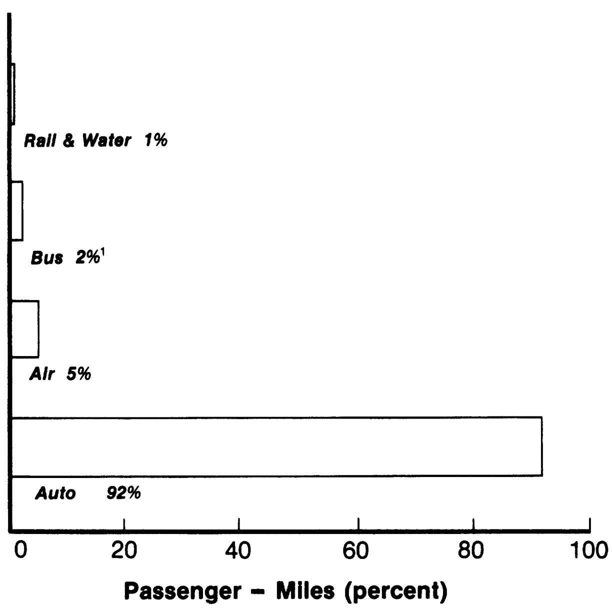
PART B
The Automobile

CHAPTER III
The Automobile Today

The dominant factor in 20th-century passenger transportation in the United States has been the private automobile. By sparking the growth of the highway system, the automobile has had a major impact on the movement of goods as well. It has been the primary source of our unparalleled personal mobility and a shaper of our environment, industry, and culture. Each alternative mode has been forced to structure its activities in terms of the links it provides to the auto and the services it offers in competition to the auto. Whether for good or ill, all present modes of travel and those proposed for the future will be judged in terms of their cost and service characteristics relative to the personal automobile.

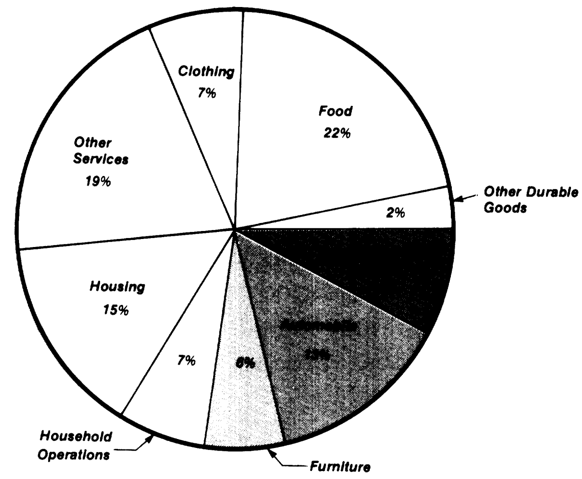
Figures III.1 and III.2 show that auto travel accounts for over 90 percent of the total passenger-miles and 13 percent of the Nation's expenditures by individuals. With this perspective in mind, it is clear that how we treat the automobile and how it treats us in the future will be critical to forming transportation policy and plans.



[1]Excludes schoolbuses.

Source: National Transportation Statistics. 1975, *Department of Transportation.*

Figure III.1. Percentage of 1975 U.S. Passenger-Miles.



Source: Survey of Current Business, March 1976.

Figure III.2. 1975 U.S. Personal Consumption Expenditures.

Automobile transportation is discussed in this chapter because its importance and ubiquity do not allow it to be categorized into interstate versus intrastate or local usage. Not only is the automobile the principal mode for most overland trips, but it also takes passengers to and from most trips by other modes. Furthermore, the shopping trip by auto serves as the final delivery link in moving most urban goods.

Exactly what *is* an automobile? From a *transportation* rather than a legalistic standpoint, the critical distinguishing feature is that of a *personal* vehicle, used principally to move people, operated by the user at the user's discretion, and usually owned (or leased or rented) by the user, who is responsible for its maintenance and upkeep. Such a transportation definition would cover all privately owned or leased automobiles plus motorcycles, light trucks used for personal transportation, vans, and recreational vehicles. Corporate fleets and rental cars would be borderline cases still classed as automotive transportation, but taxis might better be considered part of public transit.

The vehicle's exact size or shape, engine type, or fuel source are immaterial to the transportation definition. It can have four wheels or two, three, or six; it can use gasoline, diesel, electric, or hydrogen fuel; it can weigh 900 or 9,000 pounds. The critical feature is that the vehicle is essentially an extension of the legs and the will of the user, going where he wants to go, when he wants, with little direct dependence on anyone else.

In the discussion that follows, "the automobile" generally will refer to the transportation definition. However, because most data collections and analyses have used the legalistic definition usually applied to vehicle registration, separate entries for motorcycles will occur; personal automobiles and taxis may be merged; and "trucks" may include both personal- and commercial-use vehicles, as well as vans and recreational vehicles.

THE RISE OF THE AUTOMOBILE

The technological advances that made the automobile possible were an abundance of relatively cheap fuel (gasoline was then a byproduct of the kerosene used for heating and lighting) and the internal combustion engine that could use it. The economic keys were Henry Ford's production line and installment buying of cars (an innovation by General Motors Corporation), which together made autos available to the masses. Many other discoveries, inventions, and innovations have, of course, contributed to our present vehicle, but the timing of those forces paced the growth of the present automobile.

Conversely, it is likely that a personal transportation vehicle with the characteristics of the automobile would have been popular in almost any century since the earliest days of civilization. The desire for transportation better than the human legs is an old one, and vehicles or riding animals, or both, have emerged in most cultures. A motorized Roman chariot would have been as popular in its day as the horseless carriage was in our grandfather's time.

The horse never really has been the method of transportation for most people. In the "horse-and-buggy" era comparatively few well-to-do people actually owned riding horses or buggies. Many farms had work animals and work wagons which could be used for transport service, but such transportation was definitely second priority and second class. While the horse could move considerably faster than a man in a short race, the horse was not much faster nor more enduring over long distances than a man on foot. On foot, a reasonable speed was not much more than 2 miles an hour; the early flivver increased this to 20 mph.

Between the time of the Model "T" and the early 1970's, the real price of buying and driving an automobile declined steadily. The automobile became easier to drive, easier to maintain, and more reliable. For the individual, automobile transportation became a better and better bargain, and more and more autos were sold. Neither urban transit nor intercity railroads could compete with the decreasing out-of-pocket cost and the increasing convenience of the auto.

The automobile is now the principal vehicle for the personal mobility of most Americans. In 1975, the Nation's more than 100 million autos collectively logged just over 1 trillion vehicle-miles for 2.2 trillion passenger-miles. The automobile dominates our tripmaking from the very shortest journeys (more than half of all our trips are less than 5 miles) up to those of 1,000 miles, at which point it shares the market equally with the airplane. Four out of five of all persons in the United States over age 16 hold a driver's license and four-fifths of all U.S. households own one or more cars. In 1975 more than one in eight of all households owned one or more pickup trucks. More than 7 million motorcycles were registered. Our use of the automobile for personal travel figures out to an average of over 28 miles driven per vehicle per day and 22 miles per day for each licensed driver.

THE BENEFITS AND COSTS OF THE AUTOMOBILE

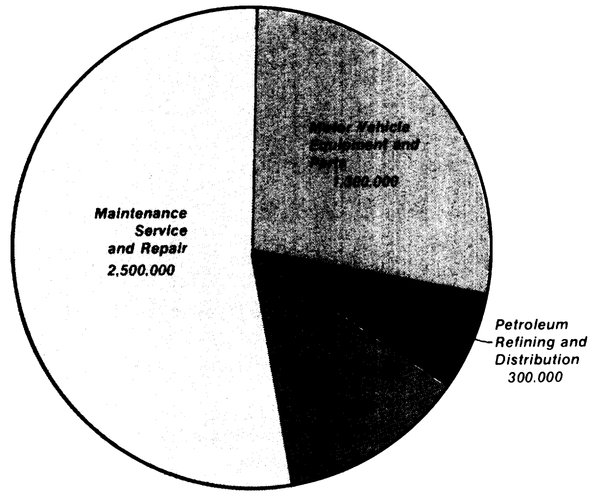
The bare data of vehicle-miles or even person-miles still give little clue to the perceived value of mobility. Table III.1 breaks down U.S. automobile use by trip purpose and distance. The data are from a 1972 survey but the relative shares, we believe, were approximately the same in 1975.

Not only is the overwhelming majority of movement of people being accomplished by automobile in the United States, but there is also a strong indication that no practical alternative now exists for many of these trips. Although urban bus and rail systems serve commuters and other travelers in some cities, and nationwide bus, air, and rail systems operate between cities, all of these systems together do

Table III.1
Auto Use by Trip Purpose.

Trip Purpose	Person-Miles	Auto Percent of Total Miles
	(Trillions)	
Local Trips (less than 30 miles)		
Commuting to Work	.38	95
Work Related	.05	97
Shopping	.15	97
Other Family Business	.27	97
Social and Recreational	.40	99
Subtotal	1.25	97
Trips Over 30 Miles (or Overnight)		
Visit Friends and Relatives	.18	79
Business and Conventions	.22	80
Outdoor Recreation	.08	93
Sightseeing and Entertainment	.29	93
Other	.15	89
Subtotal	.92	86
Total	2.17	92

Source: Nationwide Personal Transportation Study, *Federal Highway Administration.*



Source: U.S. Bureau of the Census.

Figure III.3. Auto Industry Direct Labor Distribution.

not have the capacity or flexibility of our 100-million-plus owner-operated automobiles.

The spatial and temporal patterns which exist now cannot easily be served by other modes without major new investments in system and vehicles. Not only does the automobile carry the bulk of all personal movement but our present lifestyle (developed in part because of the existence of the automobile) is such that only the car—or something very much like it—*can* do so. The automobile and its supporting industries now form a major part of the national economy. In World War II, the Nation was able to halt all auto production, institute drastic gasoline rationing, and still conduct business well enough to win the war. The same cutbacks today could idle one-tenth to one-sixth of the labor force (fig. III.3) and paralyze industry and commerce.

Clearly, the automobile is a major factor in the life of every person in the United States, whether or not he or she owns one, drives one, or even rides in one. How do we measure the benefits and costs of the automobile and the lifestyle it has produced? Despite a present tendency to nostalgia, there is little reason to believe that life in 1776, 1876, or 1926 was more satisfying for more people than in 1976. The present-day person in the United States has a wider choice of places to live, to work, to play, to become educated, or simply to visit, than his or her ancestors ever did.

One measure of the value we put on the automobile is simply what we have been willing to pay for it. Figure III.2 shows that, in terms of out-of-pocket costs, automotive transportation ranks fourth in personal consumption expenditures, behind food, housing, and other services, but ahead of clothing, furniture, medical care, and recreation. Of the nearly $1 trillion spent by persons in the United States in 1975, 13 percent, or $130 billion, went for user-operated automotive transportation. We spent $45 billion to purchase new cars, $45 billion for gas and oil, and $40 billion for parts and maintenance, plus an additional $13 billion in taxes and $17 billion for insurance. Figure III.4 shows the average cost per mile for 1976 automobiles.

SUBURBAN-BASED OPERATION
(TOTAL COSTS: CENTS PER MILE)

SIZE	ORIGINAL VEHICLE COST DEPRECIATED	MAINTENANCE, ACCESSORIES, PARTS & TIRES	GAS & OIL (EXCLUDING TAXES)	GARAGE, PARKING & TOLLS	INSURANCE	STATE & FEDERAL TAXES	TOTAL COST
STANDARD[1] WITH STANDARD EQUIPMENT, WEIGH MORE THAN 4,000 LBS. EMPTY.	4.9	4.2	3.3	2.2	1.7	1.6	17.9
COMPACT WEIGH MORE THAN 2,700 LBS. BUT LESS THAN 3,600 LBS. EMPTY.	3.8	3.4	2.5	2.1	1.6	1.2	14.6
SUB COMPACT WEIGH LESS THAN 2,700 LBS. EMPTY.	3.2	3.1	1.8	2.1	1.5	.9	12.6

[1]*Not shown are the intermediate size cars that weigh from 3,600 to 4,000 lbs empty.*

Source: Federal Highway Administration.

Figure III.4. 1976 Cost of Owning and Operating an Automobile.

Economic theory and common sense argue that a consumer in a free market will not pay more for a benefit than he perceives it to be worth. Thus, the perceived value of automotive transportation must be equal to, or greater than, the annual $160 billion its consumers pay out of pocket for it. More than the dollar value, it is important to bear in mind the relative ranking of automotive transportation compared with other major consumer purchases.

Even though the Nation purchases a large amount of automotive transportation and consumers are generally satisfied with what they buy, three important planning questions remain:

- Do those consumers who enjoy the benefits in fact pay all the costs?
- Could the same or greater benefits be provided at lower cost?
- Do the consumers know the actual financial and societal costs; and if they do, would it affect their choice?

The body of evidence indicates that consumers in the past have not paid all the external costs of automotive transportation in major areas—costs relating to environmental pollution, consumption of limited natural resources (especially energy), and safety. These have been borne by the community as a whole and, while almost everyone in the community uses automotive transportation to some extent, it is not likely that consumers would have behaved the same way if they had borne these costs directly.

When the automobile was first introduced, it was hailed by some as the solution to a serious urban solid-waste problem caused by the horse. Carbon monoxide exhaust was recognized early for the danger it presented to the occupants of a closed vehicle that had a faulty exhaust system, or to workers in enclosed spaces. However, the chemistry of photooxidant smog formation from unburned hydrocarbons and nitrogen oxides in the exhaust has only lately been understood. Lead compounds to raise octane rating are comparatively new, and their danger only recently became known. Additional pollution dangers posed by particulates, sulfates, and other exhaust components are still under investigation.

Air pollution is a classic example of an external cost. The individual driver rarely has to breathe his own car's exhaust, and he cannot identify in the smog the particular constituents his car emitted hours earlier. In fact, each individual can argue that the air quality problem is the combined result of so many cars that his own actions—how or what or even whether he drives—make no difference. On the other hand, his actions bear directly on the amount of transportation benefit he enjoys. Individually, then, the consumer sees little incentive to modify his own actions, but collectively all the consumers dump tens of million of tons of pollutants into the atmosphere every year.

It is important to note from figure III.5 that light-duty[1] vehicles are not now the sole or even the largest producers of most pollutants. Carbon monoxide, which is produced by all motor vehicles and which constitutes the greatest tonnage of pollutant, has the least adverse health impact. The automobile's relative contribution to total environmental pollution has been decreasing as emissions standards mandated under the Clean Air Act take effect. Rather than attempt to make the consumer perceive and pay the cost of pollution directly, regulations were imposed to reduce the pollutant emission rate of new cars. Of course, the purchaser of a new car pays for emission controls. In the early 1970's, part of the indirect cost of emission control was a sharp drop in fuel economy. The recent expanded use of the catalytic converter and other design changes have reversed this trend even with tougher emission standards.

[1]EPA designation for automobiles under 6,000 pounds gross vehicle weight.

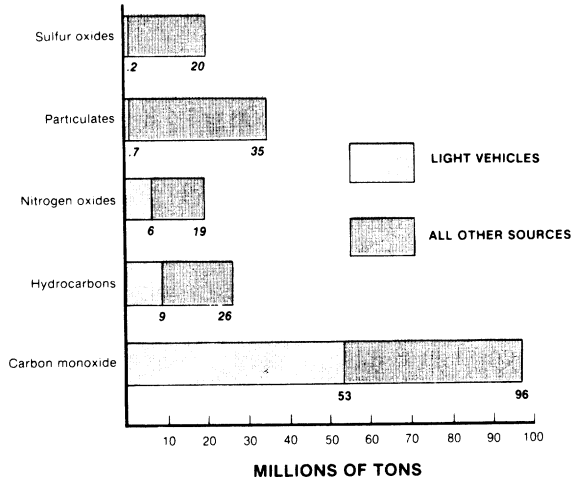
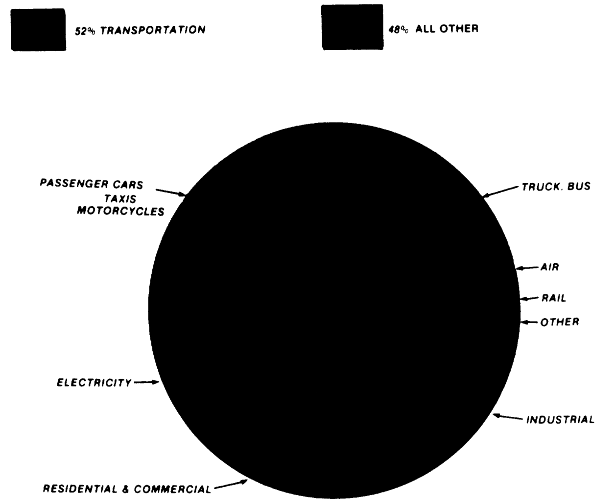
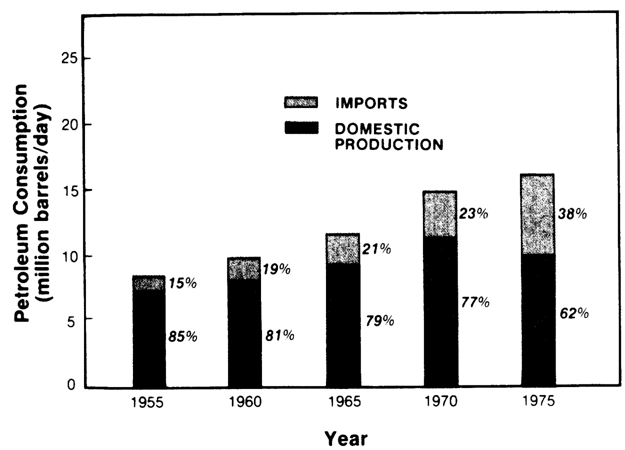


Figure III.5. Annual Pollution Load.



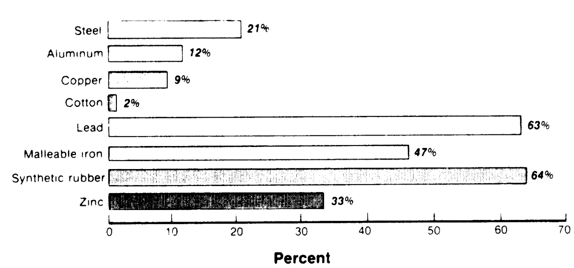
Source: 1975 Energy Statistics, *Report, Department of Transportation, Transportation Systems Center.*

Figure III.6. 1975 U.S. Petroleum by Sector.



Source: 1955-70 National Energy Outlook, *1975 Energy Statistics, Federal Energy Administration.*

Figure III.7. U.S. Petroleum Consumption by Source.



Source: Automobile Facts & Figures, 1975, *Motor Vehicle Manufacturers Association.*

Figure III.8. 1973 Consumption of Resources for Automobile Production.

A second area of external costs is the depletion of scarce resources, most notably petroleum. While the consumer pays the market price for the materials consumed in manufacturing and operating his car, many people believe that the Nation as a whole pays an additional price through increased dependence on unreliable sources, increased liability to pressure and conflict, and the risk of future severe shortages. Passenger cars, taxis, and motorcycles[2] consumed about 5.2 million barrels of gasoline per day in 1975 to dominate the sector usage shown in figure III.6. Figure III.7 shows that the United States produced 9.3 million barrels per day of crude oil in the same year, but imported 4.1 billion barrels of crude-oil and 1.6 million barrels of petroleum products per day. Thus, the consumption by automobiles was nearly equal to our total petroleum imports.

In terms of other resources, the production of automobiles consumes a significant portion of all steel, aluminum, copper, cotton, lead, iron, synthetic rubber, and zinc as shown in fig. III.8.

The Nation's 3.8 million miles of highway and right-of-way cover an estimated 33,000 square miles of land—a little less than the State of Indiana. The total area of the United States, including Alaska, is 3,536,855 square miles so that roughly 1 percent is devoted to highways.

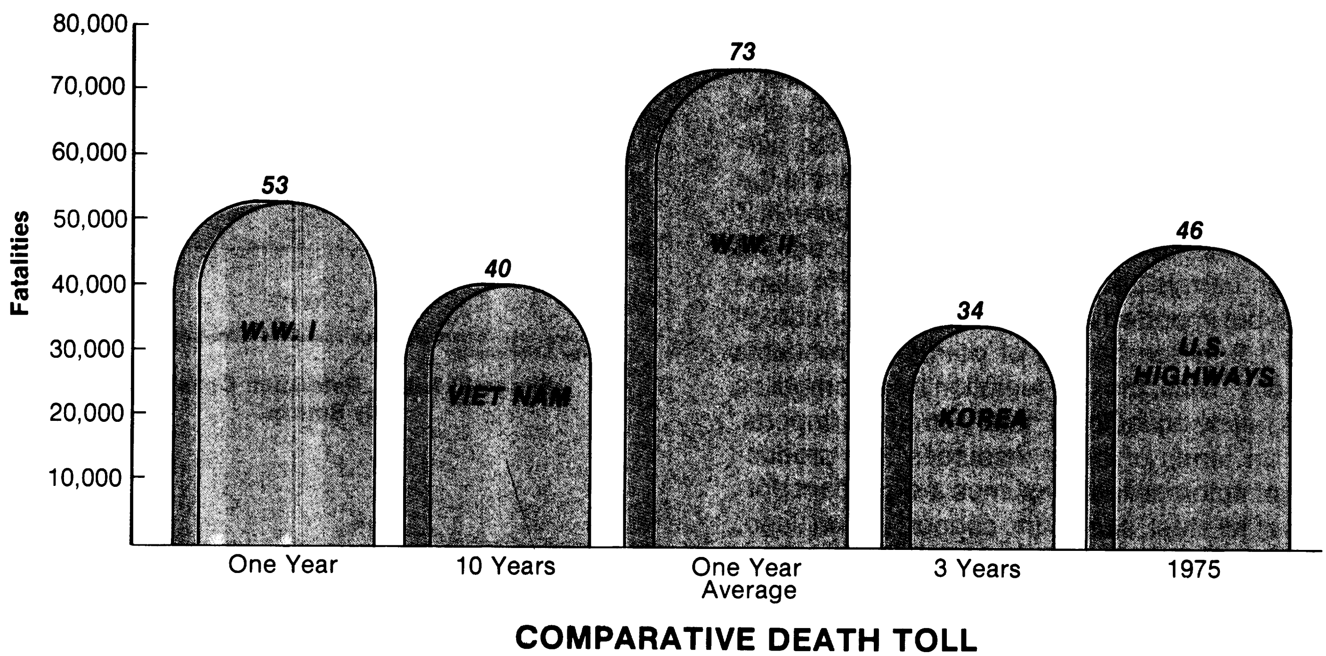
[2]Motorcycles consumed about 0.026 million barrels a day in 1975. At present, there is no plan for improved motorcycle fuel economy. By 1990, motorcycle fuel consumption may be about 0.034 million barrels per day.

Actual paving covers about 0.3 percent, with the remainder in median, shoulder, roadside parks, etc. Some 14 to 15 percent of the land in metropolitan areas is devoted to streets, with the percentage even higher in central business districts. Land used for highways is not "consumed" in the same sense that oil or iron ore reserves are consumed, but highway land is not available for other uses.

Finally, we have paid for our automobile mobility in the toll of motor vehicle accidents. In 1975, an estimated 46,000 Americans died in motor vehicle accidents. Figure III.9 gives a comparison of our highway casualty rate with recent major wars. Reported[3] disabling injuries from highway accidents totaled nearly 2 million in 1975. Motor vehicle accidents cause about 44 percent of all accidental deaths and about 12 percent of all disabling injuries. They are especially significant among 15-to-20-year-old males, accounting for 38 percent of the deaths from all causes in that age bracket, as compared to about 2 percent of the deaths for the total population.

Since about two-thirds of highway accident victims are vehicle occupants, it might be argued that these costs are, in fact, borne by the consumer. However, the remaining third of the fatalities are members of the general public; in addition, the public bears some loss for motor vehicle occupants killed or injured. Furthermore, because the risk per trip is very low—a little over 1 in 6 million for a 5-mile trip—it is doubtful if the consumer can perceive and react properly to it. The combined loss over a year is severe, and the full social costs are not reflected in the immediate costs to the users.

The real point in the shock-value illustration of figure III.9 is to emphasize that the highway accident toll can in large measure be prevented. The combined action of many public and private agencies has resulted in a steady decrease in the death rate over the last 50 years. What can be done in the future is discussed in chapter IV.



Source: Accident Facts, 1976 Edition, National Safety Council.

Figure III.9. Comparative Death Toll.

[3]Requirements for reporting injuries vary from State to State. Generally, all serious injuries are reported, but the depth of reporting minor injuries is not uniform. The total number of cases requiring medical attention in 1975 was about 4.5 million.

CHAPTER IV.
The Future for the Automobile

The personal mobility provided by automotive transportation will continue throughout this century. The automobile—or something very like it which provides its benefits at lower cost—will be with us well beyond the end of the century. Planning with respect to the automobile concentrates on improving the machine and the way in which people use it. A major study, *The Draft Report by the Federal Task Force[1] on Motor Vehicle Goals (MVG) Beyond 1980*, addresses many of the critical issues, and the discussion that follows leans heavily on this 1976 report.

EMISSIONS CONTROL

In the Clean Air Act of 1970, Congress established stringent levels of emission control for certain classes of motor vehicles. The Environmental Protection Agency (EPA), also established in 1970, was given responsibility for implementing the act. The establishment of National Ambient Air Quality Standards was authorized by this Act. These standards provide a basis for control requirements over both mobile and stationary air pollution sources.

The Clean Air Act of 1970 originally required that, beginning with the model year 1975, carbon monoxide (CO) and hydrocarbons (HC) emissions from automobiles be reduced by at least 90 percent from the 1970 levels, and that oxides of nitrogen (NO_x) emissions from model year 1976 autos be reduced by at least 90 percent from the 1971 levels. The emission reduction requirements for automobiles are frequently referred to as statutory standards and have been determined by EPA to be represented by numerical values of 0.41 grams per mile for HC, 3.4 grams per mile for CO, and 0.4 grams per mile for NO_x. The Act required that the above standards be met over the useful life of the motor vehicle, defined by EPA as the first 50,000 miles or 5 years, whichever comes first.

After several extensions, the statutory standards now are to go into effect with model year 1978. Interim standards are set at 1.5 grams per mile for HC and 15.0 for CO. The interim standards for NO_x are 3.1 grams per mile in 1976 and 2.0 grams per mile in 1977. The 94th Congress considered several proposals which would further postpone the deadlines for meeting the statutory standards for automobiles, but took no action.

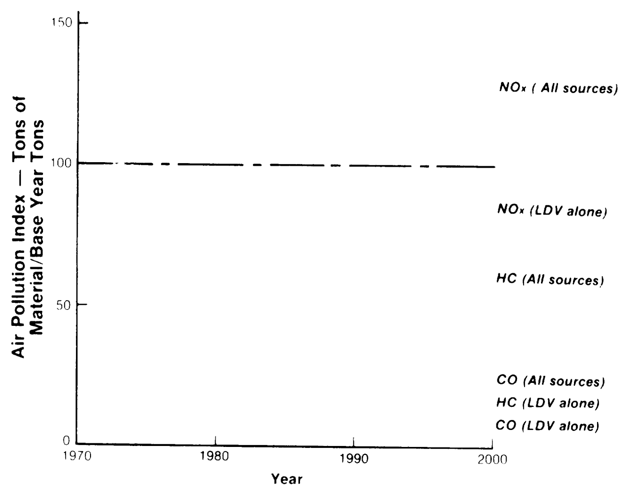
Emissions of sulfuric acid, lead, and other pollutants are currently the subject of possible EPA regulatory action and are not addressed in this report. The MVG task force report deals only with carbon monoxide, nitrogen dioxide, and photochemical oxidants—pollutants for which National Ambient Air Quality Standards have been developed. Hydrocarbons are precursors of the formation of oxidants.

The interaction between emission standards and fuel economy is strong and often negative—i.e., more stringent emission standards lead to poorer fuel economy. This is particularly true for present technology engines and for NO_x emission controls. Although one 1977 model automobile (Volvo) very nearly met the statutory emission standards, the MVG study indicated extreme difficulty in all U.S. automobile production simultaneously meeting the mandated fuel economy standards and statutory emission standards. If the 1976 standards, which reduce emissions by 85 percent, were maintained, the HC and CO emission from light-duty vehicles (LDV) alone would continue to decrease through 1990 by virtue of replace-

[1]The Secretary of Transportation was requested by the Energy Resources Council to lead the task force which included personnel representing the Department of Transportation, Environmental Protection Agency, Energy Research and Development Agency, Federal Energy Administration, National Science Foundation, Department of Commerce, Department of Defense, Department of Labor, Treasury Department, and the National Aeronautics and Space Administration. Heavier commercial trucks were treated in a separate task force draft report, *Interagency Study of Post-1980 Goals for Commercial Motor Vehicles*.

The task force dealt with the often-conflicting requirements to preserve personal mobility, protect the national economy, improve the motor vehicle fuel economy, reduce emissions, and enhance safety at a price the consumer can afford and industry can provide. Strong emphasis was placed on production and performance of future technological developments.

ment of older vehicles in the fleet. However, the sum of emissions from all sources would fail to meet clean air standards and the concentration of nitrogen dioxide would get worse (fig. IV.1). Emphasis for further emissions control will shift to commercial vehicles and stationary sources. The MVG analysis showed that several actions to reduce the emission of NO_x and HC from other sources were more cost effective than immediate application of the statutory LDV standards. The MVG study recommended delayed application of standards as shown in figure IV.2, with the assumption that appropriate action would be taken for other nonautomotive sources.

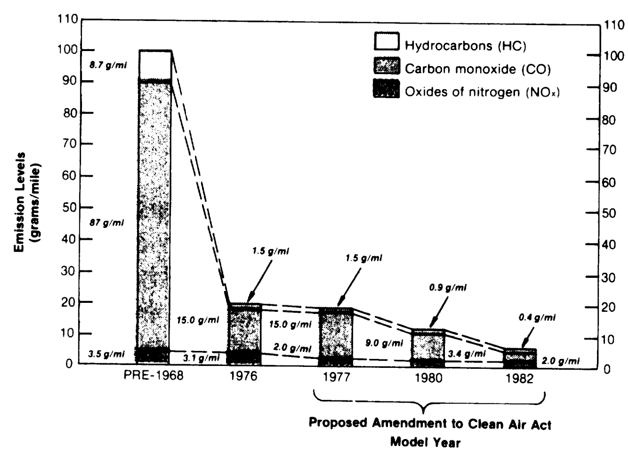


Source: Prepared from data in Report of the Panel on Air Quality, Noise, and Health of the Interagency Task Force on Motor Vehicle Goals Beyond 1980, *March, 1976.*

Figure IV.1. Effect of Freeze at 1975 Emission Standards.

Air quality violations occur in locations where a local concentration of emission activity combines with meteorological conditions to trap and hold emissions products. Most of local pollutants emitted on a per-year basis do not contribute to a severe local air quality problem, but a few tons at the wrong time and place result in a violation. If nationwide, new car emission standards are delayed, it will be especially desirable to attack the problems locally. Taxis and urban delivery or service vehicles, which log many more miles per year than the average car and operate almost exclusively in the critical air quality control regions, are candidates for special attention. An obvious step would be to require frequent inspection to insure that such vehicles continue to meet standards. The MVG study points out the general need to maintain the automobile emission control system, probably with inspection for enforcement. Such enforcement could be stepped up for critical localities and perhaps tied to traffic system management plans.

In enforcing local air quality control measures, the principle of internalized cost might be applied directly by using taxes or fees based on the relationship between the level of emission of those vehicles and the local total. Such a scheme would be particularly applicable to commercial vehicles based in, or authorized to operate in, the urban area, but it could be extended to private vehicles by a sticker or tag



[1]*In addition to the hydrocarbon emissions standards shown in the figure, there are estimated evaporative hydrocarbon losses of 2.5 g/mi for pre-1971 autos, 1.8 g/mi for 1971-79, and 0.5 g/mi after 1979.*

Source: Report of the Federal Task Force on Motor Vehicle Goals Beyond 1980, *Vol 2, Sept. 1976.*

Figure IV.2. Emission Comparison; Past, Present, and Proposed Future[1]

system. The object would be a flexible approach to press vehicle operators to reduce emissions.

FUEL ECONOMY

The Energy Policy and Conservation Act (EPCA) mandated standards for new automobile fuel economy through 1985 as shown earlier in table II.5.

The Secretary of Transportation is authorized to determine the progression of standards from 1980 to 1985 and, if circumstances warrant, he may reduce the 1985 standard to as low as 26.0 mpg. The Secretary is also authorized to set standards for other vehicles below 10,000 pounds gross vehicle weight.

Through 1980, the EPCA standards very nearly match the expected fuel economy under the auto industry's voluntary 40-percent improvement agreement with the President. The 1985 standard of 27.5 mpg, however, represents a 100-percent improvement over the 1974 base year levels and will pose a serious challenge to the industry. The MVG task force study has indicated several scenarios under which the 1985 fuel economy standard can be achieved or even exceeded, but the study points out several important caveats:

- Achievement of the 1985 standard will demand extraordinary investment by the automobile industry and considerable financial risk.
- The resulting automobiles will be lighter in weight and smaller in external size and may have poorer acceleration performance than current models. The customer appeal of these design changes is uncertain.
- Lighter weight automobiles with conventional construction could result in poorer crashworthiness. The DOT's Research Safety Vehicle (RSV) program indicates that advanced technology structures can combine lighter vehicle weight with improved crashworthiness and safety.
- Achievement of the sales-weighted standard may require more of a shift toward four- and five-passenger cars than the public desires.
- Imposition of the statutory emission standards would make it virtually impossible to achieve the 1985 fuel economy standard with conventional Otto cycle or diesel engines at any reasonable level of sales mix and performance. An advanced technology engine (Stirling or Brayton cycle) might meet both statutory-emission and 27.5-mpg-fuel-economy standards, but would be very unlikely to be in full production by 1985.

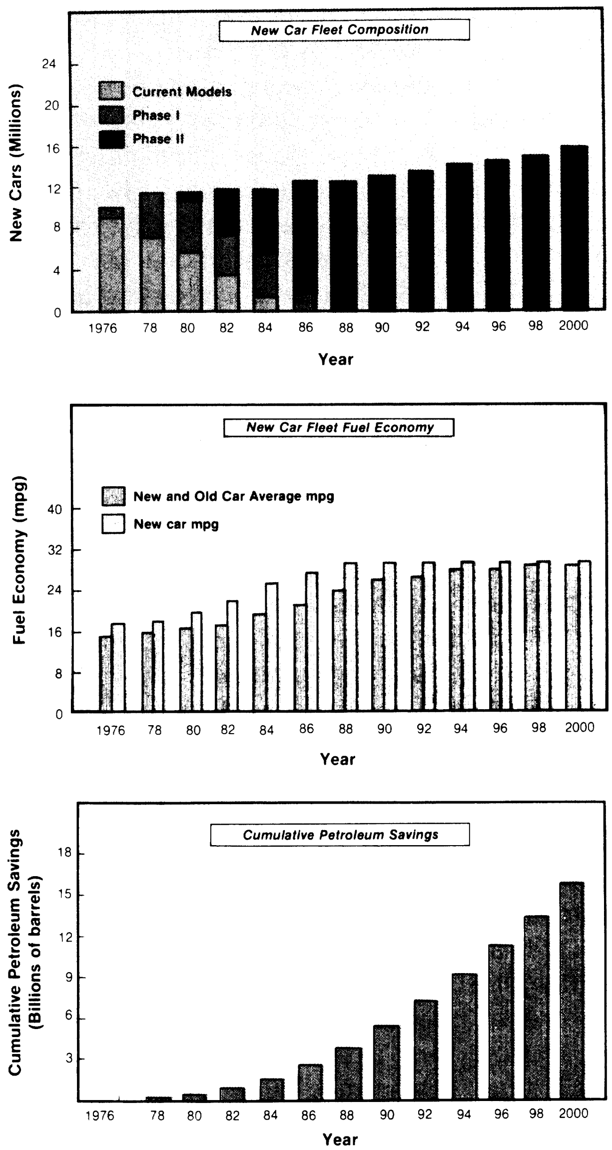
For this planning effort, it is assumed that the recommended amendments, or something comparable thereto, to the Clean Air Act will be enacted so that the fuel economy standards of the EPCA can be met on schedule. Figure IV.3 illustrates one of the scenarios from the MVG report (scenario no. 3) which combines the accelerated introduction of innovative automobile structure for lighter weight and greater strength with the best of 1975 Otto cycle engine technology.

The scenario illustrated operates in two phases, the first of which is already well under way. The first phase will replace older design models with those embodying the best present-day engine technology and weight-conscious (but conventional) structure. By 1980, roughly half the automobiles being produced will have

been converted to phase I design, and the first of phase II cars will be produced. Phase II of scenario no. 3 will keep essentially the same best conventional engines with only evolutionary improvements but will introduce new structural techniques. By 1985, all of the old (current) models will have been dropped from production and more than two-thirds of the models sold will be phase II types. The average fuel economy of the expected sales mix will be 27.5 mpg. By 1988, the production will be entirely phase II types with an average fuel economy of 29.2 mpg.

Other scenarios presented in the MVG report, which would comply with the EPCA standards, include:

- *No.* 4, Reduced Acceleration — Also with two phases but with phase II models offering reduced power-to-weight ratio and hence less spirited performance. This could be a fallback position if the advanced structural techniques do not meet expectations.
- *No.* 5, Diesel — In which phase II would replace the gasoline burning Otto cycle engine with a new lightweight diesel on the same time schedule as scenario no. 3.
- *No.* 6, Diesel/Innovative Structure — A three-phase scenario, which introduces the diesel in 1980 and innovative structure in 1986. The fuel economy in 1985 would be the same as in scenario no. 5 (27.1 mpg), but the potential would be 33.6 mpg weighted average by 1995.



Source: Report of the Federal Task Force on Motor Vehicle Goals Beyond 1980, *Sept. 1976.*

Figure IV.3. Scenario to Meet Fuel Economy Standards.

• *No.* 7, Dieselization of Large Cars and Reduced Acceleration — A two-phase scenario which combines scenarios nos. 4 and 5 in that the six-passenger models in phase II would have diesel engines and all cars would have reduced acceleration. The 1985 fuel economy is the best of all scenarios presented, 28.9 mpg, but the longer term potential is not as high as in scenarios nos. 6 or 8. (Scenario no. 8, which featured a new Stirling engine as a third phase, indicated an expected 33.7 mpg by 1995 but could not be introduced rapidly enough to meet the EPCA standards for 1985.)

It must be emphasized that the MVG task force sifted through a great many scenarios that could *not* meet the EPCA-mandated standards. The fact that four out of the eight presented would meet the standards in no way indicates the overall odds for success. The mandated standards represent very strong regulation which will require careful and flexible administration, wholehearted cooperation by the industry, the public, and other elements of government plus some measure of luck with respect to technologies still in development.

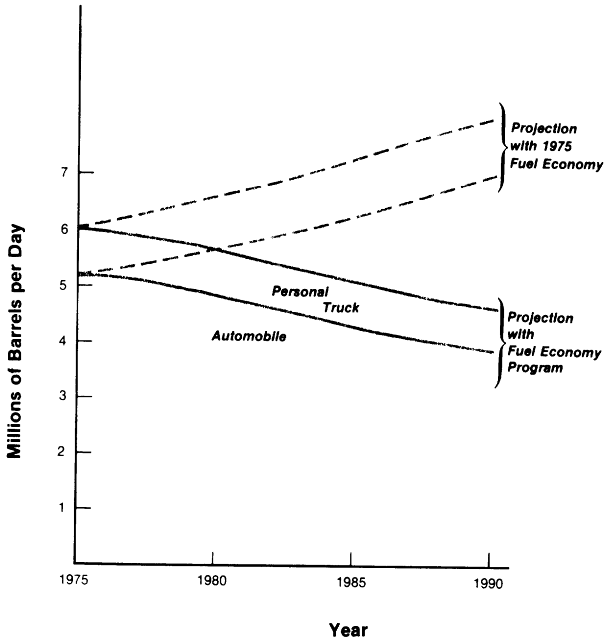
For planning purposes, it will be assumed that a successful sequence of events *will* occur and that the 1985 standard for new cars *will* be met on schedule. If so, and if entry of new cars into fleet follows expectations, then the *fleet* average for automobiles will be 20 to 21 mpg in 1985 and 25 to 26 mpg in 1990. The growth of fleet fuel economy will be more rapid than growth in vehicle-miles traveled by that fleet so that the total fuel consumed by automobiles will decrease over the period, and in 1990 be only about 80 percent of the 1975 level.

The MVG report addresses briefly the fuel economy expectation for light-duty trucks (under 10,000 pounds gross vehicle weight). Because fuel economy efforts are just beginning to focus on light-duty trucks, improvement will trail that of the passenger automobile. The expectation is that by the mid- to late-1980's, the fleet fuel economy will be improved by 25 to 50 percent. For light-duty trucks, it appears that the growth in vehicle-miles traveled will be very nearly balanced by growth in fuel economy, so that total fuel consumption in 1990 will be roughly the same as in 1975 (about 0.8 million barrels per day).

Figure IV.4 shows the combined automobile and light-duty truck energy consumption through 1990 and compares it with the projected consumption at a continuation of the 1975 average fuel economy levels. By 1990, efforts to improve passenger vehicle fuel economy can save roughly 3 million barrels of oil a day.

USE OF THE AUTOMOBILE

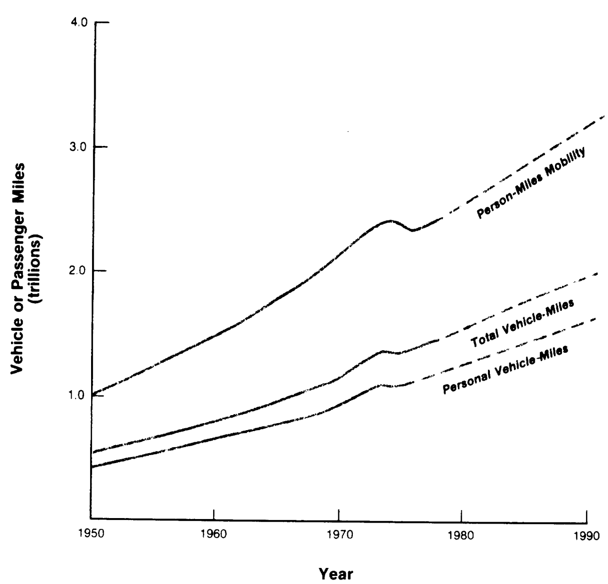
The expected savings in automobile fuel are predicated not only on advances in the fuel economy of the vehicles but also on increased



Source: Prepared for data in the Report of the Federal Task Force on Motor Vehicle Goals Beyond 1980, *Sept. 1976.*

Figure IV.4. Automotive Fuel Consumption Projections.

social responsibility in the use of the automobile. Figure IV.5 shows the projected growth in vehicle-miles and in passenger-miles through 1990. Auto occupancy is assumed to remain constant from 1975 through 1990, although it has been declining steadily since 1950. To achieve the indicated reversal of the trend in



Source: Prepared from data in Highway Travel Forecasts, *U.S. Department of Transportation, Federal Highway Administration, Office of Highway Planning, Nov. 1974.*

Figure IV.5. Projection of Automobile Passenger- and Vehicle-Miles Per Year.

auto occupancy will require changes in the pattern of auto use and ownership.

The number of vehicles owned per household has been seen to increase with household income, reaching a saturation point near the number of drivers in the household. By 1990, the licensed-driver population should exceed 161 million, 85 percent of all those over 15 years old. The combination of increasing affluence and widespread driver licensing will result in a larger number of multivehicle households, although the trend toward smaller families may reduce the saturation level per family. There will be roughly 170 million vehicles in the 1990 fleet. Some 135 million of them will be automobiles, and as many as 18 million more will be light-duty trucks, vans, recreation vehicles, etc., used primarily for personal travel.

The increasing number of multiple-car households offers the potential for special-purpose vehicles with improved overall energy consumption. The single "family" car now tends to be chosen on the basis of its maximum loading condition—all the family plus baggage on the occasional long vacation trip. The same car used for a single-occupant commuting trip is grossly oversized and consumes too much fuel. With several cars, the household may own one larger suburban or vacation vehicle and one smaller urban vehicle. If the latter has good fuel economy and is used for driving on work trips, its fuel saving may outweigh the poorer fuel economy of the other car. Even a recreation vehicle which gets fairly poor mileage may be balanced by an economical urban car.

Most automobiles in 1990 are likely to be fueled by a liquid hydrocarbon fuel—gasoline, diesel, or possibly a "broadcut" fuel which combines gasoline and diesel oil properties. Battery-powered electric vehicles will find increasing use in urban areas, but unless there are major breakthroughs in battery technology, the "electrics" are likely to be small with short range and poor performance. It should be noted that when compared to vehicles of equivalent size and performance, the electric car does not save energy as such. The large stationary generating plant can convert the primary fuel to mechanical power more efficiently than the small gasoline automobile engine. The losses in electrical generation, in electric transmission, battery charging, storage, and discharging, and in the electric motor itself dissipate any initial advantage of the electric vehicle. The electric vehicle does, however, allow use of a non-petroleum primary fuel.

A second obstacle to widespread use of electric-powered vehicles is the very magnitude of the transportation energy demand. As seen earlier in figure II.14, the total energy input to transportation is roughly equal to that for all electrical generation. Assuming approximately equal overall conversion efficiency and roughly half of all transportation energy for automobile use, a general switch to electric automobiles would require a 50-percent increase in electrical generating capacity at a time when the industry is having difficulty keeping up with conventional electricity demand.

In single-vehicle households, several opportunities exist for specialized vehicle use. The household may elect to own a minimal urban "family" car—one that seats everyone comfortably for a short trip but lacks luggage space and extra room for long-trip comfort. The family could then rent a larger car, van, or recreation vehicle for vacation trips. Growth of the vehicle-leasing industry may allow a family to lease an urban car for everyday use with an option to trade it for a larger car, station wagon, or recreation vehicle for a limited period. From an energy standpoint, it is often economical to fly to distant vacation locations and rent a car locally rather than use an oversized car in traffic every workday.

Conversely, a single-vehicle household may elect to own a suburban/vacation vehicle and rely on public or shared transportation for work and many other urban trips. The trend toward suburban apartments and condominiums and toward "townhouse" clusters, which concentrate the end points of trips, favors carpools, vanpools, paratransit, and regular transit. Some households affluent enough to own a car now elect not to. Their number may increase as the availability of special-purpose rental vehicles improves. However, the mobility that goes with ready access to a car is great and, except in large urban areas with very good public transit, many recreational, social, educational, and employment opportunities are almost inaccessible without a car. Without major changes in urban land-use patterns or lifestyle, few affluent households will be without a car.

Government policy at local, State, and Federal levels is to encourage all energy-saving alternatives to past automobile usage patterns. The next few years will see an increase in experiments and demonstrations of such alternatives, often coupled with financial support in the startup phases of regular operation. In addition, governments at all levels will continue to support measures to discourage excessive fuel-consuming automobiles. One measure, automobile-restricted zones, gives promise of reduced pollution, better safety, less fuel consumption, and center city rejuvenation. Federal-aid funds are available for planning and demonstration, and several cities have auto-restricted zone demonstrations planned or in progress.

MOTOR VEHICLE SAFETY

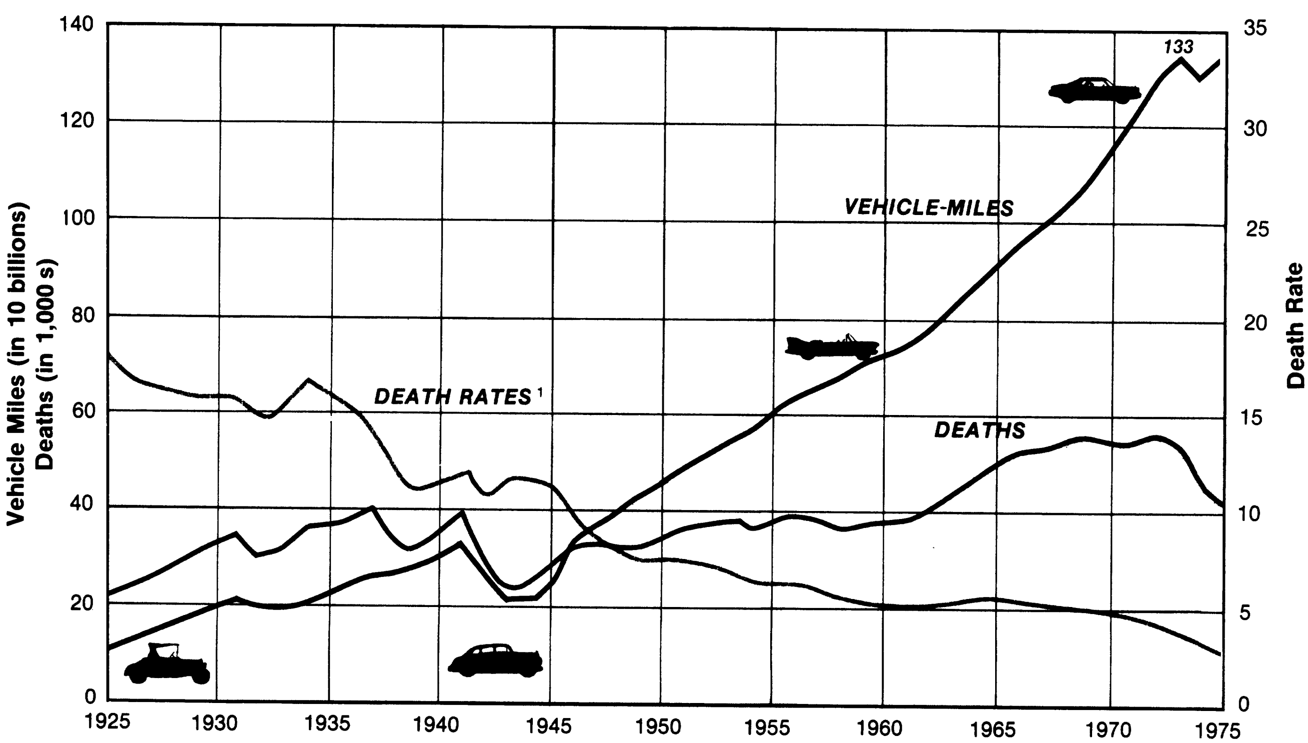
Motor vehicle safety involves the shared use of the highway with other vehicles and the characteristics of the highway itself. The discussion here is, therefore, not limited to safety countermeasures applying solely to the passenger automobile but includes various traffic control and highway countermeasures as they affect autos. Additional information on safety countermeasures appears in later chapters.

Motor vehicle accidents are the leading cause of death of persons in the United States between 1 and 44 years of age. Among persons over 45, the disease killers—heart attack, cancer, and stroke—cause the most deaths. The total number of motor vehicle deaths depends on the safety of operating a vehicle and on the total amount of motor vehicle travel. As shown in figure IV.6, the death rate, measured in deaths per 100 million vehicle-miles, generally has been declining over the past half century. However, except for a 4-year hiatus during World War II and a brief dip during the 1973–74 oil embargo, the annual number of vehicle-miles traveled (VMT) has been rising, so that the total number of highway deaths nearly tripled between 1925 and 1972.

Both the death rate and total deaths dropped significantly in 1974, in large measure because of a reduction in vehicle-miles traveled during the fuel shortage and the 55-mph speed limit imposed as a fuel-saving measure. In 1975, the total VMT resumed its rise and average speeds edged upward slightly. But the number of traffic deaths that year did not increase, indicating that more than the reduced speed limit and the reduction in vehicle-miles were at work.

Federal responsibility for motor vehicle safety is concentrated in two major areas: (a) Title 23 of the U.S. Code covers highways and the regulation of traffic on them; (b) Title 49 covers the motor vehicles themselves. All safety measures—State, local, Federal, or private—act in one of two ways: to reduce the number of accidents or to reduce the severity of the accidents that do occur. Most highway and traffic control measures are aimed primarily at reducing the incidence of accidents; e.g., limited access and directional lane separation eliminate situations in which accidents are most likely to occur. However, many accident prevention measures also act to reduce accident severity.

The 55-mph speed limit helps reduce the accident rate by giving drivers better control and more reaction time. It also serves, as shown in figure IV.7, to "bunch" the highway speeds into a narrower range and thereby reduce rear end collisions and accidents while passing. Because speeds are lower and drivers have more time to brake, those collisions that do occur happen at lower speeds with less injury and damage potential. A few highway measures such as guard rails and "breakaway" light standards are aimed solely at reducing accident severity. When the car hits the pole,



¹Deaths per 100,000,000 vehicle-miles.

Source: Accident Facts, 1976 edition, National Safety Council.

Figure IV.6. Motor Vehicle Travel, Deaths, and Death Rates.

the accident has already occurred: how the pole behaves, strongly affects the injury and damage that results.

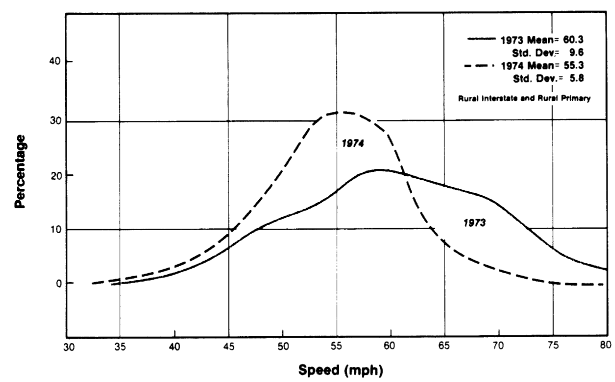
Sign of the times

It's not just a good idea. It's the law.

Measures applied to the vehicle affect both the incidence of accidents and their severity. Improvements to brakes, lights, visibility, etc., are all aimed at avoiding accidents, but at the same time any measure that gives the driver earlier warning and control tends to reduce the speed of those impacts that do occur. Even seatbelts, which are aimed primarily at keeping the occupant protected inside the vehicle structure and thus at reducing the severity of an accident, have a residual effect in accident prevention by holding the driver in position to control the vehicle better.

A few measures, such as increased vehicle structural strength and elimination of hostile interior projections, act solely to reduce occupant injuries. It is important to insure that measures that might increase the protection of the occupants of one car do not add to the dangers of occupants of other cars or of pedestrians, cyclists, etc. A very rigid, heavy structure which turns a car into a "tank" might protect its own occupants but make the car lethal to everything and everyone else on the road. Present and future vehicle structural designs are intended to keep the passenger compartment intact, while the remaining structure crushes in a controlled manner to absorb energy and cushion the shock. Many newer cars on the road today allow occupants to walk away from a 30-mph, head-on barrier crash which "totals" the car.

What is the future for highway safety? As long as human beings are subject to error, and



Source: Transportation Safety Information Report, Assistant Secretary for Environment, Safety, and Consumer Affairs, U.S. Department of Transportation.

Figure IV.7. Shift in Speed Following Enactment of 55-mph Speed Limit.

machines to wear and mechanical failure, the potential for accidents will remain. The level of transportation activity essential to economic and social well-being will increase with the population. If nothing else were done, we might see the accident and death *rates* decline slowly as older cars leave the fleet and as programs already in existence are completed. However, we would eventually lose the race with increased travel, and the total number of deaths would rise. By 1990, the highway death toll could exceed 60,000 per year. What is being done and what can be done to avoid this future loss?

Better enforcement of current laws, such as the 55-mph speed limit, is a starting place.

The Federal-Aid Highway Amendments of 1974 require that every State certifies, prior to January 1 of each year, that it is enforcing the 55-mph limit on public highways. The initial certifications under this process have been submitted by all 50 States, the District of Columbia, and Puerto Rico, and are under review within the Department of Transportation. The preparation of these certifications, along with related speed statistics and monitoring and enforcment information, will be a continuing process. The State submissions will help provide data on the fuel-saving benefits of the speed limit and on its role in reducing highway fatalities and injuries.

As part of the annual certification process, the Secretary of Transportation, through the National Highway Traffic Safety Administration, and the Federal Highway Administration has required States to submit data on their monitoring and enforcement activities, including a description of each State's speed-monitoring program, summary speed statistics, and the number of citations issued. Technical assistance has been provided by agencies of the Department of Transportation.

It is estimated that over the next 10 years, enforcement of the 55-mph speed limit would forestall nearly 31,900 fatalities, 415,000 injury accidents, and 1.6 million property damage accidents.

The *National Highway Safety Needs Study* (March 1976) deals with 37 potential highway safety countermeasures to forestall fatality and injury accidents. The list, ranked for effectiveness in saving lives, appears as table IV.1. The study was performed in response to congressional directive and was limited by the directive to programs authorized under Title 23, United States Code (USC), principally the highway safety programs and the highway safety construction programs. This table thus omits other potential measures, such as those pertaining to the safety performance of new motor vehicles as prescribed under Title 49, USC, or the regulation of motor carriers. The *Highway Safety Needs Study* also carries strong caveats concerning (a) the use of averages to represent a range of countermeasure effects, (b) the application of limited test data to a nationwide basis, and (c) the limitation of the study's benefit-cost consideration only to safety benefits and to the direct governmental and consumer costs of implementing the program.

Table IV.1
Ranking of Countermeasures by Decreasing Potential to Forestall Fatalities and Injury Accidents — 10-Year Total[1]

Countermeasure	Fatalities Forestalled	Injury Accidents Forestalled
Mandatory Safety Belt Usage	89,000	3,220,000
Nationwide 55-mph Speed Limit	31,900	415,000
Combined Alcohol Safety Action Countermeasures	13,000	153,000
Combined Emergency Medical Countermeasures	8,000	146,000
Selective Traffic Enforcement	7,560	296,000
Impact-Absorbing Roadside Safety Devices	6,780	158,000
Tire and Braking System Safety Critical Inspection—Selective	4,590	180,000
Citizen Assistance of Crash Victims	3,750	0
Skid Resistance	3,740	195,000
Regulatory and Warning Signs	3,670	143,000
Upgrade Traffic Signals and Systems	3,400	133,000
Breakaway Sign and Lighting Supports	3,250	127,000
Guardrail	3,160	52,800
Upgrade Education and Training for Beginning Drivers	3,050	131,000
Driver Improvement Schools	2,470	113,000
Periodic Motor Vehicle Inspection—Current Practice	1,840	71,900
Bridge Rails and Parapets	1,520	15,300
Pedestrian and Bicycle Visibility Enhancement	1,440	24,200
Bridge Widening	1,330	51,000
Selective Access Control for Safety	1,300	50,300
Motorcycle Rider Safety Helmets	1,150	14,400
Paved or Stabilized Shoulders	928	35,800
Wrong-Way Entry Avoidance Techniques	779	3,290
Roadway Lighting	759	29,600
Driver Improvement Schools for Young Offenders	692	27,000
Upgrade Bicycle and Pedestrian Safety Curriculum Offerings	649	11,200
Traffic Channelization	645	31,500
Roadway Alignment and Gradient	590	23,000
Clear Roadside Recovery Area	533	20,700
Median Barriers	529	2,740
Pedestrian Safety Information and Education	490	19,200
Intersection Sight Distance	468	18,300
Highway Construction and Maintenance Practices	459	18,000
Railroad-Highway Grade Crossing Protection (Automatic gates excluded)	276	1,080
Pavement Markings and Delineators	237	9,210
Warning Letters to Problem Drivers	192	3,760
Motorcycle Lights-On Practice	65	1,680

[1] *All figures have been rounded to three significant digits after internal computations were completed. All figures are subject to the caveats concerning precision of the data.*

Despite its limitations and caveats, the *Highway Safety Needs Study* presents a valuable methodology for cost-benefit estimates. Table IV.2 re-ranks the original countermeasures' list in order of increasing cost per fatality forestalled. Under this ranking, mandatory seat-

Table IV.2
Ranking of Countermeasures by Decreasing Cost Effectiveness in Present Value Dollars per Total Fatalities Forestalled — 10-Year Total[1]

Countermeasure	Fatalities Forestalled	Cost ($ millions)	Dollars per Fatality Forestalled
Mandatory Safety Belt Usage	89,000	45.0	506
Highway Construction and Maintenance Practices	459	9.2	20,000
Upgrade Bicycle and Pedestrian Safety Curriculum Offerings	649	13.2	20,400
Nationwide 55-mph Speed Limit	31,900	676.0	21,200
Driver Improvement Schools	2,470	53.0	21,400
Regulatory and Warning Signs	3,670	125.0	34,000
Guardrail	3,160	108.0	34,100
Pedestrian Safety Information and Education	490	18.0	36,800
Skid Resistance	3,740	158.0	42,200
Bridge Rails and Parapets	1,520	69.8	46,000
Wrong-Way Entry Avoidance Techniques	779	38.5	49,400
Driver Improvement Schools for Young Offenders	692	36.3	52,500
Motorcycle Rider Safety Helmets	1,150	61.2	53,300
Motorcycle Lights-On Practice	65	5.2	80,600
Impact-Absorbing Roadside Safety-Devices	6,780	735.0	108,000
Breakaway Sign and Lighting Supports	3,250	379.0	116,000
Selective Traffic Enforcement	7,560	1,010.0	133,000
Combined Alcohol Safety Action Countermeasures	13,000	2,130.0	164,000
Citizen Assistance of Crash Victims	3,750	784.0	209,000
Median Barriers	529	121.0	228,000
Pedestrian and Bicycle Visibility Enhancement	1,440	332.0	230,000
Tire and Braking System Safety Critical Inspection—Selective	4,591	1,150.0	251,000
Warning Letters to Problem Drivers	192	50.5	263,000
Clear Roadside Recovery Area	533	151.0	284,000
Upgrade Education and Training for Beginning Drivers	3,050	1,170.0	385,000
Intersection Sight Distance	468	196.0	420,000
Combined Emergency Medical Countermeasures	8,000	4,300.0	538,000
Upgrade Traffic Signals and Systems	3,400	2,080.0	610,000
Roadway Lighting	759	710.0	936,000
Traffic Channelization	645	1,080.0	1,680,000
Periodic Motor Vehicle Inspection—Current Practice	1,840	3,890.0	2,120,000
Pavement Markings and Delineators	237	639.0	2,700,000
Selective Access Control for Safety	1,300	3,780.0	2,910,000
Bridge Widening	1,330	4,600.0	3,460,000
Railroad-Highway Grade Crossing Protection (Automatic gates excluded)	276	974.0	3,530,000
Paved or Stabilized Shoulders	928	5,380.0	5,800,000
Roadway Alignment and Gradient	590	4,530.0	7,680,000

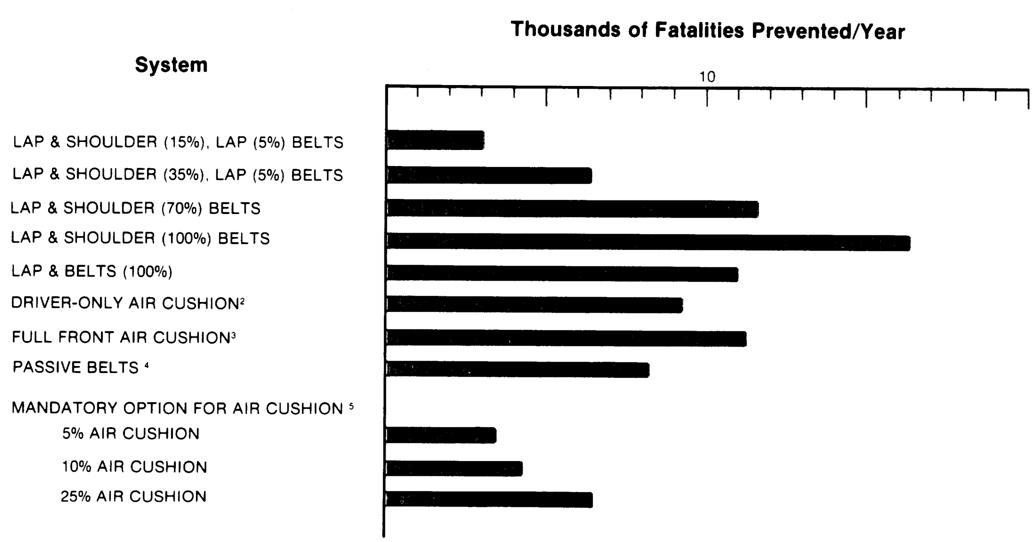
[1]*All figures have been rounded to three significant digits after internal computations were completed. All figures are subject to the caveats concerning precision of the data.*

Source: National Highway Safety Needs Report, *Department of Transportation, April 1976.*

belt usage still heads the list, providing the largest total benefit at the lowest unit cost. The 55-mph speed limit still ranks near the top, although at significantly higher unit cost. Combined alcohol safety action countermeasures, which have a potential for saving 13,000 lives annually, move to a midrange cost-benefit ranking because it is relatively expensive to implement them.

The *Highway Safety Needs Study* did not include occupant restraint measures or other vehicle safety standards applicable under Title 49. In particular, air cushions, which have been under development and study for several years, fill many of the requirements of seatbelts for occupant restraint, but public acceptance is in doubt. Measures to improve the structural integrity of vehicles are wasted if the occupant is killed or injured by striking the inside of the intact structure in a crash. Properly adjusted lap and shoulder belts provide the best form of restraint in a variety of crash situations as shown in figure IV.8. Belts, however, are "active" countermeasures requiring action by the occupant. A survey of all types of trips (intercity, urban, to church, to supermarket, etc.) indicates that only about 15 percent of occupants buckle up fully with lap-shoulder belts and an additional 5 percent use the lap belt only. In towaway accidents, however, investigators report 38 percent lap-shoulder-belt usage and an additional 4-percent usage of lap belt only, indicating that usage is much higher on trips perceived to be hazardous.

Air cushions and passive belt systems, on the other hand, require no action by the occupant and do not restrain his actions under normal circumstances. The air cushion or air bag deploys quickly in a crash to restrain the occupant's upper torso from forward motion, as does the shoulder belt in a lap-shoulder-belt system. The air cushion is not effective in side impacts or rollover crashes, nor does it protect in secondary impacts which can occur after the air cushion has deployed and collapsed. The driver can also be thrown out of position after deployment in such a way that he cannot maintain control of his vehicle. The air cushion must, therefore, be augmented by an active lap belt to increase its effectiveness in all crashes. The protection furnished by an air cushion with lap belt is approximately equal to that furnished by both belts of a lap-shoulder-belt system.



[1] *These estimates assume the car population and occupant fatality rates to be that of 1974 (approximately 100,000,000 cars and 27,200 people, respectively), 10,000,000 cars to be manufactured annually, and the distribution of injuries by severity to be the same as in 1975.*
[2] *Assumes 20 pct lap belt usage by driver and 15 pct lap and shoulder belt plus 5 pct lap belt by other front-seat occupants.*
[3] *Assumes 20 pct lap belt usage by all front-seat occupants.*
[4] *Assumes 60 pct passive belt usage; i.e., 40 pct of people disconnect the system.*
[5] *This refers to a situation in which the Federal Government requires manufacturers to make passive restraints available to the consumer as an option. These estimates assume 20 pct safety belt wearing by all front-seat occupants. One obtains these relatively low injury estimates because the air cushion does not deploy unless the accident severity exceeds that corresponding to a crash into a fixed barrier at 12 mph.*

Source: Notice of Proposed Rulemaking and Public Hearing, Motor Vehicle Occupant Crash Protection, Office of the Secretary, U.S. Department of Transportation, Part III, Federal Register, June 14, 1976.

Figure IV.8. Benefits of Occupant Restraint System.[1]

Fears have been voiced regarding hazards from the air cushion. There is no clear evidence of serious injury caused by air cushions, but the sample of documented incidents from air cushion-equipped cars to date is not adequate to establish whether such danger does or does not exist. Minor injuries have been common, but such deployment injuries are considered of little consequence relative to the more serious injuries prevented or reduced.

The air cushion does, moreover, represent an added cost to the new-car buyer estimated at from $75 to $350 for a full front-seat system. Repair and replacement costs after each deployment can add an additional $300.

In terms of immediate effect, the air cushion suffers from the serious drawback that at least 10 years would be needed to equip most of the active auto fleet. In contrast, almost all cars now on the road are equipped with seatbelts. A mandatory seatbelt-usage requirement, rigorously enforced, would have an almost immediate payoff. An immediate air cushion requirement in new cars would save roughly half as many lives over a 10-year period as an immediately enforced mandatory seatbelt requirement. The cost to equip 10 million new automobiles a year could run from $1 billion to $3 billion.

In his June 1976 notice of proposed rulemaking, the Secretary of Transportation points out the critical issue regarding the appropriate role of the Federal Government in prescribing motor vehicle safety standards. The National Traffic and Motor Vehicle Safety Act of 1966 declares the Government's intent "to reduce deaths and injuries resulting from traffic accidents." Under the terms of the Act, the Federal Government's duty in prescribing safety standards is to protect the public "against unreasonable risk of death and injury to persons in the event accidents do occur." What constitutes an "unreasonable risk" is a difficult but critical issue.

On one hand, it might be argued that seatbelts and shoulder belts are available in all cars, and that the danger of not using belts as well as the benefits of using such belts have been widely publicized. The individual's voluntary decision not to use the belt must be considered the act of a reasonable person and the risk, therefore, cannot be considered to be an "unreasonable" one. If the individual weighs the added probability of serious injury or death incurred by not buckling up against the annoyance of the belt or the time lost in adjusting it and he decides against the belt, then it might be argued that he should have the freedom to make that decision.

On the other hand, it might be argued that no reasonable individual seeks death or serious injury. Thus, if the belt system has annoyances or other drawbacks, which cause him to decide against it, the driver has been given an unreasonable choice and the risk is likewise unreasonable. If the air cushion system is technically feasible, provides equivalent protection, and does not force an unreasonable choice on the individual, then it might follow from this alternative argument that air cushions should be provided. The personal freedom questions enter again, however, since the consumer must pay the cost of providing the air cushion system. Should those individuals who would have used the seatbelt be forced to pay for the more expensive air cushion? The issue is even further complicated by other considerations: (a) the contention that air cushions offered as options would be considerably more expensive than if mass-produced as standard items, (b) the differences in performance and reliability of the system, (c) the various hazards attributed to them, and (d) the existence of still other systems such as passive belts.

The specific questions regarding the Federal role are reduced to these:

- Does the unwillingness of many people to wear safety belts expose them to an "unreasonable" risk of death or injury requiring additional occupant crash protection?
- Does the Government have the duty to protect a citizen from danger when that citizen has chosen not to use available means (e.g., lap and shoulder belts) to protect himself?
- Does the answer depend on how readily available and feasible the additional protection is, and at what cost?
- What weight should be given to considerations of personal freedom of choice and convenience in regulations concerning occupant crash protection?
- Should individuals who now use their lap and shoulder belts be required to purchase more expensive passive restraint systems in order to

contribute to achieving a broad social goal of increased motor vehicle safety?

- Will passive restraints be available in the marketplace at a reasonable cost for those who would choose them without Government regulatory action?
- To what extent should regulations governing occupant crash protection seek to preserve the role of the marketplace in making economic decisions?

A hearing on rulemaking was held on August 3, 1976, and the decision announced on December 6, 1976. The decision recognizes that air cushions, while technically practicable, have been the subject of so much controversy that public acceptance is by no means assured. The long-term interests of public safety require that any such sweeping rule be tested in the market as well as the laboratory. Accordingly, the Secretary of Transportation, William T. Coleman, Jr., announced a program that would make air cushions available to the public over the next two-model years, as optional equipment in half a million new cars at mass production prices. At the same time, the Secretary directed the NHTSA to set up with the manufacturers and the States a monitoring and accident reporting system for collecting data on air cushion effectiveness and to take steps to improve the acceptability of seat and shoulder belts in all new automobiles.

The market decision which will eventually emerge from this 2-year program cannot be predicted exactly. It is important to note that the problem is *how* to achieve the benefits of occupant restraints while respecting the rights of the individual, not whether such benefits are desirable. For purposes of this document, it is assumed that the decision will lead to a solution and that by 1990 the benefits—reducing by half the death rate among automobile front-seat occupants—will be achieved by some appropriate restraint countermeasure. In terms of highway deaths from all causes, the use of occupant restraints alone will save about 1 life in 5, reducing the 1975 death rate of 3.5 per 100 million VMT to about 2.8.

Many accidents involve drivers who have been drinking. State accident statistics confirm that there is a disproportionally high percentage of drinking drivers involved in fatal accidents. Some researchers estimate that alcohol is involved in approximately 50 percent of all fatal accidents. Two-thirds of the fatalities in those accidents involve problem drinkers who can be identified and who represent a small minority (less than 10 percent) of the driving population. Alcohol is also a significant factor in pedestrian accidents. Because per capita consumption of intoxicants is rising, it is likely that the proportion of accidents that involve alcohol will increase. From 1960 to 1974, the consumption of distilled spirits increased about 50 percent, and it appears safe to assume that per capita consumption of alcohol will have increased by at least another 15 percent by 1990.

Alcoholism is a medical problem of major national proportions. Given the high proportion of alcohol-related fatalities, highway safety countermeasures represent only one way to attack this problem. The fact that the countermeasures developed thus far to combat the drinking driver problem are somewhat expensive (it ranks 18th out of 37 countermeasures in table IV.2) means only that the problem continues to be large and that we must continue to seek more cost-effective measures against it. Many countermeasures that would prevent the alcohol-impaired person from driving would impinge on the civil liberties of the law-abiding majority.

Note that the fatalities avoided by various countermeasures and improvements cannot simply be added together. In some cases, lives saved by one countermeasure are the same lives that might also have been saved by another—e.g., those people saved from injury by seatbelts would not require medical countermeasures. In other cases, a combination of countermeasures produces additional benefits not realized with either one alone. For example, the use of an occupant restraint system is enhanced by increasing the vehicle's structural crashworthiness.

Figure IV.9 lists a number of vehicle safety improvements under Title 49 scheduled for implementation or consideration in future years. These, combined with the measures already noted in table IV.1, have considerable potential for further reducing the death rate.

Crashworthiness Federal Motor Vehicle Safety Standards (FMVSS) and Notice of Proposed Rulemaking (NPRM) Applicable to Passenger Cars

FMVSS No. 113 — Hood Latch Systems (Docket Nos. 1-17)

FMVSS No. 201 — Occupant Protection in Interior Impact (Docket Nos. 3 and 2-2)-15 mph impact protection

FMVSS No. 202 — Head Restraints - Passenger Cars
Specifies height and strength requirements for head restraints

FMVSS 202 (NPRM) — Seating Systems - Combines FMVSS 202 and and 207, requires higher and stronger seat backs - possible effective date - 1980.

FMVSS No. 203 — Impact Protection for the Driver from the Steering Control Systems (Docket No. 3)

FMVSS 203 — **New NPRM** will specify 30-mph barrier collision utilizing a Part 572 test device and FMVSS 208 injury criteria.

FMVSS No. 204 — Steering Control Rearward Displacement (Docket No. 3)
New NPRM will add a vertical deflection requirement to the current rearward movement. Effective May 1979.

FMVSS No. 205 — Glazing Materials
Specifies fracture resistance and optical qualities for glazing materials.

FMVSS No. 206 — Door Locks and Door Retention Components
Specifies strength and door retention requirements for vehicle door locks and latches.

FMVSS No. 207 — Seating Systems
Establishes strength and attachment performance requirements.

FMVSS 207 Amendment — See FMVSS 202 (NPRM)

FMVSS No. 208 — Occupant Crash Protection (Docket No. 69-7)
Complete passive protection system or head-on passive protection and lap belt system with 30-mph barrier crash test and specifies injury criteria or lap and shoulder belt protection system with belt warning.

FMVSS No. 209 — Seat Belt Assemblies (Docket No. 69-23)
Specifies strength, corrosion, latching, etc., requirements.

FMVSS No. 210 — Seat Belt Assembly Anchorages (Docket No. 2-14)
Specifies type, strength, and location of anchorages.

FMVSS No. 211 — Wheel Nuts, Wheel Discs, and Hub Caps (Docket No. 3.)
Wheel nuts, discs, and hub caps shall not incorporate winged projections.

FMVSS No. 212 — Windshield Mounting - Passenger Cars
Establish the retention requirements for windshield mountings.

FMVSS No. 214 — Side Door Strength (Docket No. 2-6)

FMVSS No. 216 — Roof Crush Resistance (Docket No. 69-7)

FMVSS No. 219 — Windshield Zone Intrusion (Docket No. 74-21)

FMVSS No. 301 — Fuel System Integrity (Docket No. 73-20)

FMVSS No. 302 — Flammability of Interior Materials
Specifies burn resistance requirements.

Crash Avoidance Federal Motor Safety Standards and NPRM's Applicable to Passenger Cars

FMVSS No. 101 — Control Location, Identification,and Illumination
Requires that essential controls be within reach of the driver and that certain of these controls be identified.

FMVSS No. 102 — Transmission Shift Lever Sequence, Starter Interlock, and Transmission Braking Effect

FMVSS No. 103 — Windshield Defrosting and Defogging Systems
Requires that all vehicles have defrosting systems which will de-ice the windshield area in front of the driver in 20 minutes when the ambient temperature is zero degrees Fahrenheit.

FMVSS No. 104 — Windshield Wiping and Washing Systems
Requires that all vehicles be equipped with 2-speed wipers and washers adequate to help clean the windshield area specified in FMVSS No. 107.

FMVSS No. 105 — Hydraulic Service Brake, Emergency Brake, and Parking Brake Systems
Consists of a series of braking performance tests which evaluate vehicles' braking performance, fade and fade recovery performance, wet recovery performance, partially failed system performance, parking brake performance, and general braking system integrity.

Equipment Requirements —
Emergency Brake System — The brake system shall be so designed that a rupture or leakage-type failure of any single pressure component of the system, except the master cylinder, shall not result in complete loss of brake system function.

Parking Brake System — A parking brake system of a friction type with a solely mechanical means to retain engagement shall be provided.

Emergency Brake System Effectiveness Indication — A red light in view of driver shall indicate a hydraulic-type failure of a partial system.

FMVSS 105a (105-75) — Hydraulic Brake Systems, Docket No. 70-27 (75-11, 75-27), Amendment to FMVSS 105 effective date 1-1-76. Consists of a series of braking performance tests similar to those of FMVSS 105 with changes in performance requirements and some added tests.

Additional Equipment —
Brake warning indicator lamp to signal:
Application of parking brake
Electrical failure in anti-lock or variable proportioning system.

FMVSS No. 106 — Brake Hoses
Establishes minimum requirements for brake hoses.

FMVSS No. 107 — Reflecting Surfaces
Requires that windshield wiper arms, inside windshield moldings, horn rings, and the frames and brackets of inside rearview mirrors have dull surfaces which will reduce the likelihood of hazardous reflection into the driver's eyes.

FMVSS No. 108 — Lamps, Reflective Devices, and Associated Equipment
Specifies requirements for lamps, reflective devices, and associated equipment for signaling and to enable safe operation in darkness and other conditions of reduced visibility.

Major Amendment of FMVSS No. 108 (Lamps, Reflective Devices, and Associated Equipment)

This proposed amendment of Standard No. 108 will significantly improve the effectiveness and reliability of the lighting systems on motor vehicles.

FMVSS No. 109 — New Pneumatic Tires
Specifies tire dimensions and laboratory test requirements for bead unseating resistance, strength, endurance, and high-speed performance; defines tire load ratings; and specifies labeling requirements for passenger car tires.

FMVSS No. 110 — Tire Selection and Rims
Specifies requirements for original equipment tire and rim selection for new cars to prevent tire overloading.

FMVSS No. 111 — Rearview Mirrors
Specifies requirements for rearview mirrors to provide the driver with a clear and reasonably unobstructed view to the rear.

Revision to FMVSS No. 111 (Rearview Mirror Systems)

Starting with 1980 model vehicles, this revision to FMVSS No. 111 will improve rearward visibility of passenger cars by approximately 50% over present Federal requirements.

Fields of Direct View
Starting with 1980 model vehicles, this new standard will establish an in-vehicle light transmission test which will improve driver visibility during low ambient light levels.

FMVSS No. 112 — Headlamp Concealment Devices
Specifies that any fully opened headlamp concealment device shall remain fully opened whether either or both of the following occur: (a) any loss of power to or within the device or (b) any malfunction of wiring or electrical supply for controlling the concealment device.

FMVSS No. 114 — Theft Protection
Requires that each passenger car have a key-locking system that, whenever the key is removed, prevents normal activation of the car's engine and also prevents either steering or self-mobility of the car, or both.

FMVSS No. 115 — Vehicle Identification
Specifies requirements for an identification number for all passenger cars to facilitate recognition of unauthorized vehicle use resulting in crashes.

FMVSS No. 116 — Motor Vehicle Brake Fluids
Establishes minimum test requirements for the three kinds of fluids; designed to prevent the sale of fluids with unsafe temperature, corrosion inducing and rubber component deterioration characteristics.

FMVSS No. 118 — Power-Operated Window Systems
Requires that power-operated window systems be inoperative when ignition is in an off position or when key is removed.

FMVSS No. 124 — Accelerator Control Systems
Establishes fail-safe and redundant return force requirements for the return of a vehicle's throttle to the idle position when the driver removes his foot from the accelerator control, or in the event of a breakage or disconnection in the accelerator control system.

Damageability, Federal Motor Vehicle Standards and NPRM's Applicable to Passenger Cars

FMVSS No. 215 — Exterior Protection
Requires passenger cars to withstand 5-mph front and rear barrier and pendulum impacts plus 3-mph corner pendulum impacts without damage to the vehicle's safety-related systems such as lights, brakes, suspension system, etc.

Bumper Standard, Part 581

Issued: February 27, 1975

Requires passenger cars to withstand 5-mph front and rear barrier and pendulum impacts without damage to the vehicles' safety related systems and additionally specific limitations on damage to non-safety-related components and vehicle surface areas. Thus the Part 581 rulemaking action includes the FMVSS 215 requirements and adds additional damage limitations which are effective for passenger cars as stated below:

Effective Sept. 1, 1978, limit damage to the bumper face bar and components which attach the face bar to the chassis.

Effective Sept. 1, 1979, limit damage to the bumper face bar to dents of ⅜ inch and limit bumper set to ¾ inch.

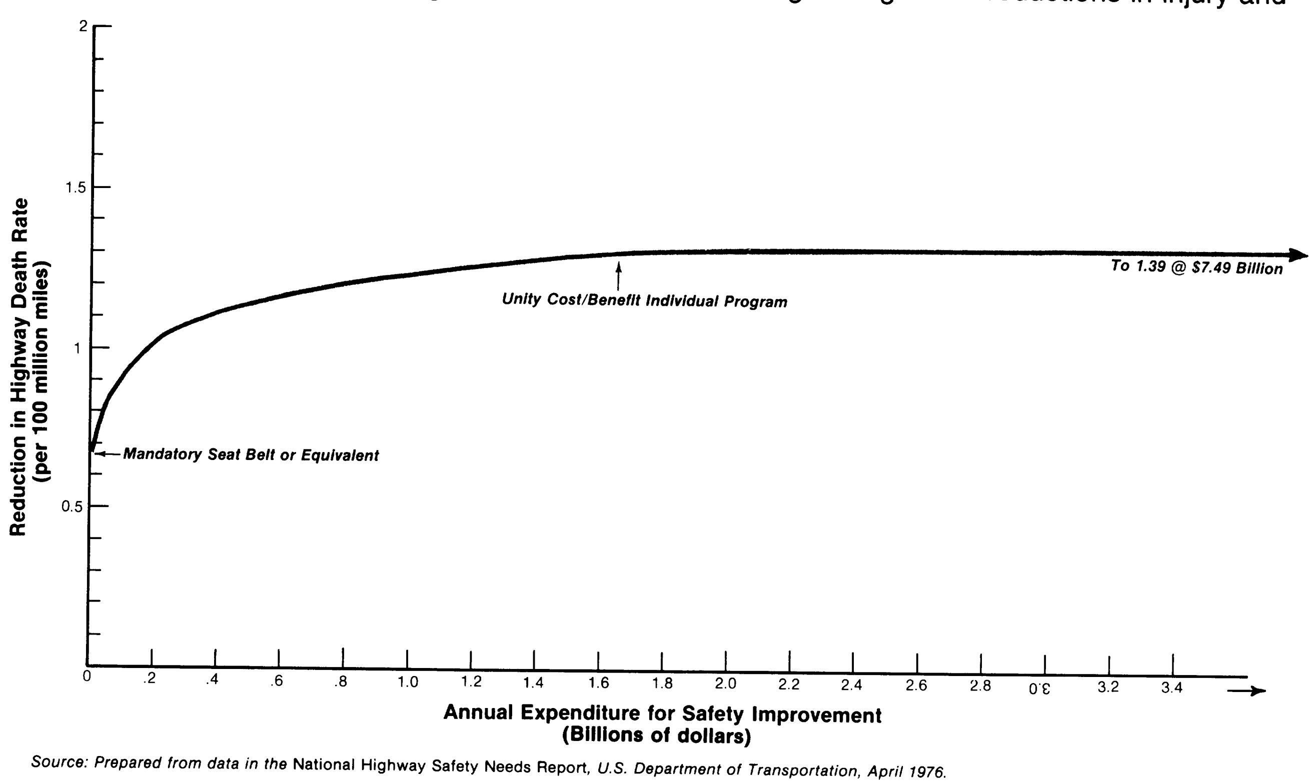
Figure IV.9. Federal Standards to Improve Safety.

The future level of highway safety depends on the present and future level of expenditures and on the specific programs selected for implementation. A rational process would first rank all candidate programs in order of cost effectiveness and implement them in that order. The resulting growth of safety payoff would progress as in figure IV.10. Note that, since each possible program is less effective than its predecessor, the payoff *per dollar spent* steadily decreases with increased total expenditure. While everyone agrees that highway safety is important, everyone also agrees that at some point the payoff becomes too small to justify further expenditure and that programs in other areas—such as disease control, for instance—may have greater lifesaving potential. There is, however, no general agreement as to exactly where such a cutoff point should be. The actual decisions are necessarily political ones, made in the light of the exigencies and the alternative opportunities that exist at the time the decisions are made.

For purposes of planning, however, the technique of benefit-cost analysis gives insight into the decision process and can provide an estimate of where a cutoff point might be made.

Benefit-cost analysis of safety programs inevitably requires placing a dollar value on the benefit of reducing fatalities and injuries. While we cannot attempt to place a value on an individual life, the National Highway Transportation Safety Administration has attempted to estimate the average social costs of a highway fatality or injury. These costs, shown in table IV.3, include such factors as loss of earnings, cost of hospitalization, property loss, and funeral expense.

Each specific safety program will have its own characteristic expectation with respect to fatalities prevented, injuries forestalled or reduced, and accidents avoided. For example, the mandatory seatbelt program would be expected to save 11,500 lives a year and forestall or reduce 641,000 injuries for a total benefit of $4.55 billion. The air cushion, almost as effective in saving lives, would not forestall as many minor injuries, because its activation would not be triggered in crashes at lower speeds. But the social benefit of air cushions would still be high at $4.23 billion. For rough-estimation purposes, a program resulting in one fatality prevented would save about $400,000 in social costs, including savings from reductions in injury and



Source: Prepared from data in the National Highway Safety Needs Report, *U.S. Department of Transportation, April 1976.*

Figure IV.10. Cumulative Payoff for Safety Expenditure.

property losses. A combination of programs that reduced the highway death rate by 1 per 100 million vehicle-miles would create a social benefit of about $5.3 billion at the 1975-VMT levels, and programs able to reduce the death rate by 1 per 100 million VMT in 1990 would create an annual social benefit near $7.3 billion.

Table IV.3
Injury Cost Distribution
(Front-seat occupants, 1975)

Injury Severity Level	No./Year	Societal Cost (millions)	Cost/Injury
Minor	2,290,000	$ 710	310
Moderate	332,000	740	2,230
Severe	54,400	310	5,700
Serious	13,600	1,140	83,900
Critical Nonfatal	2,700	510	189,000
Fatal	27,200	7,790	286,000

Source: The Federal Register, June 14, 1976.

For 1975, $5.3 billion spread over 1.33 trillion vehicle-miles works out to 0.4 cents per vehicle-mile. However, expenditure of $5.3 billion per year would go far down toward the bottom of the list in table IV.2, where the cost to forestall each additional fatality is over $5 million. A benefit-cost criterion of $400,000 would reach about two-thirds of the way down the list and achieve about 90 percent of the benefit at 20 percent of the cost of the whole list. The important point, of course, is not the length of the list but the investment criteria used in selecting from it.

Note, however, that the listing in table IV.2 treats whole classes of highway improvement projects as a single entry when each, in fact, represents a set of projects at the State or local level. For instance, the item ranked no. 34—bridge widening—shows a large potential for lives saved but at a unit cost of nearly $3.5 million each. In fact, an examination of all bridge-connected safety projects would find some bridges in need of widening, some in need of resurfacing, some in need of improved guardrails and parapets (ranked separately as no. 10 on table IV.2), and some in need of total replacement. In terms of cost-effectiveness, some bridge-widening candidates are likely to rank higher than some other bridge guardrail and parapet candidates. The relative ranking on a nationwide basis in no way means that all rail and parapet projects should be approved at a State or local level or that all widening projects should be disapproved.

Decisionmakers at the Federal, State, or local level rarely are presented with an exhaustive dollar-ranked list of all potential projects from which to make an optimum selection. Rather, the decisionmaker has annual budgets to allocate to highway safety opportunities or needs which present themselves at various times. He may have to make decisions one year without knowing fully either his opportunities or his budget for the next. Nevertheless, the aggregate of all individual decisions over time is assumed to approach, as an upper limit in benefit and cost, the outcome of decisions made by nationwide analysis.

It should also be noted that some highway projects entail a cost above the dollars invested. Taking a bridge or any highway segment out of service to repair or replace it in advance of failure may cause congestion and impose a mobility loss. The decisionmaker balances these present costs against future benefits.

The passage of time will affect the selection process in several ways. Future costs and future benefits need to be discounted to present value. The growth of vehicle-miles traveled will make each unit reduction in fatality rate worth more in terms of lives saved. At the same time, some countermeasures whose costs depend on VMT, on the number of vehicles, or the number of miles of highway will also become more expensive to implement. As the average individual's productivity increases in real terms, the social cost associated with a highway fatality will increase in dollar terms. A list like that of table IV.1 will be augmented with motor vehicle possibilities from figure IV.9 and by others perhaps not yet developed.

This planning example cannot and should not enumerate all the individual Federal, State, local, and private safety improvements to motor vehicles and the highway system. Any national-level plan must assume that the many decisions involving details will be made by the Federal Highway Administration, the National Highway Transportation Safety Administration, other Federal, State, and local agencies as well as by the private sector. As noted above, the drinking driver reflects a major national health problem. While every measure is being sought by which to prevent the alcoholically impaired person from attempting to drive, the problem remains very large, and we have not yet found very cost-effective ways of meeting it.

As a planning goal for all concerned agencies, it appears feasible to implement countermeasures which will continue the recent trend in reduction of total motor vehicle fatalities. To do so in light of expected increases in VMT will require that the fatality *rate* be cut to nearly 2.0 per 100 million vehicle-miles in 1990. However, it appears that an expenditure of something between 0.2 and 0.4 of a *cent* per vehicle-mile could pay for a set of countermeasures that would bring the fatalities near 40,000 in 1990. The goal is not, of course, to *have* 40,000 fatalities in 1990 but to cut the fatality rate by more than 40 percent and to *save* more than 20,000 lives that year compared to what the situation would be without the countermeasures. Over the interval, a cumulative added expenditure for safety of about $50 billion could save a total of nearly 160,000 lives.