	37.3057	21.9712
1999	60.0212	500.5154	37.7718	22.2494
2000	60.7958	561.3110	38.2582	22.5376
2001	61.6010	622.9116	38.7655	22.8354
2002	62.3924	685.3040	39.2617	23.1307
2003	63.1940	748.4978	39.7638	23.4302
2004	64.0514	812.5491	40.3052	23.7462
2005	64.8971	877.4458	40.8374	24.0598
2006	65.7533	943.1990	41.3761	24.3772
2007	66.6208	1009.8196	41.9221	24.6987
2008	67.4998	1077.3191	42.4752	25.0246
2009	68.3913	1145.7102	43.0362	25.3551
2010	69.2942	1215.0042	43.6044	25.6898

PRESENT VALUE OF ANNUAL COSTS = 196.6509

EQUIVALENT ANNUAL COST = 20.7459 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

4700.0	4800.0	4850.0	4900.0	5000.0	5050.0	5150.0	5200.0
5300.0	5400.0	5450.0	5500.0	5600.0	5675.0	5700.0	5800.0
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	0.0	0.0	0.0	0.0	0.0	0.0	5118.8
5217.2	5315.7	5364.9	5414.1	5512.5	5586.4	5611.0	5709.4
5785.2	5861.0	5938.8	6016.5	6096.3	6177.0	6258.7	6341.4
6425.1	6509.7	6595.3	6682.0	6770.6	6860.1	6950.7	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.00
70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
70.00	70.00	70.00	70.00	70.00	70.00	70.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	595.00
595.00	595.00	595.00	595.00	595.00	595.00	595.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	0.0	0.0	0.0	0.0	0.0	0.0	2682.00
2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00
2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00
2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	2682.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP = 85855.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Transit Buses - Option 4

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1989

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	1.4515	1.4515	0.9570	0.4946
1982	2.8921	4.3436	1.9239	0.9682
1983	4.3215	8.6652	2.9008	1.4208
1984	5.7546	14.4198	3.8976	1.8570
1985	12.3726	26.7924	9.4082	2.9643
1986	15.4030	42.1953	11.3712	4.0318
1987	29.5014	71.6968	23.0962	6.4053
1988	53.1193	124.8161	42.2720	10.8473
1989	62.9588	187.7749	47.8319	15.1269
1990	72.6369	260.4116	53.4433	19.1936
1991	76.8454	337.2568	54.0343	22.8111
1992	80.9553	418.2117	54.6754	26.2799
1993	84.9140	503.1255	55.3410	29.5730
1994	88.5658	591.6909	55.9266	32.6392
1995	91.8052	683.4958	56.5851	35.2201
1996	94.8638	778.3594	57.2176	37.6461
1997	97.1989	875.5581	57.9220	39.2769
1998	98.4638	974.0217	58.6767	39.7870
1999	99.7007	1073.7222	59.4098	40.2909
2000	100.9876	1174.7097	60.1748	40.8128
2001	102.3249	1277.0342	60.9728	41.3521
2002	103.6400	1380.6738	61.7532	41.8868
2003	104.9722	1485.6460	62.5429	42.4292
2004	106.3959	1592.0415	63.3944	43.0015
2005	107.8007	1699.8423	64.2315	43.5692
2006	109.2229	1809.0649	65.0789	44.1440
2007	110.6639	1919.7285	65.9376	44.7263
2008	112.1241	2031.8525	66.8076	45.3165
2009	113.6049	2145.4573	67.6900	45.9149
2010	115.1048	2260.5618	68.5837	46.5211

PRESENT VALUE OF ANNUAL COSTS = 431.5881

EQUIVALENT ANNUAL COST = 45.5309 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

4700.0	4800.0	4850.0	4900.0	5000.0	5050.0	5150.0	5200.0
5300.0	5400.0	5450.0	5500.0	5600.0	5675.0	5700.0	5800.0
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	4784.8	4834.6	4884.5	4934.2	5012.5	5111.8	5118.8
5148.1	5245.2	5293.8	5342.3	5439.5	5512.3	5536.6	5633.7
5708.5	5783.3	5860.1	5936.8	6015.5	6095.1	6175.8	6257.3
6339.9	6423.4	6507.9	6593.4	6680.8	6769.2	6858.6	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	40.00	40.00	40.00	40.00	35.00	35.00	70.00
110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00
110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00
110.00	110.00	110.00	110.00	110.00	110.00	110.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	160.00	160.00	160.00	160.00	349.00	349.00	595.00
950.00	950.00	950.00	950.00	950.00	950.00	950.00	950.00
950.00	950.00	950.00	950.00	950.00	950.00	950.00	950.00
950.00	950.00	950.00	950.00	950.00	950.00	950.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	544.00	544.00	544.00	544.00	1274.00	1274.00	2682.00
4922.00	4922.00	4922.00	4922.00	4922.00	4922.00	4922.00	4922.00
4922.00	4922.00	4922.00	4922.00	4922.00	4922.00	4922.00	4922.00
4922.00	4922.00	4922.00	4922.00	4922.00	4922.00	4922.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98
0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP = 85855.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Advanced Design Buses - Option 1

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1982

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0095	0.0095	0.0	0.0095
1982	0.0191	0.0286	0.0	0.0191
1983	0.0289	0.0575	0.0	0.0289
1984	0.0390	0.0965	0.0	0.0390
1985	0.0492	0.1457	0.0	0.0492
1986	0.0591	0.2048	0.0	0.0591
1987	0.0684	0.2732	0.0	0.0684
1988	0.0773	0.3505	0.0	0.0773
1989	0.0857	0.4362	0.0	0.0857
1990	0.0935	0.5297	0.0	0.0935
1991	0.0964	0.6261	0.0	0.0964
1992	0.0989	0.7251	0.0	0.0989
1993	0.1011	0.8261	0.0	0.1011
1994	0.1027	0.9289	0.0	0.1027
1995	0.1041	1.0330	0.0	0.1041
1996	0.1055	1.1384	0.0	0.1055
1997	0.1069	1.2453	0.0	0.1069
1998	0.1083	1.3536	0.0	0.1083
1999	0.1096	1.4632	0.0	0.1096
2000	0.1110	1.5742	0.0	0.1110
2001	0.1124	1.6867	0.0	0.1124
2002	0.1139	1.8006	0.0	0.1139
2003	0.1154	1.9159	0.0	0.1154
2004	0.1169	2.0328	0.0	0.1169
2005	0.1185	2.1513	0.0	0.1185
2006	0.1200	2.2713	0.0	0.1200
2007	0.1216	2.3929	0.0	0.1216
2008	0.1232	2.5162	0.0	0.1232
2009	0.1248	2.6410	0.0	0.1248
2010	0.1265	2.7675	0.0	0.1265

PRESENT VALUE OF ANNUAL COSTS = 0.6327

EQUIVALENT ANNUAL COST = 0.0667 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					
BASELINE PRODUCTION--BLPOP							
3579.0	3834.0	4107.0	4399.0	4712.0	5050.0	5150.0	5200.0
5300.0	5400.0	5450.0	5550.0	5600.0	5675.0	5700.0	5800.0
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					
REVISED BASELINE PRODUCTION--BLFOR							
0.0	3833.8	4106.8	4398.7	4711.7	5049.7	5149.7	5199.7
5299.7	5399.7	5449.7	5549.7	5599.7	5674.7	5699.7	5799.7
5876.7	5953.6	6032.6	6111.6	6192.6	6274.6	6357.6	6441.6
6526.6	6612.6	6699.6	6787.6	6877.6	6968.6	7060.6	0.0
0.0	0.0	0.0					
ATTRITION FACTOR--AF							
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					
INCREMENTAL FUEL COST--DFC							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					
INCREMENTAL MAINTENANCE COST--DMC							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					
INCREMENTAL EQUIPMENT COST--DVP							
0.0	13.00	13.00	13.00	13.00	13.00	13.00	13.00
13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
13.00	13.00	13.00	13.00	13.00	13.00	13.00	0.0
0.0	0.0	0.0					
PRICE ELASTICITY OF DEMAND--PED							
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					
ELASTICITY FACTOR--EF							
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP =110000.
RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Advanced Design Buses - Option 2

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1986

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0095	0.0095	0.0	0.0095
1982	0.0191	0.0286	0.0	0.0191
1983	0.0289	0.0575	0.0	0.0289
1984	0.0390	0.0965	0.0	0.0390
1985	8.1886	8.2851	7.4423	0.7463
1986	10.6023	18.8874	9.1720	1.4303
1987	13.0018	31.8892	10.9185	2.0833
1988	15.4104	47.2996	12.6985	2.7119
1989	17.8275	65.1272	14.5122	3.3153
1990	20.2285	85.3557	16.3427	3.8859
1991	21.3403	106.6960	16.9147	4.4256
1992	22.3432	129.0392	17.4116	4.9316
1993	23.2421	152.2813	17.8352	5.4069
1994	24.0056	176.2869	18.1618	5.8439
1995	24.3365	200.6234	18.4137	5.9228
1996	24.6582	225.2816	18.6579	6.0004
1997	24.9911	250.2728	18.9111	6.0800
1998	25.3159	275.5881	19.1573	6.1586
1999	25.6326	301.2205	19.3964	6.2361
2000	25.9625	327.1826	19.6460	6.3165
2001	26.2857	353.4683	19.8895	6.3962
2002	26.6230	380.0911	20.1441	6.4789
2003	26.9645	407.0554	20.4017	6.5628
2004	27.3307	434.3860	20.6794	6.6513
2005	27.6916	462.0774	20.9525	6.7392
2006	28.0570	490.1340	21.2289	6.8281
2007	28.4271	518.5608	21.5090	6.9181
2008	28.8022	547.3630	21.7928	7.0094
2009	29.1826	576.5454	22.0806	7.1020
2010	29.5679	606.1130	22.3722	7.1957

PRESENT VALUE OF ANNUAL COSTS = 121.9753

EQUIVALENT ANNUAL COST = 12.8679 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

3579.0	3834.0	4107.0	4399.0	4712.0	5050.0	5150.0	5200.0
5300.0	5400.0	5450.0	5550.0	5600.0	5675.0	5700.0	5800.0
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	3833.8	4106.8	4398.7	4711.7	5033.0	5132.6	5182.5
5282.1	5381.8	5431.6	5531.3	5581.1	5655.9	5680.8	5780.4
5857.2	5933.9	6012.7	6091.4	6172.1	6253.8	6336.6	6420.3
6505.0	6590.7	6677.4	6765.1	6854.8	6945.5	7037.2	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	45.00	45.00	45.00
45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00
45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00
45.00	45.00	45.00	45.00	45.00	45.00	45.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	292.00	292.00	292.00
292.00	292.00	292.00	292.00	292.00	292.00	292.00	292.00
292.00	292.00	292.00	292.00	292.00	292.00	292.00	292.00
292.00	292.00	292.00	292.00	292.00	292.00	292.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	13.00	13.00	13.00	13.00	742.00	742.00	742.00
742.00	742.00	742.00	742.00	742.00	742.00	742.00	742.00
742.00	742.00	742.00	742.00	742.00	742.00	742.00	742.00
742.00	742.00	742.00	742.00	742.00	742.00	742.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10   BASE VEHICLE PRICE--BASEP =110000.

RATE OF DISCOUNT--R = 0.10   COST OF CAPITAL RATE --CCRATE = 0.10

Advanced Design Buses - Option 2A

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1985
AND ATTAINS STEADY STATE IN 1986

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	2.4057	2.4057	1.6961	0.7095
1986	4.8216	7.2273	3.4258	1.3958
1987	7.2233	14.4505	5.1723	2.0510
1988	9.6342	24.0847	6.9524	2.6818
1989	12.0535	36.1381	8.7660	3.2874
1990	14.4567	50.5948	10.5965	3.8602
1991	16.8672	67.4619	12.4605	4.4067
1992	19.2605	86.7224	14.3414	4.9191
1993	21.6481	108.3705	16.2474	5.4007
1994	24.0056	132.3762	18.1618	5.8439
1995	24.3365	156.7126	18.4137	5.9228
1996	24.6582	181.3709	18.6579	6.0004
1997	24.9911	206.3620	18.9111	6.0800
1998	25.3159	231.6779	19.1573	6.1586
1999	25.6326	257.3103	19.3964	6.2361
2000	25.9625	283.2725	19.6460	6.3165
2001	26.2857	309.5581	19.8895	6.3962
2002	26.6230	336.1809	20.1441	6.4789
2003	26.9645	363.1453	20.4017	6.5628
2004	27.3307	390.4758	20.6794	6.6513
2005	27.6916	418.1672	20.9525	6.7392
2006	28.0570	446.2241	21.2289	6.8281
2007	28.4271	474.6509	21.5090	6.9181
2008	28.8022	503.4529	21.7928	7.0094
2009	29.1826	532.6353	22.0806	7.1020
2010	29.5679	562.2031	22.3722	7.1957

PRESENT VALUE OF ANNUAL COSTS = 101.7028

EQUIVALENT ANNUAL COST = 10.7293 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					
BASELINE PRODUCTION--BLPOP							
3579.0	3834.0	4107.0	4399.0	4712.0	5050.0	5150.0	5200.0
5300.0	5400.0	5450.0	5550.0	5600.0	5675.0	5700.0	5800.0
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					
REVISED BASELINE PRODUCTION--BLFOR							
0.0	0.0	0.0	0.0	0.0	5033.0	5132.6	5182.5
5282.1	5381.8	5431.6	5531.3	5581.1	5655.9	5680.8	5780.4
5857.2	5933.9	6012.7	6091.4	6172.1	6253.8	6336.6	6420.3
6505.0	6590.7	6677.4	6765.1	6854.8	6945.5	7037.2	0.0
0.0	0.0	0.0					
ATTRITION FACTOR--AF							
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					
INCREMENTAL FUEL COST--DFC							
0.0	0.0	0.0	0.0	0.0	45.00	45.00	45.00
45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00
45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00
45.00	45.00	45.00	45.00	45.00	45.00	45.00	0.0
0.0	0.0	0.0					
INCREMENTAL MAINTENANCE COST--DMC							
0.0	0.0	0.0	0.0	0.0	292.00	292.00	292.00
292.00	292.00	292.00	292.00	292.00	292.00	292.00	292.00
292.00	292.00	292.00	292.00	292.00	292.00	292.00	292.00
292.00	292.00	292.00	292.00	292.00	292.00	292.00	0.0
0.0	0.0	0.0					
INCREMENTAL EQUIPMENT COST--DVP							
0.0	0.0	0.0	0.0	0.0	742.00	742.00	742.00
742.00	742.00	742.00	742.00	742.00	742.00	742.00	742.00
742.00	742.00	742.00	742.00	742.00	742.00	742.00	742.00
742.00	742.00	742.00	742.00	742.00	742.00	742.00	0.0
0.0	0.0	0.0					
PRICE ELASTICITY OF DEMAND--PED							
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					
ELASTICITY FACTOR--EF							
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP =110000.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Advanced Design Buses - Option 3

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0095	0.0095	0.0	0.0095
1982	0.0191	0.0286	0.0	0.0191
1983	0.0289	0.0575	0.0	0.0289
1984	0.0390	0.0965	0.0	0.0390
1985	8.1886	8.2851	7.4423	0.7463
1986	10.6023	18.8874	9.1720	1.4303
1987	23.3237	42.2111	20.2013	3.1224
1988	28.2366	70.4477	23.4813	4.7553
1989	33.1506	103.5983	26.8233	6.3273
1990	38.0158	141.6141	30.1962	7.8196
1991	40.4825	182.0967	31.2386	9.2439
1992	42.7277	224.8243	32.1418	10.5859
1993	44.7624	269.5867	32.9091	11.8534
1994	46.5244	316.1108	33.4966	13.0279
1995	47.7498	363.8604	33.9455	13.8043
1996	48.9137	412.7737	34.3799	14.5338
1997	49.5733	462.3469	34.8465	14.7268
1998	50.2171	512.5640	35.3001	14.9170
1999	50.8457	563.4092	35.7408	15.1049
2000	51.5001	614.9092	36.2006	15.2995
2001	52.1419	667.0508	36.6493	15.4926
2002	52.8113	719.8618	37.1184	15.6929
2003	53.4892	773.3508	37.5931	15.8962
2004	54.2154	827.5659	38.1049	16.1105
2005	54.9313	882.4968	38.6080	16.3233
2006	55.6560	938.1528	39.1174	16.5386
2007	56.3903	994.5430	39.6335	16.7568
2008	57.1343	1051.6770	40.1565	16.9779
2009	57.8889	1109.5659	40.6868	17.2021
2010	58.6532	1168.2188	41.2240	17.4292

PRESENT VALUE OF ANNUAL COSTS = 224.9323

EQUIVALENT ANNUAL COST = 23.7295 MILLION DOLLARS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

3579.0	3834.0	4107.0	4399.0	4712.0	5050.0	5150.0	5200.0
5300.0	5400.0	5450.0	5550.0	5600.0	5675.0	5700.0	5800.0
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	3833.8	4106.8	4398.7	4711.7	5033.0	5132.6	5157.3
5256.5	5355.7	5405.3	5504.4	5554.0	5628.4	5653.2	5752.4
5828.8	5905.1	5983.5	6061.8	6142.2	6223.5	6305.8	6389.1
6473.4	6558.7	6645.0	6732.3	6821.5	6911.8	7003.0	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	45.00	45.00	80.00
80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
80.00	80.00	80.00	80.00	80.00	80.00	80.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	292.00	292.00	544.00
544.00	544.00	544.00	544.00	544.00	544.00	544.00	544.00
544.00	544.00	544.00	544.00	544.00	544.00	544.00	544.00
544.00	544.00	544.00	544.00	544.00	544.00	544.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	13.00	13.00	13.00	13.00	742.00	742.00	1806.00
1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00
1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00
1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10   BASE VEHICLE PRICE--BASEP =110000.
RATE OF DISCOUNT--R = 0.10   COST OF CAPITAL RATE --CCRATE = 0.10

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1985
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	2.4057	2.4057	1.6961	0.7095
1986	4.8216	7.2273	3.4258	1.3958
1987	12.6515	19.8788	9.5615	3.0900
1988	17.5667	37.4455	12.8415	4.7252
1989	22.4829	59.9284	16.1835	6.2994
1990	27.3503	87.2787	19.5564	7.7940
1991	32.2160	119.4948	22.9911	9.2249
1992	37.0303	156.5250	26.4568	10.5735
1993	41.8162	198.3412	29.9689	11.8472
1994	46.5244	244.8656	33.4966	13.0279
1995	47.7498	292.6152	33.9455	13.8043
1996	48.9137	341.5288	34.3799	14.5338
1997	49.5733	391.1018	34.8465	14.7268
1998	50.2171	441.3188	35.3001	14.9170
1999	50.8457	492.1643	35.7408	15.1049
2000	51.5001	543.6641	36.2006	15.2995
2001	52.1419	595.8059	36.6493	15.4926
2002	52.8113	648.6169	37.1184	15.6929
2003	53.4892	702.1057	37.5931	15.8962
2004	54.2154	756.3208	38.1049	16.1105
2005	54.9313	811.2520	38.6080	16.3233
2006	55.6560	866.9077	39.1174	16.5386
2007	56.3903	923.2979	39.6335	16.7568
2008	57.1343	980.4319	40.1565	16.9779
2009	57.8889	1038.3208	40.6868	17.2021
2010	58.6532	1096.9736	41.2240	17.4292

PRESENT VALUE OF ANNUAL COSTS = 193.3491

EQUIVALENT ANNUAL COST = 20.3976 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

3579.0	3834.0	4107.0	4399.0	4712.0	5050.0	5150.0	5200.0
5300.0	5400.0	5450.0	5550.0	5600.0	5675.0	5700.0	5800.0
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	0.0	0.0	0.0	0.0	5033.0	5132.6	5157.3
5256.5	5355.7	5405.3	5504.4	5554.0	5628.4	5653.2	5752.4
5828.8	5905.1	5983.5	6061.8	6142.2	6223.5	6305.8	6389.1
6473.4	6558.7	6645.0	6732.3	6821.5	6911.8	7003.0	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	45.00	45.00	80.00
80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
80.00	80.00	80.00	80.00	80.00	80.00	80.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	292.00	292.00	544.00
544.00	544.00	544.00	544.00	544.00	544.00	544.00	544.00
544.00	544.00	544.00	544.00	544.00	544.00	544.00	544.00
544.00	544.00	544.00	544.00	544.00	544.00	544.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	0.0	0.0	0.0	0.0	742.00	742.00	1806.00
1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00
1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00
1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP =110000.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Advanced Design Buses - Option 3B

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1987
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0
1986	0.0	0.0	0.0	0.0
1987	4.9878	4.9878	3.2182	1.7697
1988	9.9785	14.9663	6.4982	3.4802
1989	14.9701	29.9363	9.8401	5.1299
1990	19.9129	49.8492	13.2130	6.6999
1991	24.8540	74.7033	16.6478	8.2063
1992	29.7437	104.4470	20.1135	9.6302
1993	34.6050	139.0521	23.6256	10.9794
1994	39.3887	178.4408	27.1532	12.2355
1995	44.1662	222.6070	30.7427	13.4235
1996	48.9137	271.5205	34.3799	14.5338
1997	49.5733	21.0935	34.8465	14.7268
1998	50.2171	371.3105	35.3001	14.9170
1999	50.8457	422.1560	35.7408	15.1049
2000	51.5001	473.6558	36.2006	15.2995
2001	52.1419	525.7976	36.6493	15.4926
2002	52.8113	578.6084	37.1184	15.6929
2003	53.4892	632.0974	37.5931	15.8962
2004	54.2154	686.3125	38.1049	16.1105
2005	54.9313	741.2434	38.6080	16.3233
2006	55.6560	796.8994	39.1174	16.5386
2007	56.3903	853.2896	39.6335	16.7568
2008	57.1343	910.4236	40.1565	16.9779
2009	57.8889	968.3125	40.6868	17.2021
2010	58.6532	1026.9653	41.2240	17.4292

PRESENT VALUE OF ANNUAL COSTS = 165.8794

EQUIVALENT ANNUAL COST = 17.4996 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					
BASELINE PRODUCTION--BLPOP							
3579.0	3834.0	4107.0	4399.0	4712.0	5050.0	5150.0	5200.(
5300.0	5400.0	5450.0	5550.0	5600.0	5675.0	5700.0	5800.(
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					
REVISED BASELINE PRODUCTION--BLFOR							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	5157.3
5256.5	5355.7	5405.3	5504.4	5554.0	5628.4	5653.2	5752.4
5828.8	5905.1	5983.5	6061.8	6142.2	6223.5	6305.8	6389.1
6473.4	6558.7	6645.0	6732.3	6821.5	6911.8	7003.0	0.0
0.0	0.0	0.0					
ATTRITION FACTOR--AF							
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					
INCREMENTAL FUEL COST--DFC							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.00
80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
80.00	80.00	80.00	80.00	80.00	80.00	80.00	0.0
0.0	0.0	0.0					
INCREMENTAL MAINTENANCE COST--DMC							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	544.00
544.00	544.00	544.00	544.00	544.00	544.00	544.00	544.00
544.00	544.00	544.00	544.00	544.00	544.00	544.00	544.00
544.00	544.00	544.00	544.00	544.00	544.00	544.00	0.0
0.0	0.0	0.0					
INCREMENTAL EQUIPMENT COST--DVP							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	1806.00
1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00
1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00
1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	1806.00	0.0
0.0	0.0	0.0					
PRICE ELASTICITY OF DEMAND--PED							
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					
ELASTICITY FACTOR--EF							
1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10 BASE VEHICLE PRICE--BASEP =110000.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Advanced Design Buses - Option 4

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1989

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0095	0.0095	0.0	0.0095
1982	0.0191	0.0286	0.0	0.0191
1983	0.0289	0.0575	0.0	0.0289
1984	0.0390	0.0965	0.0	0.0390
1985	8.1886	8.2851	7.4423	0.7463
1986	10.6023	18.8874	9.1720	1.4303
1987	23.3237	42.2111	20.2013	3.1224
1988	44.3485	86.5596	38.5063	5.8422
1989	52.4272	138.9868	43.9628	8.4645
1990	60.4287	199.4155	49.4698	10.9590
1991	64.4991	263.9146	51.1520	13.3471
1992	68.2086	332.1230	52.6053	15.6033
1993	71.5753	403.6980	53.8354	17.7399
1994	74.4976	478.1956	54.7702	19.7274
1995	76.7530	554.9485	55.4771	21.2759
1996	78.8903	633.8386	56.1597	22.7306
1997	80.4961	714.3342	56.8949	23.6011
1998	81.5416	795.8757	57.6356	23.9060
1999	82.5621	878.4377	58.3550	24.2071
2000	83.6248	962.0625	59.1058	24.5190
2001	84.6669	1046.7290	59.8384	24.8285
2002	85.7538	1132.4827	60.6043	25.1495
2003	86.8545	1219.3372	61.3793	25.4752
2004	88.0338	1307.3706	62.2150	25.8187
2005	89.1962	1396.5667	63.0365	26.1597
2006	90.3729	1486.9392	63.8681	26.5048
2007	91.5652	1578.5042	64.7108	26.8544
2008	92.7734	1671.2773	65.5647	27.2087
2009	93.9986	1765.2759	66.4306	27.5680
2010	95.2397	1860.5151	67.3077	27.9320

PRESENT VALUE OF ANNUAL COSTS = 347.3193

EQUIVALENT ANNUAL COST = 36.6409 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

3579.0	3834.0	4107.0	4399.0	4712.0	5050.0	5150.0	5200.0
5300.0	5400.0	5450.0	5550.0	5600.0	5675.0	5700.0	5800.0
5877.0	5954.0	6033.0	6112.0	6193.0	6275.0	6358.0	6442.0
6527.0	6613.0	6700.0	6788.0	6878.0	6969.0	7061.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	3833.8	4106.8	4398.7	4711.7	5033.0	5132.6	5157.3
5229.9	5328.6	5377.9	5476.6	5525.9	5600.0	5624.6	5723.3
5799.3	5875.3	5953.2	6031.2	6111.1	6192.0	6273.9	6356.8
6440.7	6525.6	6611.4	6698.2	6787.1	6876.8	6967.6	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	45.00	45.00	80.00
125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00
125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00
125.00	125.00	125.00	125.00	125.00	125.00	125.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	292.00	292.00	544.00
899.00	899.00	899.00	899.00	899.00	899.00	899.00	899.00
899.00	899.00	899.00	899.00	899.00	899.00	899.00	899.00
899.00	899.00	899.00	899.00	899.00	899.00	899.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	13.00	13.00	13.00	13.00	742.00	742.00	1806.00
2909.00	2909.00	2909.00	2909.00	2909.00	2909.00	2909.00	2909.00
2909.00	2909.00	2909.00	2909.00	2909.00	2909.00	2909.00	2909.00
2909.00	2909.00	2909.00	2909.00	2909.00	2909.00	2909.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 10   BASE VEHICLE PRICE--BASEP =110000.

RATE OF DISCOUNT--R = 0.10   COST OF CAPITAL RATE --CCRATE = 0.10

Conventional School Buses - Option 1

LIST 584/L UNN CC
PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1982

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.3628	0.3628	0.0	0.3628
1982	0.3651	0.7279	0.0	0.3651
1983	0.3687	1.0966	0.0	0.3687
1984	0.3723	1.4689	0.0	0.3723
1985	0.3747	1.8436	0.0	0.3747
1986	0.3770	2.2206	0.0	0.3770
1987	0.3806	2.6012	0.0	0.3806
1988	0.3842	2.9854	0.0	0.3842
1989	0.3866	3.3719	0.0	0.3866
1990	0.3889	3.7609	0.0	0.3889
1991	0.3925	4.1533	0.0	0.3925
1992	0.3961	4.5494	0.0	0.3961
1993	0.3984	4.9479	0.0	0.3984
1994	0.4008	5.3[illegible]	0.0	0.4008
1995	0.4044	5.7531	0.0	0.4044
1996	0.4080	6.1610	0.0	[illegible]4080
1997	0.4103	6.5714	0.0	0.41[illegible]
1998	0.4127	6.9841	0.0	0.4127
1999	0.4163	7.4004	0.0	0.4163
2000	0.4193	7.8197	0.0	0.4193
2001	0.4223	8.2420	0.0	0.4223
2002	0.4254	8.6674	0.0	0.4254
2003	0.4285	9.0959	0.0	0.4285
2004	0.4316	9.5274	0.0	0.4316
2005	0.4347	9.9621	0.0	0.4347
2006	0.4378	10.3999	0.0	0.4378
2007	0.4410	10.8409	0.0	0.4410
2008	0.4442	11.2851	0.0	0.4442
2009	0.4474	11.7325	0.0	0.4474
2010	0.4506	12.1832	0.0	0.4506

PRESENT VALUE OF ANNUAL COSTS = 3.6492

EQUIVALENT ANNUAL COST = 0.3850 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

27270.0	27450.0	27630.0	27900.0	28170.0	28350.0	28530.0	28800.0
29070.0	29250.0	29430.0	29700.0	29970.0	30150.0	30330.0	30600.0
30870.0	31050.0	31230.0	31500.0	31728.0	31957.0	32188.0	32422.0
32656.0	32892.0	33131.0	33370.0	33611.0	33855.0	34100.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	27440.6	27620.5	27890.4	28160.3	28340.3	28520.2	28790.1
29060.0	29239.9	29419.9	29689.8	29959.7	30139.6	30319.6	30589.5
30859.4	31039.3	31219.3	31489.2	31717.1	31946.0	32176.9	32410.8
32644.8	32880.7	33119.6	33358.5	33599.4	33843.4	34088.3	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	13.22	13.22	13.22	13.22	13.22	13.22	13.22
13.22	13.22	13.22	13.22	13.22	13.22	13.22	13.22
13.22	13.22	13.22	13.22	13.22	13.22	13.22	13.22
13.22	13.22	13.22	13.22	13.22	13.22	13.22	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 1   BASE VEHICLE PRICE--BASEP = 19220.

RATE OF DISCOUNT--R = 0.10   COST OF CAPITAL RATE --CCRATE = 0.0

Conventional School Buses - Option 2

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1986

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.3628	0.3628	0.0	0.3628
1982	0.3651	0.7279	0.0	0.3651
1983	0.3687	1.0966	0.0	0.3687
1984	0.3723	1.4689	0.0	0.3723
1985	0.8719	2.3408	0.0	0.8719
1986	0.8775	3.2183	0.0	0.8775
1987	0.8858	4.1040	0.0	0.8858
1988	0.8941	4.9981	0.0	0.8941
1989	0.8996	5.8977	0.0	0.8996
1990	0.9051	6.8028	0.0	0.9051
1991	0.9134	7.7162	0.0	0.9134
1992	0.9217	8.6380	0.0	0.9217
1993	0.9273	9.5652	0.0	0.9273
1994	0.9328	10.4980	0.0	0.9328
1995	0.9411	11.4392	0.0	0.9411
1996	0.9494	12.3886	0.0	0.9494
1997	0.9550	13.3435	0.0	0.9550
1998	0.9605	14.3040	0.0	0.9605
1999	0.9688	15.2728	0.0	0.9688
2000	0.9758	16.2486	0.0	0.9758
2001	0.9828	17.2314	0.0	0.9828
2002	0.9900	18.2214	0.0	0.9900
2003	0.9971	19.2185	0.0	0.9971
2004	1.0043	20.2229	0.0	1.0043
2005	1.0116	21.2345	0.0	1.0116
2006	1.0190	22.2534	0.0	1.0190
2007	1.0263	23.2797	0.0	1.0263
2008	1.0337	24.3134	0.0	1.0337
2009	1.0412	25.3546	0.0	1.0412
2010	1.0488	26.4034	0.0	1.0488

PRESENT VALUE OF ANNUAL COSTS = 6.9491

EQUIVALENT ANNUAL COST = 0.7331 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

27270.0	27450.0	27630.0	27900.0	28170.0	28350.0	28530.0	28800.0
29070.0	29250.0	29430.0	29700.0	29970.0	30150.0	30330.0	30600.0
30870.0	31050.0	31230.0	31500.0	31728.0	31957.0	32188.0	32422.0
32656.0	32892.0	33131.0	33370.0	33611.0	33855.0	34100.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	27440.6	27620.5	27890.4	28160.3	28327.3	28507.2	28776.9
29046.7	29226.6	29406.4	29676.2	29946.0	30125.9	30305.7	30575.5
30845.3	31025.1	31205.0	31474.8	31702.6	31931.4	32162.2	32396.0
32629.9	32865.7	33104.5	33343.3	33584.1	33827.9	34072.7	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	13.22	13.22	13.22	13.22	30.78	30.78	30.78
30.78	30.78	30.78	30.78	30.78	30.78	30.78	30.78
30.78	30.78	30.78	30.78	30.78	30.78	30.78	30.78
30.78	30.78	30.78	30.78	30.78	30.78	30.78	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 1
RATE OF DISCOUNT--R = 0.10
BASE VEHICLE PRICE--BASEP = 19220.
COST OF CAPITAL RATE --CCRATE = 0.0

Conventional School Buses - Option 2A

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1985
AND ATTAINS STEADY STATE IN 1986

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	0.8719	0.8719	0.0	0.8719
1986	0.8775	1.7494	0.0	0.8775
1987	0.8858	2.6351	0.0	0.8858
1988	0.8941	3.5292	0.0	0.8941
1989	0.8996	4.4288	0.0	0.8996
1990	0.9051	5.3339	0.0	0.9051
1991	0.9134	6.2473	0.0	0.9134
1992	0.9217	7.1691	0.0	0.9217
1993	0.9273	8.0963	0.0	0.9273
1994	0.9328	9.0292	0.0	0.9328
1995	0.9411	9.9703	0.0	0.9411
1996	0.9494	10.9197	0.0	0.9494
1997	0.9550	11.8746	0.0	0.9550
1998	0.9605	12.8351	0.0	0.9605
1999	0.9688	13.8039	0.0	0.9688
2000	0.9758	14.7797	0.0	0.9758
2001	0.9828	15.7626	0.0	0.9828
2002	0.9900	16.7525	0.0	0.9900
2003	0.9971	17.7496	0.0	0.9971
2004	1.0043	18.7540	0.0	1.0043
2005	1.0116	19.7656	0.0	1.0116
2006	1.0190	20.7845	0.0	1.0190
2007	1.0263	21.8108	0.0	1.0263
2008	1.0337	22.8446	0.0	1.0337
2009	1.0412	23.8858	0.0	1.0412
2010	1.0488	24.9345	0.0	1.0488

PRESENT VALUE OF ANNUAL COSTS = 5.7863

EQUIVALENT ANNUAL COST = 0.6104 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

27270.0	27450.0	27630.0	27900.0	28170.0	28350.0	28530.0	28800.0
29070.0	29250.0	29430.0	29700.0	29970.0	30150.0	30330.0	30600.0
30870.0	31050.0	31230.0	31500.0	31728.0	31957.0	32188.0	32422.0
32656.0	32892.0	33131.0	33370.0	33611.0	33855.0	34100.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	0.0	0.0	0.0	0.0	28327.3	28507.2	28776.9
29046.7	29226.6	29406.4	29676.2	29946.0	30125.9	30305.7	30575.5
30845.3	31025.1	31205.0	31474.8	31702.6	31931.4	32162.2	32396.0
32629.9	32865.7	33104.5	33343.3	33584.1	33827.9	34072.7	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	0.0	0.0	0.0	0.0	30.78	30.78	30.78
30.78	30.78	30.78	30.78	30.78	30.78	30.78	30.78
30.78	30.78	30.78	30.78	30.78	30.78	30.78	30.78
30.78	30.78	30.78	30.78	30.78	30.78	30.78	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 1 BASE VEHICLE PRICE--BASEP = 19220.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.0

Conventional School Buses - Option 3

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.3629	0.3629	0.3629	0.0
1982	0.7282	1.0910	0.7282	0.0
1983	1.0970	2.1880	1.0970	0.0
1984	1.4694	3.6574	1.4694	0.0
1985	4.2938	7.9513	4.2938	0.0
1986	5.1720	13.1232	5.1720	0.0
1987	43.7124	56.8356	39.0533	4.6591
1988	53.8091	110.6447	44.7213	9.0878
1989	58.2309	168.8756	44.9618	13.2691
1990	62.4027	231.2783	45.2016	17.2010
1991	66.3370	297.6150	45.4404	20.8967
1992	70.0313	367.6460	45.6780	24.3533
1993	73.4688	441.1147	45.9149	27.5539
1994	76.6478	517.7622	46.1511	30.4966
1995	77.2300	594.9917	46.5021	30.7279
1996	77.8156	672.8071	46.8530	30.9625
1997	78.3978	751.2046	47.2040	31.1938
1998	78.9766	830.1807	47.5550	31.4216
1999	79.5588	909.7393	47.9059	31.6528
2000	80.1294	989.8684	48.2487	31.8807
2001	80.7145	1070.5828	48.6010	32.1135
2002	81.3143	1151.8967	48.9633	32.3510
2003	81.9042	1233.8005	49.3185	32.5856
2004	82.4844	1316.2847	49.6668	32.8176
2005	83.0813	1399.3655	50.0259	33.0553
2006	83.6954	1483.0605	50.3966	33.2988
2007	84.3009	1567.3611	50.7612	33.5397
2008	84.9106	1652.2717	51.1283	33.7823
2009	85.5252	1737.7966	51.4984	34.0268
2010	86.1443	1823.9407	51.8712	34.2731

PRESENT VALUE OF ANNUAL COSTS = 357.4780

EQUIVALENT ANNUAL COST = 37.7126 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

27270.0	27450.0	27630.0	27900.0	28170.0	28350.0	28530.0	28800.0
29070.0	29250.0	29430.0	29700.0	29970.0	30150.0	30330.0	30600.0
30870.0	31050.0	31230.0	31500.0	31728.0	31957.0	32188.0	32422.0
32656.0	32892.0	33131.0	33370.0	33611.0	33855.0	34100.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	27450.0	27630.0	27900.0	28170.0	28350.0	28530.0	28217.9
28482.4	28658.8	28835.1	29099.7	29364.2	29540.6	29716.9	29981.5
30246.0	30422.4	30598.7	30863.3	31086.7	31311.0	31537.4	31766.6
31995.9	32227.1	32461.3	32695.5	32931.6	33170.7	33410.7	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	13.22	13.22	13.22	13.22	30.78	30.78	189.00
189.00	189.00	189.00	189.00	189.00	189.00	189.00	189.00
189.00	189.00	189.00	189.00	189.00	189.00	189.00	189.00
189.00	189.00	189.00	189.00	189.00	189.00	189.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	0.0	0.0	0.0	0.0	0.0	0.0	777.00
777.00	777.00	777.00	777.00	777.00	777.00	777.00	777.00
777.00	777.00	777.00	777.00	777.00	777.00	777.00	777.00
777.00	777.00	777.00	777.00	777.00	777.00	777.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 8 BASE VEHICLE PRICE--BASEP = 19220.
RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Conventional School Buses - Option 3A

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1985
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	0.8726	0.8726	0.8726	0.0
1986	1.7508	2.6234	1.7508	0.0
1987	21.0830	23.7063	16.4239	4.6591
1988	31.0088	54.7152	21.9210	9.0878
1989	40.7212	95.4363	27.4521	13.2691
1990	50.2183	145.6546	33.0173	17.2010
1991	59.5302	205.1848	38.6335	20.8967
1992	68.6541	273.8386	44.3008	24.3533
1993	72.0845	345.9229	44.5306	27.5539
1994	75.2563	421.1790	44.7596	30.4966
1995	75.8279	497.0068	45.1000	30.7279
1996	76.4029	573.4094	45.4404	30.9625
1997	76.9746	650.3838	45.7808	31.1938
1998	77.5428	727.9263	46.1212	31.4216
1999	78.1144	806.0403	46.4615	31.6528
2000	78.6747	884.7146	46.7940	31.8807
2001	79.2492	963.9636	47.1357	32.1135
2002	79.8380	1043.8015	47.4870	32.3510
2003	80.4172	1124.2185	47.8315	32.5856
2004	80.9869	1205.2051	48.1693	32.8176
2005	81.5730	1286.7778	48.5176	33.0553
2006	82.1759	1368.9534	48.8771	33.2988
2007	82.7704	1451.7236	49.2307	33.5397
2008	83.3690	1535.0925	49.5868	33.7823
2009	83.9725	1619.0649	49.9457	34.0268
2010	84.5803	1703.6450	50.3072	34.2731

PRESENT VALUE OF ANNUAL COSTS = 309.6887

EQUIVALENT ANNUAL COST = 32.6710 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					
BASELINE PRODUCTION--BLPOP							
27370.0	27450.0	27630.0	27900.0	28170.0	28350.0	28530.0	28800.0
29070.0	29250.0	29430.0	29700.0	29970.0	30150.0	30330.0	30600.0
30870.0	31050.0	31230.0	31500.0	31728.0	31957.0	32188.0	32422.0
32656.0	32892.0	33131.0	33370.0	33611.0	33855.0	34100.0	0.0
0.0	0.0	0.0					
REVISED BASELINE PRODUCTION--BLFOR							
0.0	0.0	0.0	0.0	0.0	28350.0	28530.0	28217.9
28482.4	28658.8	28835.1	29099.7	29364.2	29540.6	29716.9	29981.5
30246.0	30422.4	30598.7	30863.3	31086.7	31311.0	31537.4	31766.6
31995.9	32227.1	32461.3	32695.5	32931.6	33170.7	33410.7	0.0
0.0	0.0	0.0					
ATTRITION FACTOR--AF							
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					
INCREMENTAL FUEL COST--DFC							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00	0.0
0.0	0.0	0.0					
INCREMENTAL MAINTENANCE COST--DMC							
0.0	0.0	0.0	0.0	0.0	30.78	30.78	183.00
183.00	183.00	183.00	183.00	183.00	183.00	183.00	183.00
183.00	183.00	183.00	183.00	183.00	183.00	183.00	183.00
183.00	183.00	183.00	183.00	183.00	183.00	183.00	0.0
0.0	0.0	0.0					
INCREMENTAL EQUIPMENT COST--DVP							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	777.00
777.00	777.00	777.00	777.00	777.00	777.00	777.00	777.00
777.00	777.00	777.00	777.00	777.00	777.00	777.00	777.00
777.00	777.00	777.00	777.00	777.00	777.00	777.00	0.0
0.0	0.0	0.0					
PRICE ELASTICITY OF DEMAND--PED							
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					
ELASTICITY FACTOR--EF							
1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 8　BASE VEHICLE PRICE--BASEP = 19220.

RATE OF DISCOUNT--R = 0.10　COST OF CAPITAL RATE ¬--CCRATE = 0.10

Conventional School Buses - Option 3B

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1987
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0
1986	0.0	0.0	0.0	0.0
1987	10.1052	10.1052	5.4460	4.6591
1988	20.0310	30.1361	10.9431	9.0878
1989	29.7433	59.8795	16.4743	13.2691
1990	39.2405	99.1199	22.0394	17.2010
1991	48.5523	147.6723	27.6557	20.8967
1992	57.6763	205.3486	33.3230	24.3533
1993	66.5782	271.9265	39.0243	27.5539
1994	75.2563	347.1824	44.7596	30.4966
1995	75.8279	423.0103	45.1000	30.7279
1996	76.4029	499.4128	45.4404	30.9625
1997	76.9746	576.3872	45.7808	31.1938
1998	77.5428	653.9297	46.1212	31.4216
1999	78.1144	732.0437	46.4615	31.6528
2000	78.6747	810.7180	46.7940	31.8807
2001	79.2492	889.9670	47.1357	32.1135
2002	79.8380	969.8049	47.4870	32.3510
2003	80.4172	1050.2219	47.8315	32.5856
2004	80.9869	1131.2085	48.1693	32.8176
2005	81.5730	1212.7813	48.5176	33.0553
2006	82.1759	1294.9570	48.8771	33.2988
2007	82.7704	1377.7271	49.2307	33.5397
2008	83.3690	1461.0962	49.5868	33.7823
2009	83.9725	1545.0684	49.9457	34.0268
2010	84.5803	1629.6484	50.3072	34.2731

PRESENT VALUE OF ANNUAL COSTS = 279.5757

EQUIVALENT ANNUAL COST = 29.4942 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

27270.0	27450.0	27630.0	27900.0	28170.0	28350.0	28530.0	28800.0
29070.0	29250.0	29430.0	29700.0	29970.0	30150.0	30330.0	30600.0
30870.0	31050.0	31230.0	31500.0	31728.0	31957.0	32188.0	32422.0
32656.0	32892.0	33131.0	33370.0	33611.0	33855.0	34100.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	0.0	0.0	0.0	0.0	0.0	0.0	28217.9
28482.4	28658.8	28835.1	29099.7	29364.2	29540.6	29716.9	29981.5
30246.0	30422.4	30598.7	30863.3	31086.7	31311.0	31537.4	31766.6
31995.9	32227.1	32461.3	32695.5	32931.6	33170.7	33410.7	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	183.00
183.00	183.00	183.00	183.00	183.00	183.00	183.00	183.00
183.00	183.00	183.00	183.00	183.00	183.00	183.00	183.00
183.00	183.00	183.00	183.00	183.00	183.00	183.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	0.0	0.0	0.0	0.0	0.0	0.0	777.00
777.00	777.00	777.00	777.00	777.00	777.00	777.00	777.00
777.00	777.00	777.00	777.00	777.00	777.00	777.00	777.00
777.00	777.00	777.00	777.00	777.00	777.00	777.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 8 BASE VEHICLE PRICE--BASEP = 19220.
RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Conventional School Buses - Option 4

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1989

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.3629	0.3629	0.3629	0.0
1982	0.7282	1.0910	0.7282	0.0
1983	1.0970	2.1880	1.0970	0.0
1984	1.4694	3.6574	1.4694	0.0
1985	4.2938	7.9513	4.2938	0.0
1986	5.1720	13.1232	5.1720	0.0
1987	42.5349	55.6581	37.8758	4.6591
1988	61.4158	117.0740	50.5117	10.9041
1989	67.5368	184.6108	50.7308	16.8061
1990	73.3112	257.9219	50.9487	22.3625
1991	78.7561	336.6777	51.1649	27.5912
1992	83.8681	420.5457	51.3793	32.4887
1993	88.6240	509.1694	51.5927	37.0313
1994	93.0214	602.1904	51.8049	41.2165
1995	94.7419	696.9319	52.1464	42.5955
1996	95.4607	792.3926	52.5399	42.9208
1997	96.1749	888.5671	52.9335	43.2414
1998	96.8842	985.4512	53.3270	43.5572
1999	97.5983	1083.0493	53.7206	43.8777
2000	98.2986	1181.3477	54.1050	44.1936
2001	99.0164	1280.3640	54.5001	44.5163
2002	99.7519	1380.1152	54.9063	44.8456
2003	100.4754	1480.5908	55.3047	45.1707
2004	101.1875	1581.7781	55.6952	45.4923
2005	101.9198	1683.6975	56.0979	45.8219
2006	102.6729	1786.3701	56.5136	46.1593
2007	103.4157	1889.7856	56.9224	46.4933
2008	104.1637	1993.9490	57.3341	46.8295
2009	104.9176	2098.8665	57.7491	47.1685
2010	105.6771	2204.5435	58.1671	47.5099

PRESENT VALUE OF ANNUAL COSTS = 423.6370

EQUIVALENT ANNUAL COST = 44.6921 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

27270.0	27450.0	27630.0	27900.0	28170.0	28350.0	28530.0	28800.0
29070.0	29250.0	29430.0	29700.0	29970.0	30150.0	30330.0	30600.0
30870.0	31050.0	31230.0	31500.0	31728.0	31957.0	32188.0	32422.0
32656.0	32892.0	33131.0	33370.0	33611.0	33855.0	34100.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	27450.0	27630.0	27900.0	28170.0	28350.0	28530.0	28217.9
28248.7	28423.6	28598.5	28860.9	29123.3	29298.2	29473.1	29735.5
29997.9	30172.8	30347.7	30610.1	30831.6	31054.2	31278.6	31506.0
31733.4	31962.7	32195.0	32427.2	32661.4	32898.5	33136.6	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.00
30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
30.00	30.00	30.00	30.00	30.00	30.00	30.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	13.22	13.22	13.22	13.22	30.78	30.78	183.00
195.00	195.00	195.00	195.00	195.00	195.00	195.00	195.00
195.00	195.00	195.00	195.00	195.00	195.00	195.00	195.00
195.00	195.00	195.00	195.00	195.00	195.00	195.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	0.0	0.0	0.0	0.0	0.0	0.0	777.00
1086.00	1086.00	1086.00	1086.00	1086.00	1086.00	1086.00	1086.00
1086.00	1086.00	1086.00	1086.00	1086.00	1086.00	1086.00	1086.00
1086.00	1086.00	1086.00	1086.00	1086.00	1086.00	1086.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98
0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 8 BASE VEHICLE PRICE--BASEP = 19220.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Integral School Buses - Option 1

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1982

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.3646	0.3646	0.1367	0.2279
1982	0.7181	1.0827	0.2743	0.4438
1983	1.0618	2.1444	0.4132	0.6485
1984	1.3954	3.5398	0.5535	0.8419
1985	1.7176	5.2574	0.6947	1.0229
1986	2.0284	7.2859	0.8368	1.1916
1987	2.3289	9.6147	0.9802	1.3487
1988	2.6188	12.2335	1.1250	1.4939
1989	2.6397	14.8732	1.1339	1.5057
1990	2.6603	17.5335	1.1429	1.5174
1991	2.6811	20.2146	1.1518	1.5293
1992	2.7021	22.9167	1.1608	1.5413
1993	2.7230	25.6397	1.1698	1.5532
1994	2.7436	28.3833	1.1787	1.5649
1995	2.7645	31.1477	1.1877	1.5768
1996	2.7855	33.9332	1.1967	1.5888
1997	2.8063	36.7395	1.2056	1.6007
1998	2.8269	39.5664	1.2146	1.6123
1999	2.8478	42.4142	1.2236	1.6242
2000	2.8682	45.2823	1.2323	1.6359
2001	2.8892	48.1714	1.2413	1.6478
2002	2.9035	51.0749	1.2479	1.6556
2003	2.9248	53.9997	1.2570	1.6679
2004	2.9459	56.9456	1.2659	1.6801
2005	2.9676	59.9132	1.2751	1.6926
2006	2.9898	62.9030	1.2845	1.7053
2007	3.0118	65.9148	1.2938	1.7179
2008	3.0339	68.9487	1.3032	1.7307
2009	3.0562	72.0049	1.3127	1.7435
2010	3.0837	75.0885	1.3249	1.7588

PRESENT VALUE OF ANNUAL COSTS = 18.6918

EQUIVALENT ANNUAL COST = 1.9719 MILLION DOLLARS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

3030.0	3050.0	3070.0	3100.0	3130.0	3150.0	3170.0	3200.0
3230.0	3250.0	3270.0	3300.0	3330.0	3350.0	3370.0	3400.0
3430.0	3450.0	3470.0	3500.0	3525.0	3551.0	3517.0	3602.0
3629.0	3655.0	3681.0	3708.0	3735.0	3762.0	3789.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	3037.7	3057.7	3087.5	3117.4	3137.3	3157.3	3187.1
3217.0	3236.9	3256.9	3286.7	3316.6	3336.5	3356.5	3386.3
3416.2	3436.1	3456.1	3485.9	3510.8	3536.7	3502.9	3587.5
3614.4	3640.3	3666.2	3693.1	3720.0	3746.9	3773.8	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	5.00	5.00	5.00	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	40.00	40.00	40.00	40.00	40.00	40.00	40.00
40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	353.00	353.00	353.00	353.00	353.00	353.00	353.00
353.00	353.00	353.00	353.00	353.00	353.00	353.00	353.00
353.00	353.00	353.00	353.00	353.00	353.00	353.00	353.00
353.00	353.00	353.00	353.00	353.00	353.00	353.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 8 BASE VEHICLE PRICE--BASEP = 43907.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Integral School Buses- Option 2

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1986

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.3646	0.3646	0.1367	0.2279
1982	0.7181	1.0827	0.2743	0.4438
1983	1.0618	2.1444	0.4132	0.6485
1984	1.3954	3.5398	0.5535	0.8419
1985	4.5031	8.0429	3.3953	1.1078
1986	5.4458	13.4887	4.0889	1.3569
1987	6.3791	19.8678	4.7890	1.5901
1988	7.3030	27.1707	5.4957	1.8073
1989	7.4250	34.5957	5.5385	1.8865
1990	7.5422	42.1379	5.5813	1.9609
1991	7.6552	49.7931	5.6240	2.0312
1992	7.7639	57.5570	5.6668	2.0972
1993	7.8238	65.3808	5.7105	2.1133
1994	7.8835	73.2643	5.7543	2.1292
1995	7.9434	81.2077	5.7981	2.1453
1996	8.0036	89.2112	5.8418	2.1617
1997	8.0635	97.2747	5.8856	2.1779
1998	8.1231	105.3978	5.9293	2.1938
1999	8.1830	113.5808	5.9731	2.2099
2000	8.2416	121.8223	6.0158	2.2258
2001	8.3018	130.1241	6.0597	2.2421
2002	8.3445	138.4686	6.0919	2.2526
2003	8.4054	146.8740	6.1361	2.2693
2004	8.4656	155.3396	6.1796	2.2859
2005	8.5274	163.8670	6.2245	2.3029
2006	8.5909	172.4578	6.2707	2.3202
2007	8.6536	181.1114	6.3162	2.3374
2008	8.7169	189.8283	6.3621	2.3548
2009	8.7805	198.6088	6.4083	2.3722
2010	8.8608	207.4696	6.4678	2.3930

PRESENT VALUE OF ANNUAL COSTS = 47.8240

EQUIVALENT ANNUAL COST = 5.0453 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

3030.0	3050.0	3070.0	3100.0	3130.0	3150.0	3170.0	3200.0
3230.0	3250.0	3270.0	3300.0	3330.0	3350.0	3370.0	3400.0
3430.0	3450.0	3470.0	3500.0	3525.0	3551.0	3517.0	3602.0
3629.0	3655.0	3681.0	3708.0	3735.0	3762.0	3789.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	3037.7	3057.7	3087.5	3117.4	3132.7	3152.6	3182.5
3212.3	3232.2	3252.1	3281.9	3311.8	3331.7	3351.5	3381.4
3411.2	3431.1	3451.0	3480.8	3505.7	3531.5	3497.7	3582.3
3609.1	3635.0	3660.8	3687.7	3714.5	3741.4	3768.2	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	5.00	5.00	5.00	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	40.00	40.00	40.00	40.00	215.00	215.00	215.00
215.00	215.00	215.00	215.00	215.00	215.00	215.00	215.00
215.00	215.00	215.00	215.00	215.00	215.00	215.00	215.00
215.00	215.00	215.00	215.00	215.00	215.00	215.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	353.00	353.00	353.00	353.00	481.00	481.00	481.00
481.00	481.00	481.00	481.00	481.00	481.00	481.00	481.00
481.00	481.00	481.00	481.00	481.00	481.00	481.00	481.00
481.00	481.00	481.00	481.00	481.00	481.00	481.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 8 BASE VEHICLE PRICE--BASEP = 43907.
RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Integral School Buses - Option 2A

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1985
AND ATTAINS STEADY STATE IN 1986

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	1.0094	1.0094	0.6892	0.3202
1986	2.0064	3.0158	1.3828	0.6236
1987	2.9940	6.0098	2.0829	0.9111
1988	3.9722	9.9820	2.7896	1.1825
1989	4.9374	14.9193	3.5007	1.4366
1990	5.8896	20.8089	4.2162	1.6734
1991	6.8318	27.6407	4.9382	1.8936
1992	7.7639	35.4046	5.6668	2.0972
1993	7.8238	43.2284	5.7105	2.1133
1994	7.8835	51.1119	5.7543	2.1292
1995	7.9434	59.0553	5.7981	2.1453
1996	8.0036	67.0588	5.8418	2.1617
1997	8.0635	75.1223	5.8856	2.1779
1998	8.1231	83.2454	5.9293	2.1938
1999	8.1830	91.4284	5.9731	2.2099
2000	8.2416	99.6699	6.0158	2.2258
2001	8.3018	107.9717	6.0597	2.2421
2002	8.3445	116.3163	6.0919	2.2526
2003	8.4054	124.7216	6.1361	2.2693
2004	8.4656	133.1872	6.1796	2.2859
2005	8.5274	141.7146	6.2245	2.3029
2006	8.5909	150.3054	6.2707	2.3202
2007	8.6536	158.9590	6.3162	2.3374
2008	8.7169	167.6759	6.3621	2.3548
2009	8.7805	176.4564	6.4083	2.3722
2010	8.8608	185.3172	6.4678	2.3930

PRESENT VALUE OF ANNUAL COSTS = 35.7659

EQUIVALENT ANNUAL COST = 3.7732 MILLION DOLLARS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					
BASELINE PRODUCTION--BLPOP							
3030.0	3050.0	3070.0	3100.0	3130.0	3150.0	3170.0	3200.0
3230.0	3250.0	3270.0	3300.0	3330.0	3350.0	3370.0	3400.0
3430.0	3450.0	3470.0	3500.0	3525.0	3551.0	3517.0	3602.0
3629.0	3655.0	3681.0	3708.0	3735.0	3762.0	3789.0	0.0
0.0	0.0	0.0					
REVISED BASELINE PRODUCTION--BLFOR							
0.0	0.0	0.0	0.0	0.0	3132.7	3152.6	3182.5
3212.3	3232.2	3252.1	3281.9	3311.8	3331.7	3351.5	3381.4
3411.2	3431.1	3451.0	3480.8	3505.7	3531.5	3497.7	3582.3
3609.1	3635.0	3660.8	3687.7	3714.5	3741.4	3768.2	0.0
0.0	0.0	0.0					
ATTRITION FACTOR--AF							
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					
INCREMENTAL FUEL COST--DFC							
0.0	0.0	0.0	0.0	0.0	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	0.0
0.0	0.0	0.0					
INCREMENTAL MAINTENANCE COST--DMC							
0.0	0.0	0.0	0.0	0.0	215.00	215.00	215.00
215.00	215.00	215.00	215.00	215.00	215.00	215.00	215.00
215.00	215.00	215.00	215.00	215.00	215.00	215.00	215.00
215.00	215.00	215.00	215.00	215.00	215.00	215.00	0.0
0.0	0.0	0.0					
INCREMENTAL EQUIPMENT COST--DVP							
0.0	0.0	0.0	0.0	0.0	481.00	481.00	481.00
481.00	481.00	481.00	481.00	481.00	481.00	481.00	481.00
481.00	481.00	481.00	481.00	481.00	481.00	481.00	481.00
481.00	481.00	481.00	481.00	481.00	481.00	481.00	0.0
0.0	0.0	0.0					
PRICE ELASTICITY OF DEMAND--PED							
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					
ELASTICITY FACTOR--EF							
1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 8 BASE VEHICLE PRICE--BASEP = 43907.
RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Integral School Buses - Option 3

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.3646	0.3646	0.1367	0.2279
1982	0.7181	1.0827	0.2743	0.4438
1983	1.0618	2.1444	0.4132	0.6485
1984	1.3954	3.5398	0.5535	0.8419
1985	4.5031	8.0429	3.3953	1.1078
1986	5.4458	13.4887	4.0889	1.3569
1987	10.0274	23.5161	7.6028	2.4246
1988	12.1459	35.6619	8.7109	3.4349
1989	13.0257	48.6876	8.7627	4.2630
1990	13.8560	62.5436	8.8143	5.0417
1991	14.6396	77.1832	8.8658	5.7738
1992	15.3760	92.5592	8.9171	6.4589
1993	16.0182	108.5773	8.9699	7.0483
1994	16.6139	125.1912	9.0226	7.5913
1995	16.7400	141.9312	9.0912	7.6488
1996	16.8671	158.7983	9.1598	7.7072
1997	16.9932	175.7915	9.2284	7.7648
1998	17.1185	192.9101	9.2971	7.8215
1999	17.2447	210.1548	9.3657	7.8791
2000	17.3682	227.5231	9.4326	7.9357
2001	17.4952	245.0183	9.5015	7.9937
2002	17.5832	262.6013	9.5520	8.0313
2003	17.7120	280.3132	9.6212	8.0908
2004	17.8395	298.1526	9.6895	8.1500
2005	17.9704	316.1228	9.7598	8.2106
2006	18.1046	334.2271	9.8322	8.2724
2007	18.2373	352.4641	9.9036	8.3337
2008	18.3712	370.8350	9.9756	8.3956
2009	18.5058	389.3408	10.0480	8.4577
2010	18.6731	408.0137	10.1413	8.5317

PRESENT VALUE OF ANNUAL COSTS = 85.1831

EQUIVALENT ANNUAL COST = 8.9865 MILLION DOLLARS

DATA BASE FOR TRUCK CHASSIS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					
BASELINE PRODUCTION--BLPOP							
3030.0	3050.0	3070.0	3100.0	3130.0	3150.0	3170.0	3200.0
3230.0	3250.0	3270.0	3300.0	3330.0	3350.0	3370.0	3400.0
3430.0	3450.0	3470.0	3500.0	3525.0	3551.0	3517.0	3602.0
3629.0	3655.0	3681.0	3708.0	3735.0	3762.0	3789.0	0.0
0.0	0.0	0.0					
REVISED BASELINE PRODUCTION--BLFOR							
0.0	3037.7	3057.7	3087.5	3117.4	3132.7	3152.6	3136.6
3166.0	3185.6	3205.2	3234.6	3264.0	3283.6	3303.2	3332.6
3362.0	3381.6	3401.2	3430.6	3455.2	3480.6	3447.3	3530.6
3557.1	3582.6	3608.1	3634.5	3661.0	3687.5	3713.9	0.0
0.0	0.0	0.0					
ATTRITION FACTOR--AF							
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					
INCREMENTAL FUEL COST--DFC							
0.0	5.00	5.00	5.00	5.00	5.00	5.00	25.00
25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
25.00	25.00	25.00	25.00	25.00	25.00	25.00	0.0
0.0	0.0	0.0					
INCREMENTAL MAINTENANCE COST--DMC							
0.0	40.00	40.00	40.00	40.00	215.00	215.00	325.00
325.00	325.00	325.00	325.00	325.00	325.00	325.00	325.00
325.00	325.00	325.00	325.00	325.00	325.00	325.00	325.00
325.00	325.00	325.00	325.00	325.00	325.00	325.00	0.0
0.0	0.0	0.0					
INCREMENTAL EQUIPMENT COST--DVP							
0.0	353.00	353.00	353.00	353.00	481.00	481.00	1740.00
1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00
1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00
1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	0.0
0.0	0.0	0.0					
PRICE ELASTICITY OF DEMAND--PED							
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					
ELASTICITY FACTOR--EF							
1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 8 BASE VEHICLE PRICE--BASEP = 43907.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Integral School Buses - Option 3A

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1985
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	1.0094	1.0094	0.6892	0.3202
1986	2.0064	3.0158	1.3828	0.6236
1987	5.0433	8.0591	3.2977	1.7456
1988	7.2160	15.2750	4.4058	2.8102
1989	9.3339	24.6089	5.5207	3.8132
1990	11.3967	36.0057	6.6426	4.7542
1991	13.4110	49.4166	7.7747	5.6363
1992	15.3760	64.7926	8.9171	6.4589
1993	16.0182	80.8108	8.9699	7.0483
1994	16.6139	97.4247	9.0226	7.5913
1995	16.7400	114.1647	9.0912	7.6488
1996	16.8671	131.0318	9.1598	7.7072
1997	16.9932	148.0250	9.2284	7.7648
1998	17.1185	165.1435	9.2971	7.8215
1999	17.2447	182.3883	9.3657	7.8791
2000	17.3682	199.7565	9.4326	7.9357
2001	17.4952	217.2517	9.5015	7.9937
2002	17.5832	234.8350	9.5520	8.0313
2003	17.7120	252.5470	9.6212	8.0908
2004	17.8395	270.3862	9.6895	8.1500
2005	17.9704	288.3564	9.7598	8.2106
2006	18.1046	306.4607	9.8322	8.2724
2007	18.2373	324.6978	9.9036	8.3337
2008	18.3712	343.0688	9.9756	8.3956
2009	18.5058	361.5745	10.0480	8.4577
2010	18.6731	380.2473	10.1413	8.5317

PRESENT VALUE OF ANNUAL COSTS = 70.5947

EQUIVALENT ANNUAL COST = 7.4475 MILLION DOLLARS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

3030.0	3050.0	3070.0	3100.0	3130.0	3150.0	3170.0	3200.0
3230.0	3250.0	3270.0	3300.0	3330.0	3350.0	3370.0	3400.0
3430.0	3450.0	3470.0	3500.0	3525.0	3551.0	3517.0	3602.0
3629.0	3655.0	3681.0	3708.0	3735.0	3762.0	3789.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	0.0	0.0	0.0	0.0	3132.7	3152.6	3136.6
3166.0	3185.6	3205.2	3234.6	3264.0	3283.6	3303.2	3332.6
3362.0	3381.6	3401.2	3430.6	3455.2	3480.6	3447.3	3530.6
3557.1	3582.6	3608.1	3634.5	3661.0	3687.5	3713.9	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	5.00	5.00	25.00
25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
25.00	25.00	25.00	25.00	25.00	25.00	25.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	215.00	215.00	325.00
325.00	325.00	325.00	325.00	325.00	325.00	325.00	325.00
325.00	325.00	325.00	325.00	325.00	325.00	325.00	325.00
325.00	325.00	325.00	325.00	325.00	325.00	325.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	0.0	0.0	0.0	0.0	481.00	481.00	1740.00
1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00
1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00
1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 8 BASE VEHICLE PRICE--BASEP = 43907.
RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Integral School Buses - Option 3B

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1987
AND ATTAINS STEADY STATE IN 1988

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0
1986	0.0	0.0	0.0	0.0
1987	2.2576	2.2576	1.0978	1.1598
1988	4.4681	6.7256	2.2059	2.2622
1989	6.6238	13.3494	3.3209	3.3030
1990	8.7244	22.0738	4.4427	4.2817
1991	10.7764	32.8502	5.5748	5.2016
1992	12.7793	45.6295	6.7172	6.0621
1993	14.7252	60.3547	7.8665	6.8588
1994	16.6139	76.9686	9.0226	7.5913
1995	16.7400	93.7086	9.0912	7.6488
1996	16.8671	110.5757	9.1598	7.7072
1997	16.9932	127.5689	9.2284	7.7648
1998	17.1185	144.6874	9.2971	7.8215
1999	17.2447	161.9322	9.3657	7.8791
2000	17.3682	179.3004	9.4326	7.9357
2001	17.4952	196.7956	9.5015	7.9937
2002	17.5832	214.3789	9.5520	8.0313
2003	17.7120	232.0909	9.6212	8.0908
2004	17.8395	249.9305	9.6895	8.1500
2005	17.9704	267.9009	9.7598	8.2106
2006	18.1046	286.0051	9.8322	8.2724
2007	18.2373	304.2419	9.9036	8.3337
2008	18.3712	322.6130	9.9756	8.3956
2009	18.5058	341.1189	10.0480	8.4577
2010	18.6731	359.7917	10.1413	8.5317

PRESENT VALUE OF ANNUAL COSTS = 61.8189

EQUIVALENT ANNUAL COST = 6.5217 MILLION DOLLARS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

3030.0	3050.0	3070.0	3100.0	3130.0	3150.0	3170.0	3200.0
3230.0	3250.0	3270.0	3300.0	3330.0	3350.0	3370.0	3400.0
3430.0	3450.0	3470.0	3500.0	3525.0	3551.0	3517.0	3603.0
3629.0	3655.0	3681.0	3708.0	3735.0	3762.0	3789.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	0.0	0.0	0.0	0.0	0.0	0.0	3136.6
3166.0	3185.6	3205.2	3234.6	3264.0	3283.6	3303.2	3332.6
3362.0	3381.6	3401.2	3430.6	3455.2	3480.6	3447.3	3530.6
3557.1	3582.6	3608.1	3634.5	3661.0	3687.5	3713.9	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.00
25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
25.00	25.00	25.00	25.00	25.00	25.00	25.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	0.0	0.0	0.0	0.0	0.0	0.0	325.00
325.00	325.00	325.00	325.00	325.00	325.00	325.00	325.00
325.00	325.00	325.00	325.00	325.00	325.00	325.00	325.00
325.00	325.00	325.00	325.00	325.00	325.00	325.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	0.0	0.0	0.0	0.0	0.0	0.0	1740.00
1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00
1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00
1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	1740.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 8 BASE VEHICLE PRICE--BASEP = 43907.

RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

Integral School Buses - Option 4

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

REGULATORY SCENARIO BEGINS IN 1981
AND ATTAINS STEADY STATE IN 1989

AECNR = ANNUAL ECONOMIC COST OF NOISE REGULATIONS
CAEC = CUMULATIVE ANNUAL ECONOMIC COST
OPCO = OPERATING COSTS
OTHER = OTHER COSTS
ALL IN MILLIONS OF 1978 DOLLARS

YEAR	AECNR	CAEC	OPCO	OTHER
1980	0.0	0.0	0.0	0.0
1981	0.3646	0.3646	0.1367	0.2279
1982	0.7181	1.0827	0.2743	0.4438
1983	1.0618	2.1444	0.4132	0.6485
1984	1.3954	3.5398	0.5535	0.8419
1985	4.5031	8.0429	3.3953	1.1078
1986	5.4458	13.4887	4.0889	1.3569
1987	10.0274	23.5161	7.6028	2.4246
1988	20.3134	43.8295	15.8927	4.4207
1989	22.1339	65.9634	15.9512	6.1827
1990	23.8524	89.8158	16.0094	7.8431
1991	25.4742	115.2900	16.0668	9.4073
1992	26.9981	142.2881	16.1237	10.8744
1993	28.3752	170.6634	16.1831	12.1922
1994	29.6515	200.3149	16.2421	13.4094
1995	30.4197	230.7346	16.3298	14.0900
1996	30.6506	261.3850	16.4530	14.1976
1997	30.8799	292.2649	16.5763	14.3036
1998	31.1076	323.3721	16.6995	14.4081
1999	31.3368	354.7085	16.8227	14.5141
2000	31.5613	386.2698	16.9429	14.6184
2001	31.7920	418.0618	17.0668	14.7253
2002	31.9518	450.0134	17.1573	14.7945
2003	32.1859	482.1992	17.2818	14.9041
2004	32.4177	514.6167	17.4044	15.0132
2005	32.6556	547.2720	17.5308	15.1248
2006	32.8994	580.1711	17.6608	15.2386
2007	33.1405	613.3113	17.7890	15.3515
2008	33.3839	646.6951	17.9184	15.4655
2009	33.6285	680.3232	18.0484	15.5801
2010	33.9324	714.2556	18.2160	15.7164

PRESENT VALUE OF ANNUAL COSTS = 140.5720

EQUIVALENT ANNUAL COST = 14.8298 MILLION DOLLARS

CALENDAR YEARS

1980	1981	1982	1983	1984	1985	1986	1987
1988	1989	1990	1991	1992	1993	1994	1995
1996	1997	1998	1999	2000	2001	2002	2003
2004	2005	2006	2007	2008	2009	2010	2011
2012	2013	2014					

BASELINE PRODUCTION--BLPOP

3030.0	3050.0	3070.0	3100.0	3130.0	3150.0	3170.0	3200.0
3230.0	3250.0	3270.0	3300.0	3330.0	3350.0	3370.0	3400.0
3430.0	3450.0	3470.0	3500.0	3525.0	3551.0	3517.0	3602.0
3629.0	3655.0	3681.0	3708.0	3735.0	3762.0	3789.0	0.0
0.0	0.0	0.0					

REVISED BASELINE PRODUCTION--BLFOR

0.0	3037.7	3057.7	3087.5	3117.4	3132.7	3152.6	3136.6
3110.0	3129.2	3148.5	3177.4	3206.3	3225.5	3244.8	3273.7
3302.5	3321.8	3341.1	3369.9	3394.0	3419.1	3386.3	3468.2
3494.2	3519.2	3544.2	3570.2	3596.2	3622.2	3648.2	0.0
0.0	0.0	0.0					

ATTRITION FACTOR--AF

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0					

INCREMENTAL FUEL COST--DFC

0.0	5.00	5.00	5.00	5.00	5.00	5.00	25.00
30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
30.00	30.00	30.00	30.00	30.00	30.00	30.00	0.0
0.0	0.0	0.0					

INCREMENTAL MAINTENANCE COST--DMC

0.0	40.00	40.00	40.00	40.00	215.00	215.00	325.00
610.00	610.00	610.00	610.00	610.00	610.00	610.00	610.00
610.00	610.00	610.00	610.00	610.00	610.00	610.00	610.00
610.00	610.00	610.00	610.00	610.00	610.00	610.00	0.0
0.0	0.0	0.0					

INCREMENTAL EQUIPMENT COST--DVP

0.0	353.00	353.00	353.00	353.00	481.00	481.00	1740.00
3263.00	3263.00	3263.00	3263.00	3263.00	3263.00	3263.00	3263.00
3263.00	3263.00	3263.00	3263.00	3263.00	3263.00	3263.00	3263.00
3263.00	3263.00	3263.00	3263.00	3263.00	3263.00	3263.00	0.0
0.0	0.0	0.0					

PRICE ELASTICITY OF DEMAND--PED

-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
-0.50	-0.50	-0.50					

ELASTICITY FACTOR--EF

1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98
0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.0
0.0	0.0	0.0					

VEHICLE LIFE--LIFE = 8 BASE VEHICLE PRICE--BASEP = 43907.
RATE OF DISCOUNT--R = 0.10 COST OF CAPITAL RATE --CCRATE = 0.10

APPENDIX J

MODEL NOISE ORDINANCE

A. ELEMENTS OF A MODEL ORDINANCE

In view of the previous minimal State and local interest in regulating the noise emissions of buses, it is useful to note their possible future interest in enforcing a model ordinance to be developed by EPA specifically for buses. The question often raised is that there may be difficulties in the adoption of a model ordinance by local governments when the enforcement will be directed towards the procurement of additional facilities or equipment of a city agency; namely, the local transit authority. It is to be expected that the adoption will be resisted if the enforcement interferes significantly with the operation of the fleet. This means that the test procedure must be as simple as possible, and yet consistent with good acoustical practice. Basically, there are three methods available, namely:

- o SAE J366b Test--involving a full throttle acceleration past a microphone to measure near maximum noise level.
- o Stationary Test--involving a rapid acceleration to governed engine speed in neutral gear, followed by a rapid deceleration.
- o Pass-By Test--involving a measurement of the noise level in a highway situation as the bus passes by operating under normal conditions.

In addition to the tests involving noise measurements, an effective method of enforcement can involve a careful vehicle maintenance checking procedure. A statement of the advantages and disadvantages of the four possible methods of enforcement are given in Table J-1.

In enforcing the model ordinance for newly manufactured buses, it is not necessarily essential to test every bus in a fleet. A sample of identical buses is all that is required to identify a common factor that results in an increase in noise with time--a poor muffler design, for example. All other factors causing degradation can be identified by correct vehicle maintenance at regular intervals. With this simplification, the optimum enforcement procedure can be stated as follows:

- o A stationary test on a sample of diesel-powered buses (mainly transit buses).
- o A unmodified SAE 366b test for gasoline-powered buses (mainly school buses).
- o A comprehensive procedure for bus maintenance (this will also be to the prevention of noise degradation of the older buses in the fleet).

With this background, it is possible to develop a simple, proposed model ordinance for buses.

Table J-1

Bus Noise Enforcement Methodology

Procedure	Advantages	Disadvantages
1. Controlled SAE Test	o Suitable for application to all bus types o Fairly repeatable o Well documented	o Large amount of space required o Time consuming
2. Stationary Test	o Simple o Quick o Only limited space required	o Difficult for application to ungoverned engines (school buses)
3. Uncontrolled Pass-By	o Simple o Expedient	o Not as accurate as other methods o Requires driver cooperation
4. Vehicle Maintenance Check	o Expedient o Strong possibility of adoption by local agencies	o Does not provide quantitative results

B. PROPOSED MODEL ORDINANCE

Applicability

The provisions of the model ordinance shall apply to any engine-powered vehicle with an enclosed passenger compartment designed for the transportation of passengers on a street or highway and having a Gross Vehicle Weight Rating (GVWR) in excess of 10,000 lbs., that is manufactured after the year ____.

Standards For Buses Equipped With An Engine Governor

No person shall operate a motor vehicle as defined above that is powered by an engine with an engine speed governor and emits on A-weighted which generates a noise level in excess of ____ dB when measured with fast response with the vehicle stationary at a distance of 50 feet from the vehicle centerline, on a line perpendicular to the exhaust outlet, when the engine is accelerated at full throttle in neutral from idle to the governed engine speed.

Standards For Buses Not Equipped With An Engine Governor

No person shall operate a motor vehicle as defined above that is not equipped with an engine speed governor and emits an A-weighted noise level in excess of __ dB when measured according to the test procedures defined by the EPA Procedure for Measurement of the Noise Emissions of New Buses (modified SAE J366b).

Vehicle Maintenance Procedure

(Recommended Practice Rather Than Part of An Ordinance)

Regular vehicle maintenance for all buses shall include inspection and necessary repair of the following equipment in addition to normal running maintenance:

1. Exhaust Systems

- o Mufflers and connecting pipes should be in normal working order, be free of visible corrosion and external carbon deposits.
- o Flexible joints should be free of carbon deposits and should not exude smoke, fumes, etc.
- o Exhaust manifold bolts and gaskets should be checked for tightness and replaced where necessary.

2. Body Work

- o All access doors and panels should be checked for proper closure and weatherstripping.
- o Where applicable, engine belly pans should be in place and correctly fitted.

REFERENCES

APPENDIX J

1. U.S. Environmental Protection Agency, "Noise Source Regulation in State and Local Noise Ordinances," Report No. 550/9-75-020, February 1979.

2. Society of Automotive Engineers, "Exterior Sound Level for Heavy Trucks and Buses", SAE Standard J366b.

3. "Interstate Motor Carrier Noise Emission Standards," Federal Register, Vol. 38, No. 144, July 27, 1973.

4. "Interstate Motor Carrier Noise Emission Standards--Final Regulations on Compliance," Federal Register, Vol. 40, No. 178, September 12, 1975.

5. "Existing Noise Regulations Applicable to Buses," Draft Final Report submitted by Wyle Laboratories under EPA Contract No. 68-01-3516, prepared for the Office of Noise Abatement and Control, June 24, 1976.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA 550/9-80-212	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Regulatory Analysis for the Final Noise Emission Regulation for Buses		5. REPORT DATE July 1980
		6. PERFORMING ORGANIZATION CODE EPA/200/02
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT NO. EPA 550/9-80-212
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Environmental Protection Agency Office of Noise Abatement and Control (ANR-490) Washington, D.C. 20460		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS U.S. Environmental Protection Agency Office of Noise Abatement and Control (ANR-490) Washington, D.C. 20460		13. TYPE OF REPORT AND PERIOD COVERED Final
		14. SPONSORING AGENCY CODE EPA/200/02

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This document presents the technical data and analysis used by EPA in developing the Noise Emission Regulation for Buses. The information presented includes a detailed discussion of: buses and the bus industry; baseline noise levels for current buses; the noise control technology available; the adverse health and welfare impacts of bus noise and the potential benefits of regulation; the expected costs and potential economic effects of regulation; the measurement methodology; the enforcement procedures; and existing State, local, and foreign noise regulations applicable to buses.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Buses, transit buses, intercity buses, school buses, noise emission regulation, economics, health and welfare analysis, noise control technology, enforcement, measurement methodology		

18. DISTRIBUTION STATEMENT Release unlimited	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 890
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

United States
Environmental Protection
Agency

Washington DC 20460

Official Business
Penalty for Private Use
$300

Special Fourth-Class Rate
Book
Postage and Fees Paid
EPA
Permit No. G-35