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# HIGHWAY TRAVEL FORECASTS

## U. S. DEPARTMENT OF TRANSPORTATION FEDERAL HIGHWAY ADMINISTRATION OFFICE OF HIGHWAY PLANNING NOVEMBER, 1974

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### ABSTRACT

Highway planning on a comprehensive scale has been conducted jointly by the Federal Highway Administration (FHWA - formerly the Bureau of Public Roads) and the State highway departments since 1935. Although the Federal-Aid Road Act of 1916 marked the beginning of the State and Federal partnership in road building, the Federal-Aid Highway Act of 1934 provided that 1.5 percent of the Federal-aid funds apportioned for any year to a State could be used for surveys, plans, and engineering and economic investigations of projects for future construction. An integral part of these planning activities has been the forecasting of future travel demand. The forecasting methodology which evolved has subsequently improved and has been refined over the years. Historically, forecasts have been prepared by the State highway departments in cooperation with the Federal Highway Administration and have been reported to the FHWA on a periodic basis in conjunction with highway needs studies, cost allocation studies, and the Interstate cost estimates.

This paper describes a Federal Highway Administration analysis of major factors which influence travel, projections of these factors, and the resultant travel forecasts. Comparisons are made with the travel forecasts historically prepared by the States in cooperation with the FHWA.

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## FOREWORD

This travel forecast review is reported by Gary Maring, Highway Planning Technical Coordinator, Office of Highway Planning. Major contributing papers and technical guidance were provided by a travel forecast committee consisting of Messrs. Messer and Jarema of the Program Management Division; Messrs. French and Liston of the Highway Statistics Division; Messrs. McDonnell and Fleet of the Urban Planning Division in the Office of Highway Planning; and by Mr. Broderick of the Policy Planning Division, Office of Program and Policy Planning. Mr. W. L. Mertz, Associate Administrator for Planning, was chairman of the travel forecast committee. Acknowledgment is extended to others who provided input and review.

## INTRODUCTION

Highway planning on a comprehensive scale has been conducted jointly by the Federal Highway Administration (FHWA - formerly the Bureau of Public Roads) and the State highway departments since 1935. Although the Federal-Aid Road Act of 1916 marked the beginning of the State and Federal partnership in road building, the Federal-Aid Highway Act of 1934 provided that 1.5 percent of the Federal-aid funds apportioned for any year to a State could be used for surveys, plans, and engineering and economic investigations of projects for future construction. An integral part of these planning activities has been the forecasting of future travel demand. The forecasting methodology which evolved has subsequently improved and has been refined over the years.

Historically, forecasts have been prepared by the State highway departments in cooperation with the Federal Highway Administration and have been reported to the FHWA on a periodic basis in conjunction with highway needs studies, cost allocation studies, and the Interstate cost estimates.

In light of the current energy situation with resulting fuel constraints and recommendations regarding various strategies for reducing the reliance on the automobile plus the declining birth rates, significant questions have been raised concerning the validity of existing highway travel forecasts. This paper describes a Federal Highway Administration analysis of major factors which influence travel, projections of these factors, and the resultant travel forecasts. Comparisons are made with the travel forecasts historically prepared by the States in cooperation with the FHWA.

Section I includes a discussion of results and conclusions. Section II discusses the development of highway travel, including both historical **change** and recent trends. Section III identifies and presents

projections of the major socio-economic factors affecting highway travel. Section IV is the major section of the report and presents an analysis of highway travel forecasts based on alternative assumptions regarding the influencing factors.

## **I. DISCUSSION OF RESULTS AND CONCLUSIONS**

From an annual growth of 4.6 percent of the last 20 years, highway travel is expected to increase at a lower rate of 2 to 3 percent per year to 1990 due to such factors as vehicle saturation; lower growth rate of numbers of licensed drivers, and fuel constraints. Highway travel is expected to grow overall at approximately 2.4 percent compounded annually in the period to 1990. The 1972 Interstate Cost Estimate and National Highway Needs Study included highway travel forecasts of about 2.6 percent annual growth from 1970 to 1990. These forecasts appear reasonable based on the analysis in Section IV.

An annual growth rate in highway travel of 2 to 3 percent in the period to 1990 appears consistent with the anticipated increase

in population, licensed drivers, vehicles, and personal income discussed in Sections III and IV. Even with constraints on fuel, the 1990 highway travel projections appear reasonable if there are significant changes to smaller more efficient vehicles. The change in consumer attitude toward more efficient vehicles and the industry's capability to respond were demonstrated during the fuel shortage of late 1973 and early 1974.

The period to 1980 will be the most critical. There will be a higher than normal increase in the demand for travel with a large number of persons entering the high driving ages as a result of the post World War II baby boom. This is the period when fuel availability will be most critical. Supply will be limited primarily to existing sources, and the vehicle fleet will not have reached the full fuel saving potential because of the older more inefficient vehicles still being driven. Lower annual travel growth rates of near 2 percent or below may occur to 1980 under these conditions. These rates will be very dependent on prompt efforts by industry and government to improve vehicle efficiencies and on availability of fuel.

In the period 1980 to 1990 more fuel probably will be available for transportation through development of new sources and conversion of some power demands to fuels other than oil, and the vehicle population should be much more efficient. The annual travel growth rates therefore could be higher during this period, say 2.5 percent or greater.

Although the U.S. population fertility has dropped to just below 2.1 (i.e., the rate to stabilize the population assuming no net immigration), the population will continue to grow well past the year 2000. This is due to the large number of women in the child bearing age group as a result of the high post World War II fertility rates. Fluctuations in fertility rates over the forecast period will not have a significant effect on 1990 travel projections because those who will be driving by 1990 are already born.

The distribution of the population continues to change. Population continues to increase in urban areas. In the United States at the turn of the century, about 40 percent of the Nation's population lived in urban areas; now it's more than 70 percent and by 2000 it could reach 85 percent, which means over 60 million persons may have to be accommodated in U.S. urban areas in less than three decades.<sup>1</sup> In realistic terms, this could mean construction of at least the equivalent of one-half of what physically exists in urban America today. It also means significantly increased need for transportation service.

This emphasizes the need for positive planning and development of transportation corridors and facilities to aid in shaping and controlling land use development. Land transportation corridors and facilities are a very permanent structuring element of all cities. Routes established in the major cities of the world centuries ago continue to function today as major transportation corridors. These same corridors are in use even though the transportation technology and even modes of transportation have changed, sometimes several times. Although the span of time is shorter, the corridors of U.S. cities have likewise maintained their permanence through transportation evolutions. Recognizing permanence, it is important to develop corridors for future city growth that contribute to modal coordination, flexibility, accessibility, and efficiency to a greater extent than corridors that now exist.<sup>2</sup> Transportation corridors can provide a structure that conforms to the accessibility needs of established land uses, or can provide a structure that precedes, stimulates, and guides land use. Corridors can provide flexibility in making provision for individual and public transportation provide flexibility for use of new technology, and can provide for other uses such as utilities.<sup>3</sup>

Emphasis must be placed on efficiency in transportation services. Per-passenger mile use of energy must be optimized to provide for the economic and social transportation needs of an increasing population within the constraints of limited natural resources. Increasing use of energy efficient strategies such as carpooling, exclusive lanes for peak hour bus service, provision for walking and bicycling, and separation of conflicting movements are needed. Although these strategies do not curtail substantially the total national vehicle-miles of travel projected in Section IV, they do contribute to reduction of peak hour congestion, the demand for fuel, and pollution.

## **II. HIGHWAY TRAVEL AND ITS RELATIONSHIP TO TRAVEL BY OTHER MODES**

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<sup>1</sup> Engineering News Record; 'Probing the Future,' Vol. 192, No. 18, April 20, 1974.

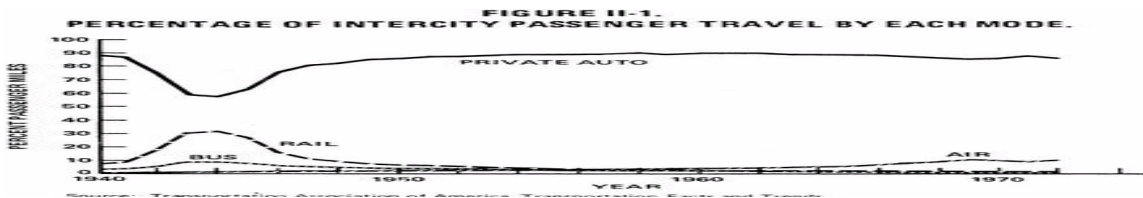
<sup>2</sup> N. L. Copper. Master's Thesis, "Urban Transportation: Decentralized Decision Making to Metropolitan Regions Through Advance Acquisition for Multi-Modal Corridors," Indiana University; Bloomington, Indiana; 1970.

<sup>3</sup> Jack E. Leisch. Highway Research Record 293, "Transportation System in the Future Development of Metropolitan Areas," Washington, D.C., 1969.

This section presents a perspective of travel by all modes and then focuses specifically on highway travel, both historical and recent trends as a base for developing the forecasts in later sections.

### A. Total Travel - All Modes

For intercity passenger travel, private auto transportation predominates as shown in Figure II-1. With the exception of the World War II period the private auto portion of intercity travel has varied slightly within a range from 85 percent to 90 percent, accounting for 87 percent of intercity travel in 1972. The bus share rose to a peak of 8.8 percent in 1943 and 1944, but declined to approximately 2 percent by 1972. Rail passenger service has decreased from a World War II peak of 31 percent of intercity passenger-miles to slightly less than 1 percent in 1972. Water transport has not been a major factor in intercity passenger travel in the past 40 years, and is not expected to change significantly in the future. At its peak, water transport accounted for about 0.7 percent of total intercity travel and since 1956 it has remained relatively stable at about 0.3 percent. The most significant gains in intercity passenger travel have been by air. Before World War II commercial air travel accounted for less than 1 percent of intercity travel. Such service now accounts for over 9 percent. Transportation by privately owned aircraft, of little consequence prior to World War II, is now approaching rail in its share of intercity passenger movement.



Intercity passenger-miles of travel by mode for 1960 and 1970 are shown in Table II-1 along with the corresponding share for each mode. Also shown in Table II-1 is the percent change in intercity passenger-miles by modes between 1960 and 1970.

**Table II-1. Intercity Travel**

Mode	1960		1970		Percent Change in Passenger-Miles 1960-1970
	Passenger-Miles Number (billions)	Percent	Passenger-Miles Number (billions)	Percent	
Automobile	796	90.1	1,026	87.0	45.3
Air	34	4.3	114	9.7	235.3
Bus	19	2.5	25	2.1	31.6
Rail	22	2.8	11	0.9	-50.0
Water	3	0.3	4	0.3	33.0
Total	784	100.0	1,180	100.0	50.5

Source: Transportation Association of America, "Facts and Trends," March Edition, 1971.

The highway modes account for almost all urban travel. Automobiles account for nearly 94 percent of the passenger-miles of travel while an additional 2.7 percent and 0.6 percent respectively are contributed by buses and taxicabs for a total of 97.2 percent as shown in Table II-2 for 1970.

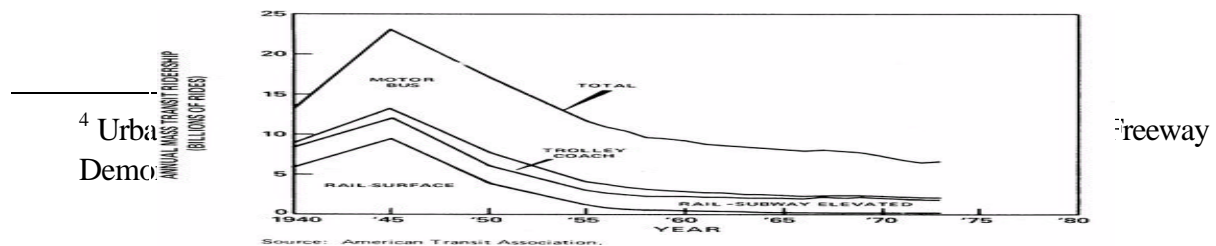
Rail transit accounts for the remaining 2.8 percent of the urban passenger-miles of travel. The decline in mass transportation between 1960 and 1970 is evident in Table II-2 and is a continuation of the trend experienced since World War II as shown in Figure II-2. Rising personal income, increasing automobile ownership, and decentralization of population and employment have been among the primary causes of decreasing patronage, revenues, and services. Within the past few years, however, increased public support of mass transportation services has offered the possibility that this trend might be arrested or even reversed. Bus patronage showed a reversal in 1973 as shown in Figure II-2. Highway travel forecasts should specifically address increased shifts from auto to possibly more efficient modes as a result of energy constraints and proposed policies for reducing auto travel particularly in urbanized areas (e.g., increased parking costs, tax on commuters, and greatly increased transit service). An example of the latter is use of exclusive bus carpool lanes during peak hours (e.g. Shirley Highway in the Washington, D. C. metropolitan area) . The Shirley Highway Corridor bus share of the market has significantly<sup>4</sup> These and other increased from 28 to 41 percent from 1968 1973. - strategies are making the transport facilities more efficient and can effect reductions in vehicle miles of travel and fuel consumption.

Mode	1960		1970		Percent Change in Passenger-Miles 1960-1970
	Passenger-Miles		Passenger-Miles		
	Number	Percent	Number	Percent	
Automobile	(billions) 423.3	88.4	(billions) 736.7	93.9	74.0
Bus	28.3	5.9	20.9	2.7	-26.3
Rail Transit	18.5	3.9	16.9	2.2	- 8.5
Commuter Rail	4.6	1.0	4.6	0.6	0.0
Taxi	3.9	0.8	5.1	0.6	30.8
Total	478.6	100.0	784.2	100.0	63.8

Source: 1972 National Transportation Report, Department of Transportation, July 1972.

**Table II-2. Urban Travel**

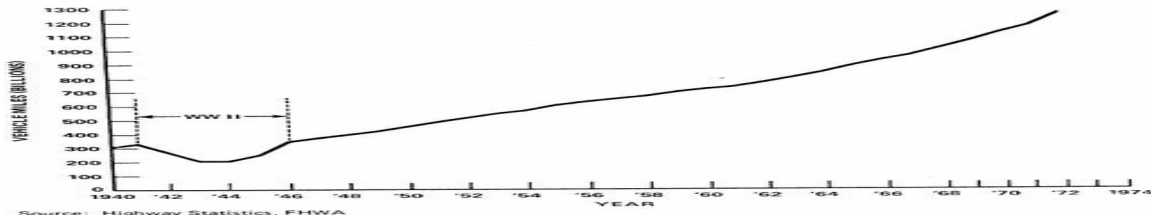
**Figure II-2. Urban Transit Patronage Trend**



## B. Highway Travel

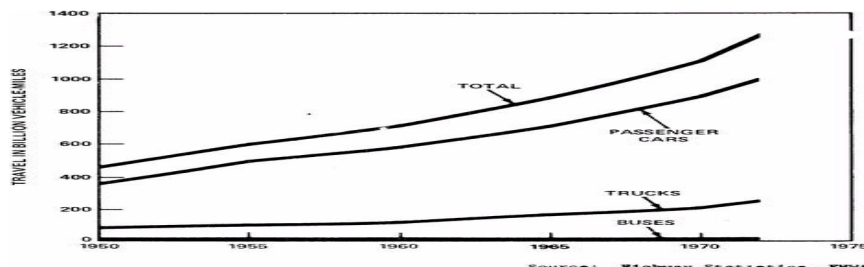
### Historical Trends and Characteristics

With the exception of the war years 1943-45, highway travel (includes passenger cars, truck, buses, taxis, and motorcycles) in the United States has increased annually from 1940 through 1972 as shown in Figure II-3. In the 20-year period from 1953 through 1972, travel in the Nation increased 147 percent or an average of 4.6 percent per year. The greater portion of that travel growth came in the latter part of the period. The average annual growth increase in vehicle-miles in the period from 1962 to 1972 of 5.2 percent was significantly greater than the 4.1 percent annual growth from 1952 to 1962. The estimated total travel for 1973 is 1,309 billion vehicle-miles, an increase of only 3.2 percent over 1972 travel, and at the time of this writing it appears that 1974 will show a decrease.



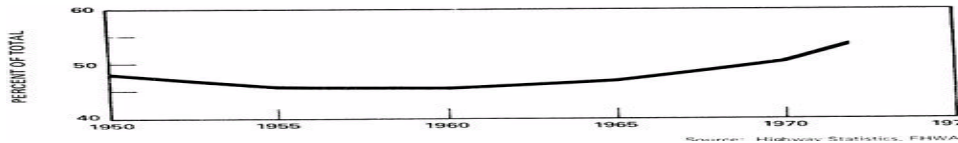
**Figure II-3. Annual Estimate of Vehicle Miles of Travel**

The relative proportion of highway travel by vehicle types is shown in Figure II-4. The passenger car portion (including motorcycles) of total highway travel remained relatively constant, with minor fluctuations, at about 80 percent throughout the 1950 to 1972 period. Truck travel was 19.8 percent of total travel in 1950 and again in 1972. The portion of bus travel has decreased from 1 percent in 1950 to 0.4 percent in 1970. Passenger-car travel is expected to continue to account for about 80 percent of the total in the future, with truck and bus travel maintaining approximately 20 percent of total travel.



**Figure II-4. Highway Travel by Vehicle Type**

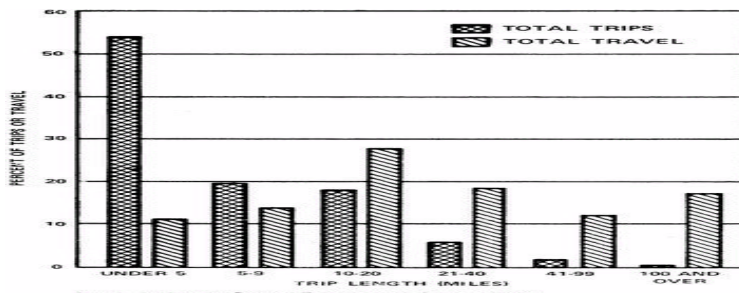
The urban share of total travel which was 47.6 percent in 1950 had decreased to 45.4 percent by 1955. It has since increased again until in 1972 it was 53.5 percent of the total. Perhaps the primary factors contributing to the increase in the percent of urban travel have been the increasing urbanization of the population and the inclusion in the urban areas of some mileage which was formerly classed as rural. Current forecasts indicate that by 1990 more than 57 percent of total national travel could be urban. The trend in the urban portion of total travel is shown on Figure II-5.



**Figure II-5. Urban Travel as a Percent of Total Motor Vehicle Travel**

Figure II-6 shows that approximately 54.2 percent of total automobile trips are under 5 miles in length and account for 11.1 percent of the vehicle miles of travel. At the other extreme, trips of 100 miles and over account for 0.8 percent of automobile trips and 17 percent of travel.

The distribution of vehicle trips and miles of travel, classified by major purpose of travel, is shown in Table II-3. Trips to and from work are the largest single category -- accounting for over 32 percent of the trips and about 34 percent of all vehicle-miles traveled.



**Figure II-6. Proportions of Passenger Car Trips and Travel by Trip Length**



Purpose of travel	Trips	Vehicle-miles	Average trip length
	(Percent)	(Percent)	(miles)
Earning a living			
To and from work	32.3	34.1	9.4
Related business	4.4	8.0	16.0
Total	36.7	42.1	10.2
Family Business			
Medical and dental	1.8	1.6	8.3
Shopping	15.4	7.6	4.4
Other	14.2	10.4	6.5
Total	31.4	19.6	5.5
Educational, civic, and religious	9.4	5.0	4.7
Social and recreational			
Vacation	0.1	2.5	165.1
Visit friends or relatives	9.0	12.2	12.0
Pleasure rides	1.4	3.1	19.6
Other	12.0	15.5	11.4
Total	22.5	33.3	13.1
All purposes	100.0	100.0	8.9

Source: Nationwide Personal Transportation Study, FHWA  
(Printed in Part II of the 1972 National Highway  
Needs Report)

**Table II-3. Distribution of Passenger Car Trips and Travel by Purpose of Travel**

### Recent Trends

The purpose of this section is to describe the recent monthly experience in highway travel as affected by the petroleum shortage. However, in order to fully comprehend the change in recent monthly travel patterns, a brief description of the typical monthly travel distribution, which has been established over time, provides meaningful background for comparative purposes.

The monthly distributions of nationwide travel by road class and for all roads and streets combined are shown in Figure II-7. The curves shown for 1972 are representative of the characteristic change in travel by month.

The curve for main rural roads shows that daily travel is at a low point in January, rising slowly through February, with a more rapid rise in March as the weather improves and becomes warmer. There is a slower yet steady rise through April and May. A more rapid rise is evident in June as schools close and the vacation season begins, and travel normally reaches a peak in July and August.

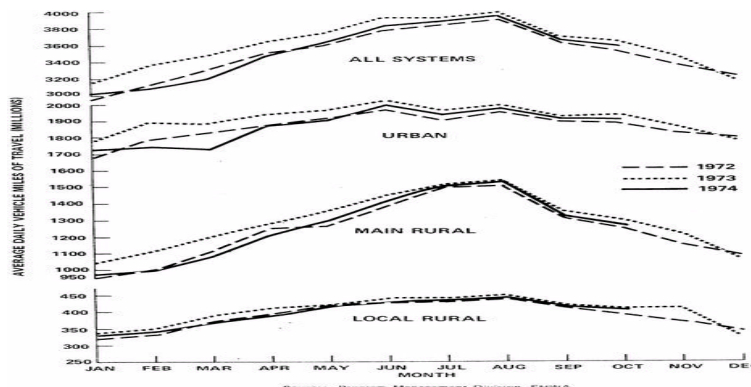
The sharp decrease in travel from August to September is partially attributable to the fact that households with school-age children no longer have the freedom to travel that they had in the summer

months. The decrease in daily travel from October through December is more gradual and may be attributable in most parts of the United States to the general worsening of the weather in these months.

The same pattern is evident in the curves for local rural roads and for all systems, though not as pronounced, particularly in the case of local rural roads which are not affected as much by vacation travel as main rural roads.

Urban travel increases from January through June and decreases from August through December. There is one characteristic of urban travel, however, which is not shown by the curves of the other systems. Travel in July is less than either June or August. It is likely that there are two causes for this. First, urban travel is generally lower on holidays than on other days (July 4 is the only holiday during June, July, and August). The second factor is possibly that July is usually a peak vacation month.

Variations in the normal monthly travel pattern are quite evident in the 1973 curves shown in Figure II-7. Uncertainty about fuel availability, and in some parts of the Nation actual shortages and long lines at service stations, caused people to reduce their discretionary travel. Awareness of the energy crisis and a desire to do their part in reducing fuel usage caused others to either cancel trips which could be canceled or to combine trips for greater efficiency and less travel. The first quarter of the year indicated a normal increase in travel with a growth of approximately 5.5 percent as compared to the similar quarter in 1972. The increase for the second quarter in 1973 was 4.4 percent. The third and fourth quarters of 1973 reflected a significant decrease in the rate of growth over 1972 with changes of only +2.6 and +1.4 percent, respectively.



**Figure II-7. Average Daily Vehicle Miles of Travel by Month**

A contributing factor to the relatively small growth in travel during the last quarter of 1973 was a decrease in December 1973 travel of 2.6 percent compared to December 1972. This was the first month in 1973 in which travel was below that of the same month in the previous year.

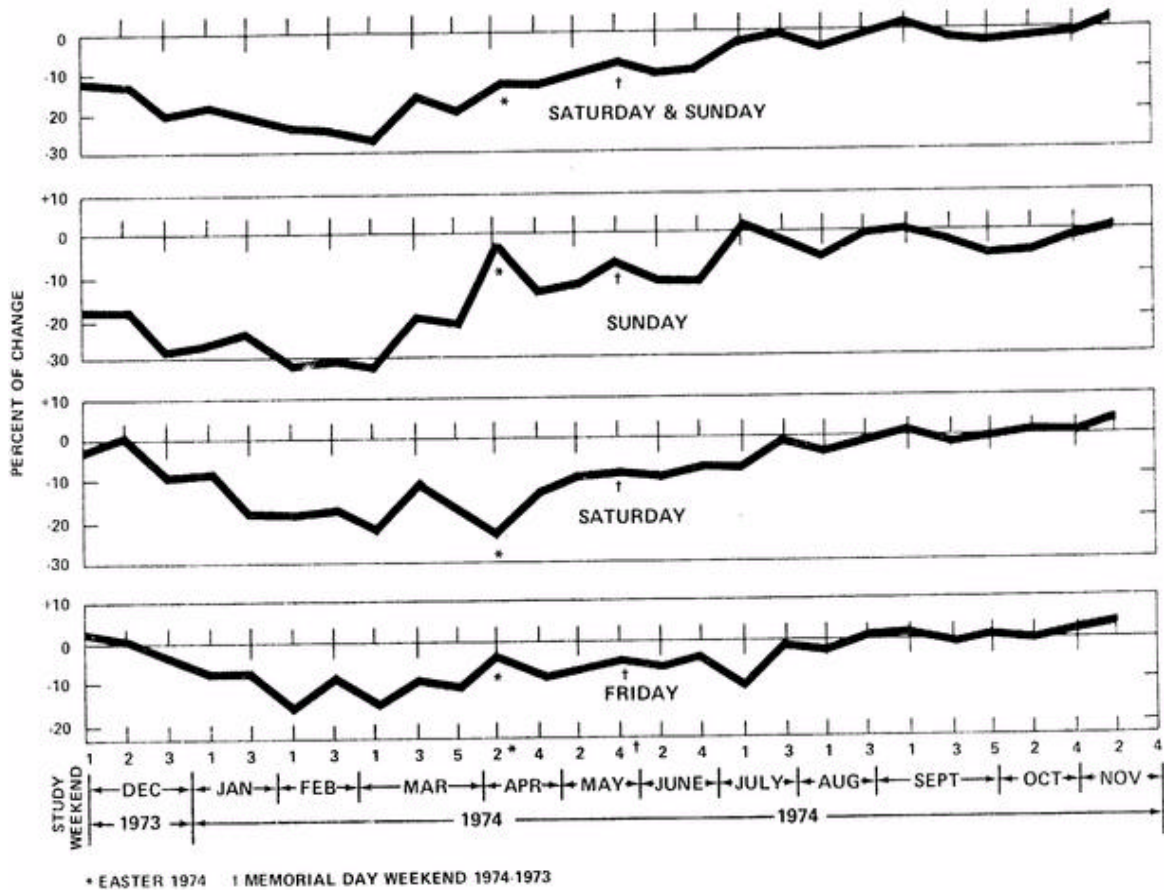
The decline in travel continued into 1974 as reflected by decreases of 4.2 percent in January and 8.5 percent in February. After reaching the maximum decrease in February, the rate of decrease has gradually declined with July 1974 indicating a -1.1 percent and August showing a -0.8 percent change

compared to the similar months in 1973. However, the cumulative 8 month total travel through August 1974 is -3.8 percent below the same period in 1973.

Following former President Nixon's November 1973 request for the voluntary Sunday closings of service stations, bi-weekly monitoring of weekend travel began. As shown in Figure II-8, Sunday traffic volumes decreased by 18 percent in December, 25 percent in January, and 30 percent in February and early March. Decreases of 20 percent were noted in late March, followed by a decrease of approximately 12 percent in April and May, and 10 percent in June compared to similar periods during the previous year. Sunday travel during the period July through early November fluctuated within 5 percent of last year's levels.

Obviously fuel availability has a very direct impact on highway travel, affecting discretionary travel (e.g., weekend) more than the average weekday travel. Fuel availability is treated as a specific constraint in developing highway travel forecasts in Section IV.

**Figure II-8. Average Percent Change in Traffic Volumes from Same Days in the Previous**



\* EASTER 1974 † MEMORIAL DAY WEEKEND 1974-1973

Source: Program Management Division - FHWA.

Year

### III. MAJOR SOCIO-ECONOMIC FACTORS INFLUENCING HIGHWAY TRAVEL

There are a number of factors which historically have been identified as the primary determinants of highway travel; the major ones being population, licensed drivers, income, auto ownership, and settlement patterns. Energy (fuel) consumption has often been mentioned as a causal factor but really is more an effect of highway travel as it has been traditionally viewed. In this analysis, fuel availability is specifically isolated as a constraint on highway travel.

Historical trends in these factors can be viewed in Figure III-1 and in Table III-1 and can be seen to generally parallel the growth of highway travel.

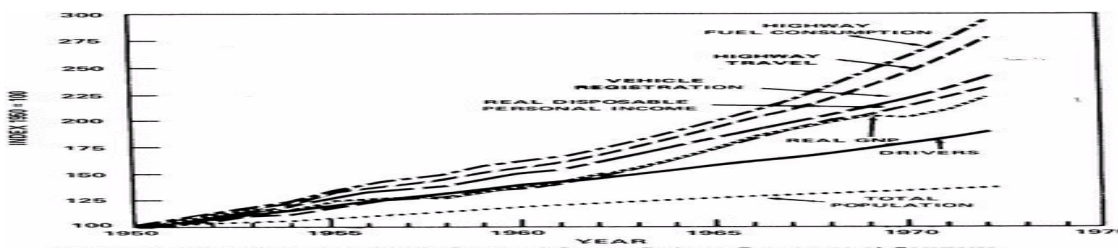


Figure III-1. Index of Highway Use of Motor Fuel, Registered Motor Vehicles, Licensed Drivers, U.S. Population, GNP and Disposable Personal Income

CALENDAR YEAR	POPULATION		DRIVERS			MOTOR VEHICLE REGISTRATIONS			VEHICLE-MILES OF TRAVEL			FUEL CONSUMPTION		
	TOTAL (MIL)	DRIVING AGE (15 AND OVER) (MIL)	MALE (MIL)	FEMALE (MIL)	TOTAL (MIL)	AUTO-MOBILE (MIL)	TRUCKS (MIL)	TOTAL (MIL)	AUTO-MOBILE (BIL)	TRUCKS (BIL)	TOTAL (BIL)	AUTO-MOBILE (BIL)	TRUCKS (BIL)	TOTAL (BIL)
1940	132.5	99.9	-	-	42.2	27.2	2.0	29.2	242.6	22.6	265.2	16.3	2.6	18.9
1950	151.9	110.9	-	-	57.3	40.4	8.8	49.2	363.4	24.6	388.0	21.3	11.3	32.6
1960	180.0	123.9	-	-	77.3	61.7	15.2	76.9	488.1	130.7	618.8	41.2	16.7	57.9
1965	193.5	133.2	57.3	40.9	98.2	75.2	23.1	98.3	711.6	176.2	887.8	50.3	20.8	71.1
1967	199.6	138.4	59.2	42.8	102.0	80.4	21.5	101.9	731.7	178.8	910.5	53.1	21.3	74.4
1968	199.4	140.8	61.2	44.2	105.4	82.6	22.8	105.4	751.7	178.8	930.5	53.3	21.3	74.6
1969	201.1	143.2	62.3	45.0	107.3	84.3	23.0	107.3	771.2	187.4	958.6	53.1	22.2	75.3
1970	203.8	146.0	63.3	46.2	109.5	85.6	23.9	109.5	811.9	201.6	1,013.5	53.5	22.2	75.7
1971	206.2	148.7	64.3	47.1	111.4	87.3	24.1	111.4	851.0	212.7	1,063.7	53.8	22.2	76.0
1972	208.2	151.5	66.0	48.4	113.4	89.9	24.6	114.5	911.2	224.1	1,135.3	54.2	22.2	76.4

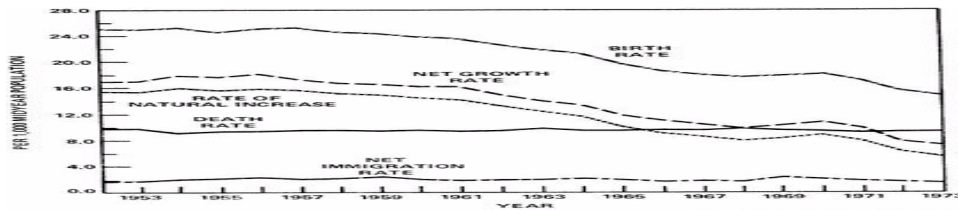
Table III-1. Historical Data - Population, Drivers, Motor Vehicles, Travel, and Fuel Consumption

Trend projections of the basic factors influencing travel have often been used in the planning process for forecasting travel, and in many cases have resulted in conservative forecasts particularly during the growth period of the late 1940's, 1950's, and 1960's. However, recent Environmental and energy pressures have reduced confidence in such trend projections. Zero population growth is advocated, vehicle saturation or leveling out at a constant person-per-vehicle ratio, is an approaching probability, and of course the recent fuel constraints raise the possibility of significant changes in driving habits and life styles.

In this section, historical trends and alternative projections of the basic demographic, economic, and sociological factors influencing travel are explored.

## A. Population

An understanding of what is happening to the population and its age distribution is necessary in determining highway travel demands. From 1960 to 1970, the population of the U.S. grew from 151 million to 203 million, an increase of 34 percent. This growth is a result of the higher birth rates of the late 1940's and 1950's. Figure III-2 shows historical birth rates, death rates, immigration and net growth. The death rate and immigration rates are stable. The birth rate (number of births per 1,000 population) however has varied significantly in recent history and is the major uncertainty in demographic projections.

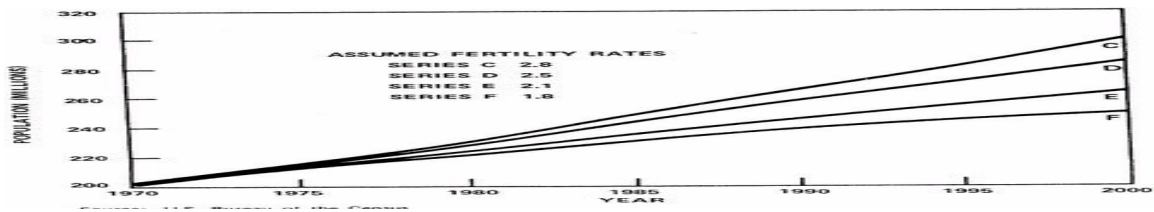


**Figure III-2. Annual Rates of U.S. Population Net Growth, Births, Deaths, and Net Immigration**

The number of children-per-woman in the child bearing age group (fertility rate) dropped since the early 1800's to a low in 1935--just over two--but rose to 3 1/3 in the late 1940's, continued high during the early 1950's but since then has decreased steadily until in 1973 the fertility rate has dropped to an all time low of 1.9 which is below the 1935 low. Because of the uncertainty in fertility rates, the Bureau of the Census makes four different population projections based on varying fertility rate assumptions. The alternative series shown in Figure III-3 provide possible future outcomes which appear reasonable at present. The highest series (Series A) was dropped and a new low series (Series E) added a few years ago because of lower fertility rates followed shortly by a drop of Series B and the addition of Series F. Series E assumes a fertility rate of 2.1, the value needed for the population to replace itself after the age structure has stabilized. Series F was added as the fertility rate continued to drop. The four projections, C-F, now provide a range from 239 million to 266 million in 1990 and a possible range from 250 million to just over 300 million persons in the year 2000.

**Figure III-3. Projections of Total Population of the United States**





In 1973 a record low fertility rate of 1.9 was reached. If this were sustained long enough, population growth would slow down and eventually stop. In fact, the population total would peak and start downhill since 1.9 is below the replacement level. Zero population growth is a long way off, however. Assuming a 2.1 fertility rate the population will increase by about 80 million in the next 40 years, similar to the growth in the last 40 years. Because of the post World War II baby boom there are a large number of women in the childbearing age groups. The population would not stabilize until the year 2040 assuming a constant 2.1 fertility rate with no net immigration.

National highway studies have previously used the B Series for forecasting purposes; however with the 1972 National Highway Needs Study the States were required to lower their population projection to Series D. Initially, it would seem that reduction of population projections to Series D or below would have a significant effect on future travel projections, and in fact, it will for very long-term planning (i.e., 2000 and beyond). However, for 1980 and 1990 the implied changes in travel are relatively insignificant. In 1980 there should be no change in the number of potential drivers since all have already been born. For 1990 there will be a very slight reduction in potential drivers between the ages of 15 and 17. There could be some changes in household travel due to changing family size but the impact on total travel forecasts is not expected to be large.

It is important to consider implications of the population age distribution. Because of the 'high birth rate of the post World War II period, there is a large population under age 25. This is shown on Figure III-4 for 1970. By 1980, the largest population groups will have moved by 10 years to the 15-34 group and by 1990 to the 25-44 group. This is significant because of the higher travel. per licensed driver in the 25-49 age groups as discussed below.

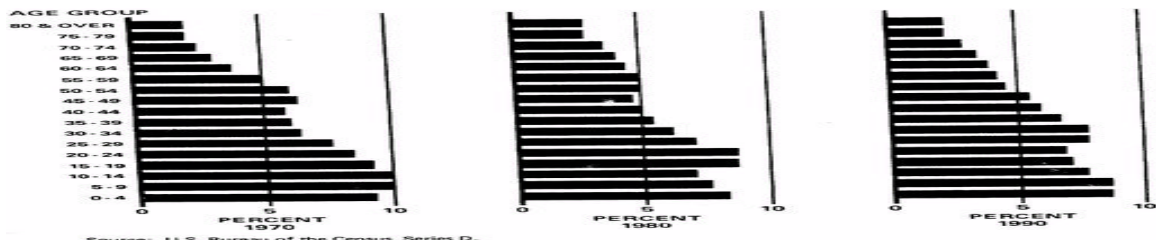


Figure III-4. Population Age Distribution Nationwide 1970, 1980, 1990

## B. Licensed Drivers and Miles Driven

The resident population of the United States in 1940 was 132.5 million, of which 45.3 million were licensed drivers. Women made up 27 percent of the drivers. By 1950, of the 151.9 million people in the United States 62.2 million held driver licenses, and by 1960 the driver segment had grown to 87.3 million of a total resident population of 180 million. The most recent decennial census showed a population total of 203.8 million of which 111.5 million were drivers. The female portion of the total has increased to 43.2 percent, an increase of about 16 percentage points during the 30 years since 1940. The percent of the population licensed as drivers by age and sex for the period 1951-1956 and 1970 can be seen in Table III-2.

**Table III-2. Percent of Population Licensed as Drivers by Age and Sex for 1951-1956 and**

Age	Percent of drivers					
	Males			Females		
	1951 - 1956	1970	Percentage difference	1951 - 1956	1970	Percentage difference
16 - 20	65.8	72.3	+ 6.5	31.6	57.9	+26.3
21 - 29	89.0	93.5	+ 4.5	50.6	77.1	+26.5
30 - 39	90.8	93.8	+ 3.0	53.8	75.9	+22.1
40 - 49	87.4	94.3	+ 6.9	46.8	73.4	+26.6
50 - 59	80.9	91.4	+10.5	32.3	58.0	+25.7
60 - 69	65.6	81.6	+16.0	18.2	42.4	+24.2
70 & over	37.8	61.8	+24.0	7.0	20.2	+13.2
All ages	78.3	87.0	+ 8.7	39.2	61.5	+22.3

Source: Nationwide Personal Transportation Study

### 1970

Table III-2 compares the population licensed as drivers in 1951-56 with similar 1970 data based on a home interview sample.<sup>5</sup> The 1970 data show that the percentage of the male population licensed to drive is between 91 and 95 percent for the age group between ages 21-59.

In general, the lower the percentage of drivers licensed in 1951-1956 the greater the increase, but in all cases the percentage licensed is less than 95 percent. Thus, the 95 percent figure may be considered a limiting value. The reasons for nonlicensing of the remaining 5 percent would include a preference not to drive, handicaps which prevent qualification, institutionalized persons, and former drivers whose licenses are revoked.

Females licensed as drivers show quite consistent increases in the proportion licensed ranging from 22 to 27 percentage points for all ages up to 69 years. If the proportions of licensed females continued to increase at past rates, then by 1990 the proportion licensed would exceed 90 percent for the ages 21.-49 and be between 85 and 90 percent for the 50-59 age group. These increases are considered a maximum.

<sup>5</sup> R. E. Gish. Nationwide Personal Transportation Study, "Characteristics of Licensed Drivers," Report No. 6, FHWA, April 1973.

The number of licensed drivers in the United States has been estimated to 1990 in relation to the forecasted persons of driving age, (15 and over) as shown in Table III-3.

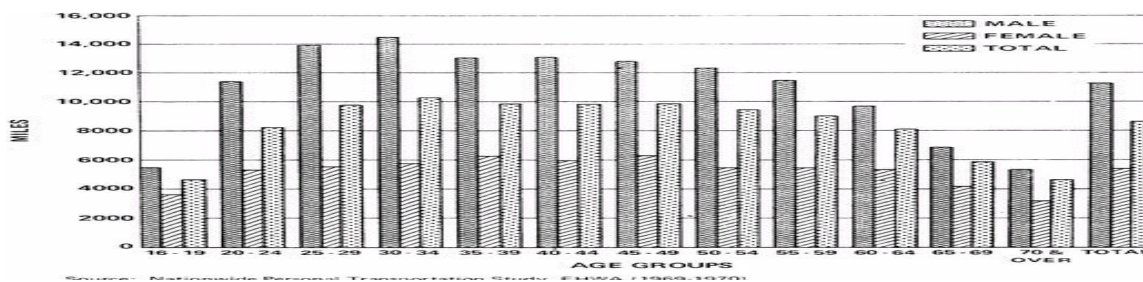
This is a likely estimate of licensed drivers based on the driving age population by 1990 and a gradual increase in percent licensed as shown in Table III-3. However, in Section IV, alternative assumptions are made regarding the forecasted number of drivers by age group and sex, and the effect on total travel is analyzed.

Year	Driving Age Population (15 years and over)	Licensed Drivers	Percent of Licensed Drivers of the Forecasted Persons of Driving Age (15 and over)
	(Millions)	(Millions)	
1950	110.9	62.2	56.4
1960	123.9	87.3	70.4
1970	146.0	111.5	76.4
1972	151.5	118.4	78.2
		Estimated	
1975	157.5	126.5	80.3
1980	167.9	137.8	82.1
1985	179.1	149.8	83.6
1990	189.7	161.2	85.0

Source: Highway Statistics Division, FHWA.

**Table III-3. Projections of Licensed Drivers**

In the Nationwide Personal Transportation Study (NPTS) drivers were asked to estimate their annual miles driven.<sup>6</sup> This distribution is shown in Figure III-5. The highest mileage age groups are between 25 and 54. The variance shown by age and sex indicates the importance of these factors in estimating future vehicle-miles of travel. Particularly important is the anticipated effect of the post-World War II birth rates in the high driving age group. Alternative assumptions are made in Section IV regarding future driving rates by age group and the effect on total travel is analyzed.



**Figure III-5. Estimated Average Annual Miles Driven Per Licensed Driver by Age and Sex**

## C. Income

<sup>6</sup> R. E. Gish. Nationwide Personal Transportation Study, "Characteristics of Licensed Drivers," Report No. 6, FHWA, April 1973.



Household vehicle tripmaking and travel, as shown in Table III-4, increase as the level of household income increases from 4,708 annual miles for households receiving less than \$4,000 annual income to almost 25,000 miles for households receiving over \$15,000 annual income. This relationship is confirmed in a survey of families by Lansing and Hendricks.<sup>7</sup> Future travel projections should therefore explicitly recognize projected changes in real personal income.

Annual household income	Annual trip rate per household	Annual vehicle-miles per household	Average trip length
(Dollars)	(Number)	(Number)	(Miles)
Under 4,000	580	4,708	8.1
4,000-9,999	1,433	12,262	8.6
10,000-14,999	1,949	17,497	9.0
15,000 and over	2,526	24,410	9.7

Source: Nationwide Personal Transportation Study, FHWA.

**Table III-4. Annual Passenger Car Trip Rates, Vehicle-Miles of Travel Per Household, and Average Trip Length By Household Income**

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<sup>7</sup> Lansing and Hendricks, "Automobile Ownership and Residential Density", University of Michigan for FHWA, June 1967.

As the labor force expands more rapidly in the 1970's and early 1980's than in previous decades, real income per capita could rise more rapidly than previously. In the mid-eighties, the labor force and income growth probably will slow due to the low birth rate years of the 1960's. The National Planning Association projects higher than normal growth in real per capita income through the mid-1980's (Note: Near term projections through 1976 have been revised downward in light of recent declines in real income growth) due to an assumed lower unemployed rate, a low fertility rate, and a slight increase in the percentage of potential workers who enter the labor force.<sup>8</sup> The growth rate from 1970 to 1983 is projected at 3.0 percent annually in constant dollars. The Bureau of Labor Statistics<sup>9</sup> projects growth rates in real disposable income to increase from the 1968-1972 average of 2.7 percent a year to 3.7 percent in the 1972-1980 period and then fall to about 2.3 percent growth in the 1980-1985 period. In Section IV, family and household income projections will be used in deriving travel forecasts. The National Planning Association projects household consumer unit) income to increase significantly to 1980 and beyond, particularly the number of households with incomes over \$15,000. This is also reflected in the Bureau of the Census family income projections.<sup>10</sup> Shifting income brackets will tend to increase travel demand if past relationships hold.

#### **D. Auto Ownership**

During the period 1940 to 1970 motor vehicle registrations increased by more than 200 percent, from 32.5 million to 108.4 million. The percentage of households owning an automobile has remained relatively constant in recent years. The growth has been in the multicar household. In 1970, 35 percent of households had two or more cars as compared to 22 percent in 1960. (Census of Housing, 1970) The number of persons available to drive the cars obviously must be considered. A limiting factor appears to be the approaching saturation of vehicle ownership as compared to driving age population (15 years and over). The ratio of-driving age population per registered vehicle has decreased to 1.29 in 1972 as shown in Table III-5. For the purpose of projections the ratio of driving age persons to vehicles is assumed to reach about 1.1 by 1990. This ratio could fall below 1.0, particularly in times of

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<sup>8</sup> National Planning Association, "Projection Highlights," Vol. 3, No. 2, March 1973.

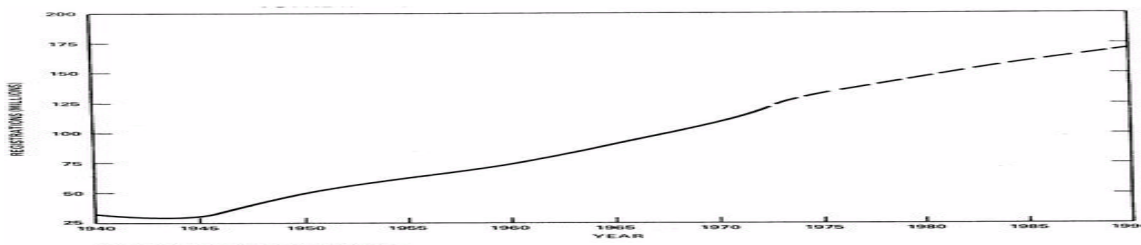
<sup>9</sup> "The New BLS Projections for 1980 and 1985," Summary of Address by Ronald E. Kutscher, Bureau of Labor Statistics, to the National Economists Club, April 2, 1974.

<sup>10</sup> Bureau of the Census, Current Population Reports, "Illustrative Projections of Money Income Size Distributions for Families and Unrelated Individuals." Series P-23, No. 47, February 1974.

affluence, with the unemployment rate very low and increasing per capita income. Multicar ownership, a substantial demand for rental cars, large taxicab fleets, and a demand for leased cars tend to push the ownership ratio closer to 1.0 and possibly even below 1.0. However, all of these factors probably would have to be present and working toward increasing the vehicle fleet to reduce the ratio below 1.0 nationwide. The limit of approximately 1.1 driving-age-persons per vehicle appears reasonable for 1990. The resulting forecast shown in Table III-5 is 169.8 million total motor vehicles in 1990. This includes 136.3 million automobiles based on the historical relationship of about 80 percent automobiles of the total registered vehicles. The above constraint of persons in the driving age group for future years produces a reduced growth rate of vehicles to 1980 and 1990 as shown in Figure III-6.

Calendar Year	Driving Age Population/ (15 yrs. and over)	Total Motor Vehicle Registrations <sup>2/ 3/</sup>			Driving-Age Population Per Registered Vehicle
		Automobiles	Trucks & Buses	Total	
	(Millions)	(Millions)	(Millions)	(Millions)	
Actual:					
1940	99.5	27.5	5.0	32.5	3.06
1950	110.9	40.4	8.8	49.2	2.25
1960	123.9	61.7	12.2	73.9	1.68
1965	134.7	75.2	15.1	90.3	1.49
1970	146.0	89.3	19.1	108.4	1.35
1972	151.5	96.9	21.6	118.5	1.28
Estimated:					
1975	157.5	106.5	25.3	131.8	1.19
1980	167.9	117.5	28.7	146.2	1.15
1985	179.1	127.4	31.3	158.7	1.13
1990	189.7	136.3	33.5	169.8	1.12

**Table III-5. Projections of U.S. Total of Population, Motor Vehicle Registrations, and Driving-Age Population Per Registered Vehicle**



**Figure III-6. Total Nationwide Motor Vehicle Registrations**

The size mix of the automobile population is also very much of interest because of the implications for fuel consumption. During 1973 and early 1974, the share of the automobile market shifted substantially in favor of small cars as shown in Table III-6. The industry has demonstrated the ability to convert to the production of smaller cars, and it probably can supply approximately 4 to 5 million compact and economy (sub-compact) cars per year by 1975, nearly 7 million by 1980, over 8 million by 1985, and about 10 million by 1990. This does not include the imports which could account for approximately 2 million each year. If the demand for smaller more efficient vehicles continues at the expense of larger cars, the estimated distribution of automobile registrations by car size shown in Table III-7 is a possible result. This shift, of course, will be sensitive to such factors as fuel availability and price, and to government induced incentives. (Note: Since an automobile is typically driven 100,000 miles before it is junked after 10 years, the vehicle size mix for a future registration year is determined by the vehicles produced during each of the preceding 10 to 15 years.) Recent experience, as fuel has become more available, indicates a slowing of the trend to smaller cars.

CALENDAR YEAR	SUBCOMPACT	COMPACT	STANDARD	TOTAL
1969	1,000,000	1,000,000	1,000,000	3,000,000
1970	1,000,000	1,000,000	1,000,000	3,000,000
1971	1,000,000	1,000,000	1,000,000	3,000,000
1972	1,000,000	1,000,000	1,000,000	3,000,000
1973 (6 months)	1,000,000	1,000,000	1,000,000	3,000,000

1/ Cars classified as follows:

SUBCOMPACTS (ECONOMY)	COMPACTS	STANDARD (REGULAR)
Gremlin	Apollo	All others
Pinto	Comet	
Vega	Dart	
Imports	Hornet	
	Maverick	
	Nova	
	Omega	
	Valiant	
	Venue	

**Table III-6. Percentage Distribution of New Car Sizes<sup>1/</sup>**

Year	Economy (Sub-Compact) (millions)	Compact (millions)	Regular (Standard) (millions)	Total (millions)
1973 <sup>1/</sup>	13.1	23.0	65.5	101.6
1975	18.1	24.9	63.5	106.5
1980	29.5	30.9	57.1	117.5
1985	50.4	40.2	36.8	127.4
1990	73.8	40.7	21.8	136.3

**Table III-7. Estimated Distribution of Automobile Registrations by Vehicle Size, 1973-1990**

This is not intended to be an official prediction or forecast of vehicles by size, but an indication of the increases in overall fuel efficiency which seem possible to 1980 and 1990. A recent Department of Transportation and Environmental Protection Agency Study<sup>11</sup> indicates that 40 percent or greater improvement in the fuel efficiency of the new car fleet is feasible by 1980. This assumed shift to a more efficient vehicle fleet in Table III-7 is an important factor in the forecast analysis in Section IV. One

<sup>11</sup> Department of Transportation and Environmental Protection Agency. "Potential for Motor Vehicle Fuel economy Improvement-Report to Congress", October 1974.

consideration under this assumption is the safety implication of smaller, lighter weight vehicles.<sup>12</sup> The fuel efficiencies implied by the above projected shifts to the smaller cars could be at least partially accomplished with existing technology applied to the existing vehicle size mix if safety implications became a constraint in shifts to smaller cars.

1/ Excludes armed forces overseas. Derived from P25, No. 477, Series C and E, March 1972, Bureau of the Census, U. S. Department of Commerce.

2/ Recorded figures are shown through 1972.

3/ Estimates by Highway Statistics Division, FHWA. for 1975-1990. (Note: Near term estimates may be revised in early 1975 as later registration data become available).

1/ Actual Source: Highway Statistics Division, FHWA (Note: This distribution is input to the analysis in Section IV as an illustration of the likely increase in overall vehicle fuel efficiency particularly under constrained fuel assumptions and government incentives).

## **E. Fuel Availability**

From 1940 to 1970 highway fuel consumption increased by 319 percent from 22 billion gallons to 92.3 billion, while vehicle-miles of travel increased by some 270 percent from 302.2 billion to 1120.7 billion. The average travel per vehicle each year showed a minor but steady increase, and the growth in vehicle sizes, weights, power options, engine horsepower, highway speeds, and emission controls combined with proportions of travel increasing in urban area have reduced the number of miles per gallon.

The spot shortages of gasoline in the last three quarters of 1973, that developed into a national problem requiring fuel allocation, introduced a new factor into the American life style. A changing attitude was reflected in the turn to smaller cars by buyers, the moves by car manufacturers to shift assembly lines to smaller cars, and the decreasing availability of unlimited amounts of gasoline at retail. The small car (compact and sub-compact) share of the U.S. market in 1973 rose to about 40 percent by the end of the year as shown in Table III-6.

During late 1973 and early 1974 the recognition of a fuel shortage and an Arab boycott on petroleum precipitated a series of actions by the Federal Government. Former President Nixon called upon Congress to pass legislation to implement Project Independence, a program designed to make the United States energy self-sufficient by the early 1980's. The major departments that have energy responsibilities increased research to establish our current position and plan for the future. The Federal

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<sup>12</sup> University of North Carolina Highway Safety Research Center, "Relationship Between Driver Crash Injury and Passenger Car weight," and "Safety, Small Cars and the Gasoline Shortage," 1974.

Energy Administration emerged to establish and apply controls on existing petroleum supplies, and to design an emergency gasoline rationing plan.

In order to bolster dwindling supplies, effort was turned to new methods for recovering additional oil from existing wells, more offshore drilling was begun, oil shale lands were leased for development, the Alaska pipeline construction was cleared by Congress, and some available foreign oil was purchased at advanced prices.

Oil imports were 25.8 percent of total domestic demand in 1971. In 1972 imports had increased to 29 percent, and by the time of the Arab oil boycott the percentage of imports had become about 36 percent. It is clear that at present, and for the next few years, we will depend on imports to meet our annual oil requirements. Domestic oil from shale, though promising in the total amounts potentially available, will cost more than other domestic oil, and the production capacity by 1985 probably will be no more than 5 to 10 percent of current demand. Some shifts of oil used by industry and utilities to transportation will occur, but this conversion will take several years.

The Alaska north slope oil cannot be shipped in quantity until the pipeline is completed, and according to current estimates of the situation, the pipeline will not be in use before 1978. Some of the oil might be shipped by tanker during a very short season each year, but that amount would be relatively small. Therefore, our supply situation during the remainder of this decade appears to be a reliance primarily on existing wells and the oil that we can import. Conservation will be necessary to hold demand to available supply. Constrained fuel assumptions and associated travel implications are specifically addressed in Section IV.

## F. Settlement Patterns

Not only is the total population and its age distribution important to travel demand but also the spatial distribution of the population. The portion in urban places of 2,500 or more population increased from 64 percent to almost 74 percent between 1950 and 1970.

To observe the changing distribution of population within metropolitan areas a tabulation with respect to Standard Metropolitan Statistical Areas (SMSA's) is shown below:

<b>Percent of Total Population<sup>13</sup></b>			
<b>Location of Population</b>	<b>1950</b>	<b>1960</b>	<b>1970</b>
Inside SMSA	62.6	66.7	68.6
Central city	35.5	33.4	31.4
Outside central city	27.1	33.3	37.2
Outside SMSA	37.4	33.3	31.4

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<sup>13</sup> 1970 Census, Final Report, PC (1), A-1, U.S. Summary (1970 definition)

The growth of the suburbs is indicated by the increasing percentage of population living outside the central city but within the SMSA. (It should be noted that there are rural areas included in the SMSA's due to the inclusion of complete counties).

Urbanized area statistics indicate that the population of the suburbs increased by 44 percent between 1960 and 1970 while the population for the central cities increased about 10 percent.<sup>9/</sup> The growth of the suburbs is also evidenced by the decrease in population density of urbanized areas--from about 5,400 to 3,752 to 3,376 people per square mile for 1950, 1960, and 1970 respectively. This trend in population distribution has generally led to greater travel demand. In the central city a number of trips can be made by walking but in the suburbs there is no longer the corner drugstore or the neighborhood grocery, and trips are most often by vehicles. As the suburbs expand, the average distance from home to work increases. Suburban households therefore tend to make more vehicle trips and produce more vehicle miles of travel than central city households.<sup>14</sup>

The urbanized area population in the United States is projected to increase from 11.8.5 million in 1970 to about 176 million in 1990. This is about a 49 percent growth. Total population is projected to increase about 25 percent as shown below:

Year	Total Population <sup>15</sup>	Urbanized Population <sup>14</sup>	% Urbanized
1960	179.3 million	95.8	53
1970	203.2 million	118.4	58
1990	253.4 million	176.3	70

The growth in urbanized population must also be analyzed in terms of central city vs. suburban growth. One way of looking at the situation would be to assess the likelihood of various alternative growth assumptions of the central city and their effect in picking up the total urbanized area growth. As a part of the 1972 National Highway Needs Report, alternative assumptions regarding central city vs. suburban growth projections were made based on the 34 largest cities -- those expected to exceed 1 million population by 1990.<sup>16</sup> The low assumption for 1990 had these urbanized areas maintaining their current absolute population in the central city.

The high assumption stated that the current share of the urbanized area population would be maintained in the central cities to 1990. This would be a reversal of past trends and would result in significant

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<sup>14</sup> Lansing and Hendricks, op. cit.

<sup>15</sup> 1970 Census, "U.S. Summary, Number of Inhabitants," PC(I)-A1, December 1971, and projections based on, FHWA, National Highway Needs Report, Part II April 1972. (Note: This projection lies between Series D and E assumptions and may be somewhat high based on recent fertility rates.)

<sup>16</sup> National Highway Needs Report, Part II, FHWA, 1972.

population growth within the central cities. The same total population growth is assumed in both alternatives above. Most likely some percentage between these assumptions will actually occur. If the population growth assumptions above are extended to all urbanized areas, then the projections below would occur:

Year	Urbanized Area Population	Central City Population	% Central city
1960	95.8 million	57.9 million	60
1970	118.4 million	63.9 million	54
1990	176.3 million (low)	63.9 million	36
1990	176.3 million (high)	92.9 million	54

In either growth assumption the suburbs will receive 50 percent or more of population growth. Central cities, although receiving the smaller absolute share of urbanized population growth, are expected to remain viable and important centers of activity in urban regions particularly because of the government, business, and personal service employment opportunities, the large existing investment in central cities, and the diversity of activity they offer.

Shifts in population and employment distributions in urban regions are important indicators of differential growth in vehicle-miles of travel in the area. It appears that there will continue to be significant growth in suburban population and households. These households tend to generate more trips and travel than central city households.<sup>17</sup> It should be possible, however, to reduce some travel demand in developing suburban communities through land use planning that provides services within walking or biking distance of residential areas.<sup>18</sup>

#### **IV. HIGHWAY TRAVEL FORECAST ANALYSIS**

In this section, a range of projections of travel and influencing factors are developed and analyzed.

##### **A. Analysis of Highway Travel Forecasts Based on the Major Contributing Socio-Economic Factors**

###### **Population, Licensed Drivers, Miles Driven Per Year**

As the number of persons of driving age population for 1980 and 1990 is one of the most important as well as most certain of the factors influencing travel, this analysis focuses on future travel estimates based on varying assumptions of licensed drivers in each age group and the vehicle-miles per year by drivers in

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<sup>17</sup> Lansing and Hendricks, op. cit.

<sup>18</sup> Gary E. Maring. Highway Research Record No. 406, "Pedestrian Travel Characteristics", 1972.



each age group. Low, medium, and high assumptions for proportions of licensed drivers in each population age group, miles per driver, and resulting calculations to determine vehicle-miles are displayed in Appendix A, Table A-1. Driver and travel growth rates are summarized in Table IV-1.

The "low" projection assumes no increase in travel per driver and proportions of drivers in each age group and therefore reflects only the increased population by age group for 1980 and 1990. This projection uses 1970 licensed driver proportions and miles per driver by age group from the Nationwide Personal Transportation Study to compute travel for 1980 and 1990. This is an intentionally low assumption to establish what appears to be a lower limit for travel forecasts, and implies conditions such as a severely constrained economy and fuel supply. This indicates travel increases for 1980 and 1990 of only 18.8 and 33.4 percent respectively or 1.7 percent and 1.5 percent

1969-1970 <sup>1</sup> Base		1980			1990		
		Low <sup>2</sup>	Medium <sup>3</sup>	High <sup>4</sup>	Low <sup>2</sup>	Medium <sup>3</sup>	High <sup>4</sup>
D	Total Drivers						
I	(Percent Increase						
V	from Base)						
E	Annual Miles Per	17.8	25.0	25.0	30.5	47.9	47.9
R	Driver (Percent	0.8	3.3	31.3	2.2	11.2	62.2
S	Increase from Base)						
T	Percent Increase	18.8	31.9	64.1	32.4	64.5	140.0
R	from Base						
A	Annual Compound						
V	Growth Rate	1.7	2.8	5.1	1.5	2.6	4.5
E	from Base						

annual compound growth rates respectively from the base year as shown in **Table IV-1**.

The "medium" projection is based on assumed increases in both proportions of licensed drivers and annual miles driven. As discussed in Section III, from the early 1950's to 1970 the percent of the men licensed as drivers in each age group has increased resulting in a maximum of 94.3 percent in the 40-49 age group.<sup>19</sup> (See Table III-2.) Women drivers as a percent of their age group increased by 22.1 percentage points to a maximum of 75.9 percent for the 30-39 age group. For the medium projection, the percent of women licensed in each age group was assumed to increase to within 5 percentage points of the 1970 male driver percent licensed for respective age groups. The result is that, for both sexes combined, about 90 percent would be licensed by 1990 in the age groups 25-54. For the "medium" projection, the miles per licensed driver values were assumed to increase also. The discussion in Section III indicated that the average miles per year by women drivers were less than 50 percent of the miles driven by men, but the age groups 16-19, and 65 and over drove 66 and 60 percent respectively of the miles driven by men in the same age groups. From this it was assumed that miles per driver for women would increase to 60 percent of the male values for each age group 20 and over by 1990. This is an increase of 8 to 14 percent in miles per driver from 1970 to 1990 for both sexes combined for the principal driving age groups. The medium assumption results in a 2.6 percent annual growth rate in travel from 1970 to 1990.

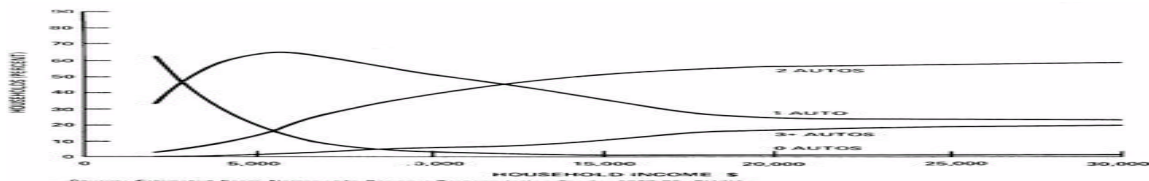
The "high" projection uses the values for proportions of licensed drivers by age group from the medium projection. The 1990 mileage per driver is based on a special analysis of the Nationwide Personal Transportation Study data for male drivers in households having annual incomes of \$7,500 or more. All

<sup>19</sup> R. E. Gish. Nationwide Personal Transportation Study, "Characteristics of Licensed Drivers," Report No. 6, FHWA, April 1973.

drivers were assigned this relatively high rate of travel. For 1980, the miles per licensed driver value was interpolated directly between the 1970 and 1990 values. This implies that some type of motorized personal transportation vehicle will be available to and within the means of practically all adults who desire such transportation, and that both males and females will drive equally high mileages. The intentionally high assumption results in a 4.5 percent annual growth rate in travel to 1990. This is approximately the growth rate of the past 20 years. This assumption is not likely to occur with the probable constraints on fuel, saturation of motor vehicle ownership, and possible reduction in long trips due to lower speed limits and higher fuel prices.

### Income-Auto Ownership-Travel Relationships

As discussed in Section III, there exists a significant relationship between household income and the magnitude of travel generated by the household. Household income and auto ownership have been found to be two of the strongest indicators of trips and travel in urban transportation studies. The relationship between income and car ownership shows a high degree of stability across urban regions based on individual urbanized area origin-destination data as well as data from the 1970 census. This relationship, between car ownership and household income based on the Nationwide Personal Transportation Study (NPTS), is shown in Figure IV-1. The main attribute of the relationship is that it incorporates the effect of auto ownership saturation beyond certain income ranges. This relationship is used in deriving 1990 travel projections.



**Figure IV-1. Car Ownership vs. Household Income**

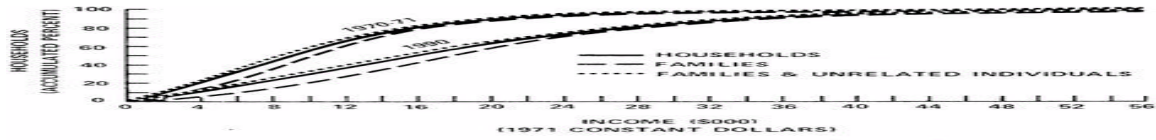
This cross classification procedure utilizes the census projections of income distributions and the basic income-auto ownership relationships and travel per household based on the NPTS.

Figure IV-2 shows income distribution curves for 1971 and 1990 families and families and unrelated individuals taken from census income projections using the Series E population growth and 3.0 percent compound annual income growth. Also shown is the 1970 household income distribution from the 1970 census. All are in 1971 constant dollars. The 1990 households are projected for this analysis to hold the same relationship to families throughout the income distribution as in 1970-1971. The 1990 household income distribution is used to derive household auto ownership distributions based on the curves in Figure IV-1. Percent households are converted to number of households based on total projected 1990 households.<sup>20</sup> Travel per household by car ownership category from the NPTS<sup>21</sup> is

<sup>20</sup> National Planning Association, Projection Highlights, Vol. 3, No. 2, March 1973.

<sup>21</sup> R. H. Asin and P. V. Svercl. Nationwide Personal Transportation Study, "Automobile

utilized to determine 1990 vehicle-miles of travel. Table IV-2 summarizes the results of this procedure and also shows some comparative estimates for 1971 and 1990.<sup>22</sup>



**Figure IV-2. Percent Distribution of Families and Families & Unrelated Individuals 1971 and 1990 with 1970 and 1990 Households**

Item	Highway Statistics 1970*	NPTS 1969-70	Application of Forecast Procedure	
			1970	1990
Households (millions)		63.4		86.5**
Car Ownership (million)	89.3	87.5	82.1***	138.4***
Annual Automobile Vehicle-Miles (billions)	901.0		866.7***	1,431.9***
Percent Compound Growth Rate: 1970 - 1990				2.5%

**Table IV-2. Projections of Highway Travel Based on Household Income and Car Ownership**

- \* See Table III-1.
- \*\* Households projected based on extension of 1970-198:-) projections (1.7 percent annual growth rate) from National Planning Associations, Projection Highlights, Vol. 3, No. 2, March 1973.
- \*\*\* Derived values according to procedure described in in-house working paper, Urban Planning Division, Planning Procedures Branch, FHWA, July 1974.

<sup>2/</sup> Bureau of the Census, Current Population Report, "Special Studies," p. 23, No. 47, February, 1974.

Vehicle-miles of travel by automobile for 1990 were estimated from the procedure to be 1,432 billion vehicle-miles of travel. This represents an annual compound growth rate of 2.5 percent between 1970 and 1990. If a 2.0 percent compound annual income growth is assumed above, the compound growth rate for travel is reduced to 2.4 percent. The 2.5 percent growth is close to the medium projection in

Ownership," Report No. 11, 1974.

<sup>22</sup> The detailed procedure and calculations are contained in an in-house paper by the Urban Planning Division, FHWA.

the preceding analysis of licensed drivers. It must be emphasized that this analysis is independent of fuel constraints.

### **Fuel Availability and Vehicle Mix**

Because fuel availability and the future fuel consumption rates of vehicles are major uncertainties, several assumptions are developed in the following analysis. Assuming existing vehicle technologies, the following analysis examines interrelationships of vehicle supply, total fuel consumption, miles per gallon per vehicle, and annual miles driven per vehicle. Using the estimated automobile registrations by vehicle mix (i.e., regular (standard), compact, and economy (subcompact)) as a base from Section III, gasoline consumption and travel can be estimated using several assumptions. The following five assumptions are considered:

1. The average annual vehicle-miles and miles per gallon for each vehicle size that existed in 1972 will remain constant so total vehicle-miles and total fuel consumption will be a function of those factors. The shift in car sizes is in accordance with Table III-7.
2. The average annual vehicle-miles for total automobiles will remain constant but those for individual automobile sizes may vary. The miles per gallon will remain constant at the 1972 level for each automobile size.
3. The average annual vehicle-miles per automobile will vary as stated in Assumption 2 and the miles per gallon will vary as more efficient cars in each size class are developed.
4. The total gasoline that can be made available will be that shown for 1972, the base year. Average annual vehicle-miles and miles per gallon may change as demand changes and more efficient cars are developed.
5. This assumption is the same as in 4, except that the total gasoline available will be increased after 1980.

#### **Forecast Based on Assumption 1 -**

Progressive gasoline savings each year after 1980 could be realized from such a mix of automobiles, even if all of them are powered by gasoline rather than by alternative energy sources. For example, Table VM-1 from "Highway Statistics, 1972" shows that the annual average miles traveled by all automobiles in 1972 was 10,184 miles, at 13.49 miles per gallon, each using an average of 755 gallons of gasoline. Using these travel per vehicle and fuel consumption factors for the entire period to 1990, the estimates shown in Table IV-1 result. Between 1972 and 1990, travel would rise by 35.3 percent (1.7 percent annually), total gasoline consumption by only 4.1 percent. The detailed calculations for each assumption are shown in Appendix B.

#### **Forecast Based on Assumption 2 -**

Another view of future gasoline consumption by automobiles might assume that as motorists convert from larger cars to smaller ones, their individual demands for travel would not decrease. If the gasoline is available to support their travel, the average vehicle-miles would increase for compact and economy

cars by amounts sufficient to keep the overall vehicle-mile average at the 1972 level of 10,184 annual miles per vehicle. Under this assumption the travel and gasoline consumption shown in **Table IV-3** could occur. In this case the changes from 1972 to 1990 are a little larger than in Assumption 1. Travel would rise by 40.7 percent (1.9 percent annually), and total gasoline consumption by 7.9 percent.

Alternative Assumptions	1980				1990			
	Vehicle-miles of Travel		Fuel consumption		Vehicle-miles of travel		Fuel consumption	
	Total (Billions)	Annual increase from base (compound annual percent)	Total (billion gallons)	Miles per gallon	Total (billions)	Annual increase from base (compound annual percent)	Total (billion gallons)	Miles per gallon
Assumption 1	1,181	2.3	81.3	14.5	1,334	1.7	76.1	17.5
Assumption 2	1,197	2.4	82.2	14.6	1,388	1.9	78.9	17.6
Assumption 3	1,197	2.4	75.8	15.7	1,388	1.9	67.8	20.5
Assumption 4	1,152	2.0	73.1	15.8	1,493	2.3	73.1	20.4
Assumption 5	1,152	2.0	73.1	15.8	1,640	2.9	80.4	20.4
1972 Base*	986.4		73.1	13.49	986.4		73.1	13.49

\* Source: FHWA, "Highway Statistics." Note: See Appendix B for calculations.

### Forecast Based on Assumption 3 -

The automotive industry has indicated that by 1975 it should be able to produce standard size cars that would attain about 15 miles per gallon in mainly urban driving (16 miles per gallon was used for analysis as being more representative of overall driving conditions). If this proves to be true, at least one-third of the standard size cars registered in 1980 could be these more efficient models, and by 1985 and 1990 all of them could be these types. This assumption is used to illustrate a combination of efficiency gain through shifts in the vehicle mix and through improved efficiencies of existing standard size vehicles. The resulting average fuel efficiency of the total automobile fleet by 1980 is 15.7 miles per gallon and by 1990 is 20.5 miles per gallon. A recent Department of Transportation and Environmental Protection Agency study indicates that 40 percent or greater improvement in the fuel efficiency of the new car fleet is feasible from 1974 to 1980.

6/ Significant improvement in efficiency has already been realized with the 1975 models.

Annual miles per vehicle is held at 10,184 miles as in Assumption 2. Total fuel consumption increases to 1980 would be held to less than 4 percent of the 1972 level of 73.1 billion gallons and in fact would fall below 1972 levels by 1990 because of the continuing increase in vehicle fuel consumption efficiencies. Travel would rise 1.9 percent annually to 1990.

### Forecast Based on Assumption 4 -

The key to this forecast is total automobile gasoline consumption of 73.1 billion gallons. If supply considerations require that future consumption cannot exceed the 1972 consumption, the average annual miles of travel by the different automobile sizes would have to be adjusted as the total number of vehicles increase. For this estimate it is reasonable to expect that miles per gallon, by vehicle size, would follow a similar pattern to that shown in Assumption 3. The average miles per gallon for all vehicles would reach 20.4 by 1990. This estimate shows an increase in travel of 51 percent by 1990 over 1972 or 2.3 percent annually, and demonstrates how growth in numbers of automobiles and travel

could occur without increasing gasoline consumption. It should be noted that travel under this assumption is constrained to 2.0 percent annually through 1980.

### **Forecast Based on Assumption 5 -**

This forecast is a modification of Assumption 4. Fuel consumption is held at the present 73.1 billion gallons through 1980 but is allowed to rise 5 percent to 1985 and 10 percent by 1990. This seems possible through development of new sources of oil and conversion of industrial and utility uses to non-oil sources. Travel in this Assumption would be constrained to 1980 as in Assumption 4 to only a 2.0 percent annual growth rate. Allowing for significant increases in travel from 1980-1990 (i.e. 3.8 annual growth rate) realizes an annual growth rate of 2.9 percent over the entire period 1972-1990.

6/ Department of Transportation and Environmental Protection Agency. "Potential For Motor Vehicle Fuel Economy Improvement - Report to Congress", October 1974.

Of the four assumptions that have been considered, the first two are the most unlikely. As persons convert from larger to smaller cars, (or to more efficient cars), their demands for travel probably will not change unless availability of gasoline forces a reduction. Therefore, the retention of the 1972 level of annual miles per vehicle for each car size probably will not occur. Also, since efforts are being made to make all sizes of cars more fuel efficient, the miles per gallon for each car size is likely to rise. Assumption 3 is more realistic in that miles per gallon for each car size is increased to reflect possible fuel efficiencies under industry and government efforts. However, the average travel per automobile is constrained at the 1972 level of 10,184 miles per year. This may not be realistic for the entire period to 1990. Assumption 4 utilizes the fuel efficiencies as in Assumption 3 but allows average miles per vehicle per year to vary. Fuel consumption, however, is constrained at the 1972, level. In Assumption 5, total fuel consumption is allowed to rise after 1980 by 5 percent to 1985 and to a maximum by 1990 of 10 percent above the 1972 fuel consumption. Assuming the shift to more efficient cars, the total vehicle forecast stated herein, and some increase in fuel availability after 1980, Assumption 5 is a possible result. This is considered a maximum with all of the factors above working together.

The travel growth rates for Assumption 3, 4, and 5 seem to be in the range of likely future events. The annual highway travel growth rates are 1.9, 2.3, and 2.9 percent respectively as shown in Table IV-3. The detailed calculations for each assumption are shown in Appendix B, Tables B-2 to B-6. Table B-I, Appendix B, explains how the factors of vehicles, miles per vehicle, total vehicle-miles and miles per gallon were derived.

The assumption regarding estimated numbers of vehicles by size class and the implied increased miles per gallon are not presented as official projections but only illustrative of reasonable gains in fuel efficiency in light of existing technology and assumed fuel constraints. It is technically feasible to produce an automobile of almost standard size with a fuel efficiency of 27 miles per gallon or about double the 1972 average of 13.49 miles per gallon by use of a diesel engine.<sup>23</sup> On the other hand,

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<sup>23</sup> Environmental Protection Agency. "Fuel Economy and Emission Control," November, 1972.

gasoline fuel injection and other known technical refinements are capable of increasing gasoline engine efficiency by well over 20 percent. The increasing miles per gallon for the vehicle fleet shown in Table IV-3, therefore, could occur through shifts in the vehicle mix and through increased efficiency of all vehicles.

### Highway Travel Forecasts Prepared by States in Cooperation with FHWA

The latest complete forecasts of highway travel prepared by the State highway departments were developed in 1971 for the 1972 Interstate Cost Estimate. The 1990 total vehicle-miles of travel forecasted for the 1972 Interstate Cost Estimate was 1,859 billion vehicle-miles of travel. (Historically 79-80 percent of total highway travel is by automobiles.)

These forecasts from both the 1972 Interstate Cost Estimate and the 1972 National Highway Needs Study reflect a 2.6 percent annual growth rate in travel for the 20-year period from 1970 to 1990. Since the rate of growth historically has been about 4.2 percent annually, it is evident that a much reduced rate of growth of travel is anticipated to 1990 than had been experienced previously. Experience from 1970 to 1972 shows higher than average travel growth rates of 5.9 percent in 1971 and 6.9 percent in 1972. The decrease in the rate of travel growth in the latter part of 1973 reduced the overall 1973 increase to 3.2 percent and an actual decrease is likely for 1974 at the time of writing. As a result, the implied growth rates to 1990 are now 2.4 percent compounded annually to reach the forecast vehicle-miles from the 1972 studies.

The 2.6 (or 2.4 percent as modified) annual growth rate projected by the States in cooperation with FHWA appears reasonable based on the preceding analyses of licensed drivers, driving rates, car ownership, fuel constraints, and income.

### Summary of Highway Travel Forecast Analyses

Table IV-4 presents a summary of the forecasts using the various methodology and assumptions in this section. All forecast growth rates have been adjusted to a 1974 base for comparison. This is based on an estimated decrease of about 3.5 percent in travel for 1974 as compared to 1973.

Forecast Base	Annual Compound Growth Rate to 1990 (Percent)		
	From 1970	From 1972	From 1974
Licensed Drivers			
Low	1.5		1.1
Medium	2.0		1.5
High	2.5		2.0
Income - Car Ownership	2.5		2.3
Vehicle Mix, Fuel Consumption Per Vehicle, Total Fuel Consumed, and Miles Per Vehicle			
Assumption 1		4.0	4.0
Assumption 2		4.0	4.0
Assumption 3		4.0	4.0
Assumption 4		4.0	4.0
State Submitted Forecast*	2.6		2.6

\*Adjusted to estimated 1974 base year for comparison

Table IV-4. Summary of Highway Travel Forecasts



It appears that a compound growth rate in travel of about 2.0-3.0 percent annually to 1990 is likely based on the preceding analysis of licensed drivers, income, car ownership, vehicle mix and fuel consumption. The licensed driver analysis shows a higher than average demand for travel in the period to 1980 with the large numbers of drivers (i.e., from the post World War II baby boom) reaching the high driving age groups. On the other hand, fuel availability will likely be most critical through 1980 with reliance on existing sources and with the necessary gradual transition to a more efficient vehicle mix. Annual travel growth rates to 1980, therefore, will probably be less than 2.4 percent annually (most likely near 2.0 percent or below).

Growth rates in the period 1980-1990 could exceed 2.4 percent annually, assuming the availability of more fuel and a continuing effort to achieve a more efficient vehicle fleet.

An overall growth rate of 2.4 percent compounded annually to 1990 seems reasonable based on the factors analyzed in this section.

## **B. Analysis of Other Significant Factors Which Influence the Highway Travel Forecasts Elasticity of Demand for Gasoline**

The price elasticity of demand for gasoline has been analyzed by many economists. A recent study<sup>24</sup> indicated a short run price elasticity of -0.07 to -0.14 and long-term elasticity (4 years or more) of -0.26 to -0.30. A recent in-house study showed an average price elasticity of -.278.<sup>25</sup> An increase from 35 cents per gallon to 70 cents per gallon, or 100 percent would be expected to result in an immediate 7 to 14 percent reduction in demand. This is considered to be relatively inelastic. With annual increases of 4 to 8 percent in recent years, this approximates a leveling of growth.

European experience indicates a long-term elasticity lower than above. Gasoline costs are over 300 percent higher in West Germany than in the United States while consumption per capita is about one-third that in the United States. A long-term price elasticity of -.278 would indicate a West German consumption of about 84 percent below that in the United States rather than two-thirds or 67 percent noted above. Of course, there are geographic and cultural differences that must be considered, although real per capital income is about the same.

Price increases effect lower income households more severely. In 1972 it was estimated that fuel costs amounted to 15-17 percent of the cost of operating an automobile. The early 1974 increase of gasoline

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<sup>24</sup> Environmental Protection Agency and Council of Environmental Quality. A Study of the Quarterly Demand for Gasoline and Impacts of Alternative Gasoline Taxes, Data Resources, Inc., December 1973.

<sup>25</sup> FHWA. In-House Study - "An Empirical Study of the Elasticity of Demand for Gasoline in the U.S.," April 9, 1974.



prices resulted in increased fuel costs to 25-27 percent of total operating costs. With the purchase price of a standard size car nearly double<sup>26</sup> that of a subcompact, those who plan to purchase a new car can save on both vehicle cost and fuel cost by purchasing a small more efficient car. Those in a position to purchase a new car can actually reduce their per mile operating costs through purchase of a smaller more efficient car. The lower income owners who tend to own older cars<sup>27</sup> are in a more difficult position since the purchaser of a used car is limited to a selection from the cars produced in prior years. Since these were principally standard-size cars it is more difficult for a low income household to maintain constant per vehicle-mile costs.

An example helps to understand the effect of income and price elasticity. At 17,000 miles per year for a new 20 m.p.g. car using 60 cents-per-gallon gasoline, the year's gasoline would cost about \$500 or 2 percent of a \$25,000 annual family income. At 7,000 miles per year for a 7-year old 10 m.p.g. car using gasoline at 60 cents per gallon, the year's gasoline would cost \$420 or 6 percent of a \$7,000 per year annual family income. The low income family could be forced to reduce both fuel purchases and travel, while those with higher incomes could reduce fuel purchases with little reduction in travel. As time passes, the proportion of small older used cars will increase and the low income family travel may again increase somewhat.

### **Characteristics of Travel Demand and Possible Fluctuation Under Constraints**

Total travel in the household is made up of several different kinds of trips which have different levels of importance to the family. A constraint such as fuel shortage can alter the trips that are made for each purpose and result in changes in total travel.

The travel to and from work is essential. Travel to and from work accounts for about 34 percent of all automobile travel. Many of the longest auto work trips are from the outskirts of the urbanized area where efficient transit is unfeasible. In other cases, workers living in the center city are employed near the periphery. Doctors and craftsmen must transport their equipment and tools expeditiously.

Managers and salesmen often have voluminous records, catalogs, and samples. Other workers must travel extensively in connection with their work, or frequently work late hours, or at other times that cannot be accommodated by carpools or transit. Where workers are in effective carpools, this will usually provide greater fuel efficiency on a passenger-mile per gallon basis than most transit operations. Thus, with travel to and from work accounting for 34.1 percent of auto travel and related business travel for another 8.0 percent, much of it with no feasible alternative, it is evident that some basic amount of work travel, below the 42.1 percent total, cannot be eliminated without severe economic disruption.

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<sup>26</sup> L. Liston and R. Sherrer. "Cost of Operating a Motor Vehicle," FHWA, 1974.

<sup>27</sup> Harry E. Strate. Nationwide Personal Transportation Study, "Annual Miles of Automobile Travel," Report No. 2, April 1972.

Family business, such as medical and dental trips, shopping, banking, and other similar errands, account for another 19.6 percent of auto travel; education, civic, and religious account for another 5.0 percent. The remaining 33.3 percent of auto travel is for social and recreational purposes. Some of this travel can be reduced or eliminated by consolidating trips and planning routes to minimize unnecessary travel. Some long vacation trips or pleasure drives can be eliminated or closer facilities utilized. Again, the severe curtailment or complete elimination of such travel could cause excessive impacts on individual life styles and employment in association with recreational activities.

It is evident that there are strong motivations and requirements for a substantial level of auto transportation. In the case of trucks and buses, much of their travel is essential to social and economic needs, although here too, economies are feasible.

Since there has been a significant increase in discretionary travel in recent years, the possibility of reducing this type of travel is worth exploring. In response to the shortage of gasoline in early 1974, for example, households cut down on travel, particularly on shopping and social-recreation travel.<sup>28</sup>

By altering tripmaking habits at the household level, reductions in vehicle-miles of travel can be made. Following are examples of substantial reductions in tripmaking and the resultant savings in vehicle-miles of travel (VMT).

6. If auto shopping trips were reduced by 20 percent, total VMT could be reduced by 1.5 percent.
7. If auto-oriented social-recreational trips were reduced by 20 percent, then about 6.5 percent of total VMT could be saved.
8. If the number of work trips nationwide by automobile were reduced by 20 percent, then about 7 percent of total VMT could be saved.<sup>29</sup>

### **Availability and Use of the Transportation System Auto Occupancy**

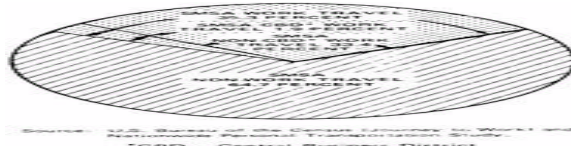
A considerable amount of attention has been directed to decreasing the number of vehicle trips required to serve a given number of person trips or increasing the average automobile occupancy of urban trips. This would help to reduce congestion, improve air quality, and reduce gasoline consumption. The influence of changes in vehicle-miles of travel is shown to vary quite differently, depending on the segments of travel considered.

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<sup>28</sup> National Opinion Research Center, February 22, 1974.

<sup>29</sup> Calculated from Table II-3 of this report.

For example, in Standard Metropolitan Statistical Areas (SMSA). an aggressive carpooling program aimed at increasing automobile occupancy for Central Business District (CBD) oriented work trips would result in a reduction of less than 1 percent of total VMT in the SMSA's.<sup>30</sup> Although CBD work trips are so evident during the rush hours, they account for less than 2 percent of areawide VMT as shown in Figure IV-3.



**Figure IV-3. Estimated Distribution of Standard Metropolitan Statistical Area (SMSA) Vehicle Miles of Travel**

Non-CBD work auto travel accounts for approximately 30 percent of the VMT in the SMSA's. It is estimated that increasing auto occupancy for all non-CBD oriented work trips by 50 percent would reduce total SMSA travel by about 12 percent. However the lower density of residence and employment sites in the suburbs can make carpool programs more difficult to organize.

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<sup>30</sup> This estimate is based on journey to work data from the 1970 Bureau of the Census publication "Detailed Characteristics, Final Report PC(1)-01.

Figure IV-4 based on census journey-to-work data for SMSA's shows the estimated percent of VMT that could be saved if varying degrees of carpooling were achieved for all SMSA auto work trips. Figure IV-4 is based on U.S. Bureau of the Census, journey-to-work data which shows a base automobile occupancy of 1.2 person trips per vehicle trip, The Nationwide Personal Transportation Study shows 1.4 person trips per vehicle trip for work and 1.5 to 1.6 person miles per vehicle-mile.<sup>31</sup> The person mile per vehicle mile measure is generally preferred for travel and energy related analyses because it is weighted by trip length.

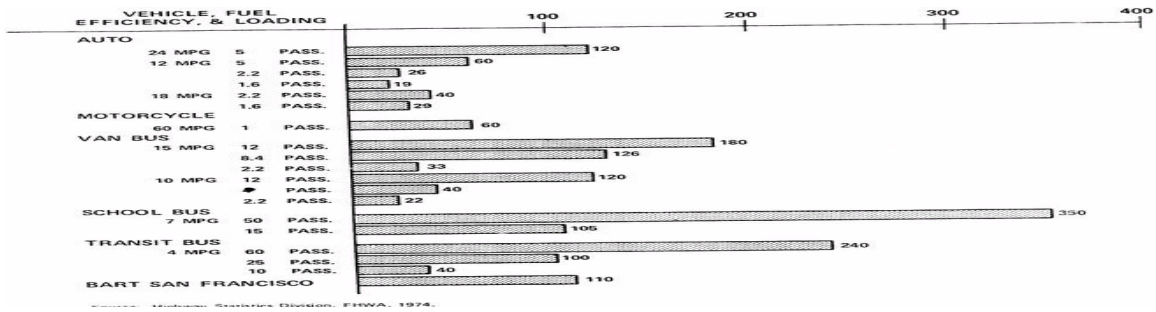


**Figure IV-4. Estimated Decrease in Total SMSA Vehicle-Miles of Travel When Car Occupancy is Increased for SMSA Work Trips**

## Transit

For maximum fuel efficiency, transit is probably better suited to transporting those traveling to and from work than for other trip purposes. During these periods maximum transit loading can be achieved while the auto work travel occupancy is at a minimum of 1.4 to 1.6 person miles per vehicle-mile, or 14 to 16 passenger-miles per gallon in a 10 mile per gallon car. This can be increased to 40 passenger-miles per gallon with an occupancy of 2 in a 20 m.p.g. car. When all bus deadheading and low occupancy travel is included, typical efficient transit bus operation achieves approximately 12 passenger-miles per bus-mile or 48 passenger-miles per gallon in a 4 m.p.g. bus. Where buses are operated only during rush hours on exclusive lanes with a high proportion of standees and few stops, maximum fuel efficiencies of 100-150 passenger-miles per gallon can be achieved even with substantial deadheading. Maximum carpool efficiencies with 5 persons in a 20 m.p.g. car are 100 passenger-miles per gallon, or with 10 persons in a 15 m.p.g. van-bus, 150 passenger-miles per gallon. Motorcycles achieve 60 passenger-miles per gallon. Thus, improved fuel efficiency for the work trip can be achieved through high m.p.g. vehicles, carpooling, and improved transit service where excessive deadheading can be avoided. Figure IV-5 shows relative fuel efficiencies of various vehicle types and loadings.

<sup>31</sup> H. E. Strate. Nationwide Personal Transportation Study Report No. 1, "Automobile Occupancy", FHWA, April, 1972.



**Figure IV-5. Comparative Fuel Efficiency of Various Modes of Passenger Transportation**

Significant shift to exclusive bus lanes (e.g., Shirley Highway)<sup>32</sup> at the aggregate nationwide level for all urbanized areas was studied. A relatively small percent of total VMT (less than 0.5 percent) can be saved by assuming a successful high type express bus system to central cities for work travel. This, of course, results from the fact that CBD oriented work travel is relatively small. As shown in Figure IV-3, CBD oriented work travel is about 2 percent of total SMSA travel. Regardless, urban public transit should be promoted where it is more fuel efficient. In addition, public transit has an important role in providing service to the elderly, young, disabled, and others who do not drive or have a car available.

### Bicycle and Walk Trips

For some households a partial solution to fuel constraints may be found in that most basic of all means of transportation--walking--and a closely related means--bicycling. If it were possible to convince a significantly large percentage of present auto users to become walkers and bicyclists, then there would be attendant reductions in automobile travel and gasoline consumption.

Reduction in the very short trips by automobile probably will have more impact on reducing gasoline consumption than travel because most of these trips are from cold starts and probably involve a high proportion of stops, starts, and speed changes.

The Nationwide Personal Transportation Study shows that 62.5 percent of all trips are 5 miles or less in length. However, these trips account for only 16 percent of the travel. These conditions are illustrated in Figure IV-6. These plots show the cumulative percentage distribution of vehicle trips and vehicle travel respectively for trip lengths of 50 miles or less. Since the short trips represent a small portion of the travel, even a shift of all trips of 2.5 miles or less to the bicycle or walk mode would result in the reduction of only about 6 percent of the travel. In terms of trips this would mean the shifting of about 40-45 percent of the vehicle trips to these two modes, which admittedly would be difficult. Shifting of all trips less than 1 mile would reduce travel by less than 2 percent but would be 24 percent of all trips.

<sup>32</sup> UMTA. "The Shirley Highway Express Bus on Freeway Demonstration Project/ Second Year Results," November, 1973.

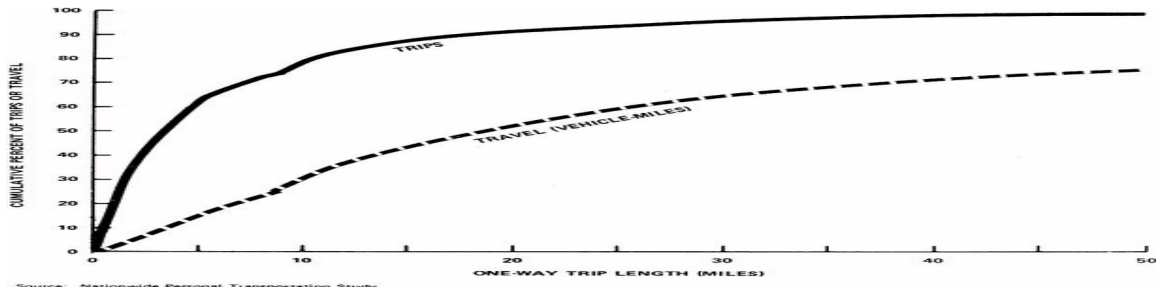


Figure IV-6. Cumulative Distribution of Passenger Car Trips and Travel by Trip Length

Weather conditions, trip purpose, physical fitness of the individual, safety, stage in the family life cycle, and convenience tend to influence the decision to take the car. The provision of facilities is encouraged (bikeways, racks, etc.) but cannot solely be counted on to effect significant shifts from the automobile. Economic incentives, possibly in the form of increased automobile user cost, would appear to be necessary to realize significant shifts to the bicycle and walk mode.

APPENDIX A

AGE	ITEM	1980 - 20		1990		1990		1990	
		BASE \$/	LOW \$/	BASE \$/	HIGH \$/	LOW \$/	BASE \$/	HIGH \$/	BASE \$/
15 - 19	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	81.9 - 11,137	12,402	63.5 - 12,000	-	11,940	55.1 - 14,130	-	11,940
20 - 24	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	83.6 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
25 - 29	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	84.8 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
30 - 34	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	86.1 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
35 - 39	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	87.4 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
40 - 44	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	88.7 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
45 - 49	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	90.0 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
50 - 54	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	91.3 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
55 - 59	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	92.6 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
60 - 64	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	93.9 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
65 - 69	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	95.2 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
70 - 74	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	96.5 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
75 - 79	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	97.8 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
80 - 84	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	99.1 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
85 - 89	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	100.4 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
90 - 94	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	101.7 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
95 - 99	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	103.0 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222
TOTAL	Population in age group, 100,000 Miles per driver per year Vehicle-miles of travel, million	104.3 - 14,400	17,242	64.4 - 12,000	-	12,222	57.6 - 15,000	-	12,222

Table A-1. Projections of Highway Travel5/ Based on Alternative Assumptions Concerning Proportions of Drivers in Each Age Group and Annual Miles Per Driver for 1980 and 1990



## APPENDIX B

Year and Automobile Size	Number of Automobiles (Millions)	Annual Miles Per Vehicle	Total Vehicle-Miles (Automobiles) (Billions)	Miles Per Gallon	Total Gasoline Consumption (Billion gals)	Gallons Per Vehicle
1972						
Standard	63.0	10,370	653.3	12.0	54.3	
Compact	22.0	10,000	220.0	16.0	13.7	
Economy	11.9	9,500	113.1	22.0	5.1	755
Total	96.9	10,184	986.4	13.49	73.1	
1980						
Standard	57.1	10,370	592.1	12.0	49.3	
Compact	30.9	10,000	309.0	16.0	19.3	
Economy	29.5	9,500	280.3	22.0	12.7	
Total	117.5	10,054	1,181.4	14.5	81.3	692
1985						
Standard	36.8	10,370	381.6	12.0	31.8	
Compact	40.2	10,000	402.0	16.0	25.1	
Economy	29.5	9,500	279.8	22.0	12.8	
Total	106.5	9,950	1,063.4	16.0	69.7	648
1990						
Standard	21.8	10,370	226.1	12.0	18.8	
Compact	40.1	10,000	407.0	16.0	25.4	
Economy	23.8	9,500	201.1	22.0	9.3	
Total	85.7	9,789	834.2	17.8	53.5	558
1990/1972	+40.7%	-3.9%	+1.7% compound- ed annually	+29.7%	+4.1%	

Table B-2. Estimated Vehicles, Travel, and Gasoline Consumption Assumption Number 1

Year and Automobile Size	Number of Automobiles (Millions)	Annual Miles Per Vehicle	Total Vehicle-Miles (Automobiles) (Billions)	Miles Per Gallon	Total Gasoline Consumption (Billion gals)	Gallons Per Vehicle
1972						
Standard	63.0	10,370	653.3	12.0	54.3	
Compact	22.0	10,000	220.0	16.0	13.7	
Economy	11.9	9,500	113.1	22.0	5.1	755
Total	96.9	10,184	986.4	13.49	73.1	
1980						
Standard	57.1	10,370	592.1	12.0	49.3	
Compact	30.9	10,000	309.0	16.0	19.3	
Economy	29.5	9,500	280.3	22.0	12.7	
Total	117.5	10,054	1,181.4	14.5	81.3	692
1985						
Standard	36.8	10,370	381.6	12.0	31.8	
Compact	40.2	10,000	402.0	16.0	25.1	
Economy	29.5	9,500	279.8	22.0	12.8	
Total	106.5	9,950	1,063.4	16.0	69.7	648
1990						
Standard	21.8	10,370	226.1	12.0	18.8	
Compact	40.1	10,000	407.0	16.0	25.4	
Economy	23.8	9,500	201.1	22.0	9.3	
Total	85.7	9,789	834.2	17.8	53.5	558
1990/1972	+40.7%	-3.9%	+1.7% compound- ed annually	+29.7%	+4.1%	

Table B-2. Estimated Vehicles, Travel and Gasoline Consumption Assumption Number 1

Year and Automobile Size	Number of Automobiles (Millions)	Annual Miles Per Vehicle	Total Vehicle-Miles (Automobiles) (Billions)	Miles Per Gallon	Total Gasoline Consumption (Billion gals)	Gallons Per Vehicle
1972						
Standard	63.0	10,370	653.3	12.0	54.3	
Compact	22.0	10,000	220.0	16.0	13.7	
Economy	11.9	9,500	113.1	22.0	5.1	755
Total	96.9	10,184	986.4	13.49	73.1	
1980						
Standard	57.1	10,370	592.1	12.0	49.3	
Compact	30.9	10,000	309.0	16.0	19.3	
Economy	29.5	9,500	280.3	22.0	12.7	
Total	117.5	10,054	1,181.4	14.5	81.3	700
1985						
Standard	36.8	10,403	382.9	12.0	31.9	
Compact	40.2	10,400	418.1	16.0	26.1	
Economy	29.5	9,550	280.2	22.0	12.8	
Total	106.5	10,184	1,081.2	16.0	70.8	633
1990						
Standard	21.8	10,435	227.5	12.0	19.0	
Compact	40.1	10,428	418.4	16.0	26.2	
Economy	23.8	9,375	223.2	22.0	10.2	
Total	85.7	10,184	869.1	17.8	55.4	579
1990/1972	+40.7%	0.0%	+1.9% compound- ed annually	+30.4%	+7.9%	

Table B-3. Estimated Vehicles, Travel, and Gasoline Consumption Assumption Number 2

Calculation for Improved Efficiency of Standard Vehicles as Input to Assumptions 3, 4, and 5

If standard size vehicle efficiency were increased overall to 16 m.p.g. after 1975 as is indicated possible by the automobile industry, then by 1980 at least one-third of the standard size cars could be the more efficient type and by 1985 and 1990 all could be the more efficient type. Under this assumption less gasoline would be needed as follows:

Year	Number of Automobiles (millions)	Total VM (billions)	Gasoline Consumption M.P.G.	(billion gal)
1980				
Standard Size				
Old type	38.1	395.1	12	32.9
New type	19.0	197.0	16	12.3

Total	57.1	592.1	13.1	45.2
1985				
Standard Size				
(New type)	36.8	382.9	14.5	26.4
1990				
Standard Size				
(New type)	21.8	227.5	16	14.2

The saving would be 4.1 billion gallons in 1980, 5.5 billion gallons in 1985, and 4.7 billion gallons in 1990.

Year and Automobile Size	Number of Automobiles (Billions)	Annual Miles Per Vehicle	Total Vehicle-Miles (Automobiles) (Billions)	Miles Per Gallon	Total Gasoline Consumption (Billion gals)	Gallons Per Vehicle
1972						
Standard	63.0	10,370	653.3	12.0	54.3	
Compact	22.0	10,000	220.0	16.0	13.7	
Economy	13.9	9,500	132.1	22.0	5.1	755
Total	99.9	10,157	995.4	13.4	73.1	
1980						
Standard	57.1	10,370	592.1	13.1	45.2	
Compact	30.9	10,300	318.3	17.0	18.7	
Economy	29.5	9,700	286.2	23.0	12.4	659
Total	117.5	10,182	1,196.6	15.7	76.3	
1985						
Standard	36.8	10,405	382.9	14.5	26.4	
Compact	40.2	10,400	418.1	17.5	23.9	
Economy	29.5	9,800	290.4	24.0	12.1	574
Total	106.5	10,535	1,091.4	18.3	62.4	
1990						
Standard	21.8	10,435	227.5	16.0	14.2	
Compact	40.7	10,428	424.4	18.0	23.6	
Economy	73.8	9,725	718.2	20.5	34.8	497
Total	136.3	10,184	1,370.1	21.7	62.6	
1990/1972	+40.7%	0.0%	(1.9% compound- ed annually)	+51.7%	-7.3%	

Table B-4. Estimated Vehicles, Travel, and Gasoline Consumption Assumption Number 3

Year and Automobile Size	Number of Automobiles (Billions)	Annual Miles Per Vehicle	Total Vehicle-Miles (Automobiles) (Billions)	Miles Per Gallon	Total Gasoline Consumption (Billion gals)	Gallons Per Vehicle
1972						
Standard	63.0	10,370	653.3	12.0	54.3	
Compact	22.0	10,000	220.0	16.0	13.7	
Economy	13.9	9,500	132.1	22.0	5.1	755
Total	99.9	10,157	995.4	13.4	73.1	
1980						
Standard	57.1	9,700	554.1	13.1	42.3	
Compact	30.9	10,100	312.1	17.0	18.4	
Economy	29.5	9,700	286.2	23.0	12.4	622
Total	117.5	9,800	1,152.4	15.8	73.1	
1985						
Standard	36.8	10,950	403.1	14.5	27.8	
Compact	40.2	10,600	426.1	17.5	24.3	
Economy	29.5	10,000	295.0	24.0	12.3	574
Total	106.5	10,517	1,124.2	18.0	64.4	
1990						
Standard	21.8	11,700	255.1	16.0	15.9	
Compact	40.7	11,400	463.8	18.0	25.8	
Economy	73.8	10,600	782.4	24.2	32.3	536
Total	136.3	10,900	1,481.3	21.7	74.0	
1990/1972	+40.7%	+7.5%	(2.2% compound- ed annually)	+51.7%	0.0%	

Table B-5. Estimated Vehicles, Travel, and Gasoline Consumption Assumption Number 4

Year and Automobile Size	Number of Automobiles (Billions)	Annual Miles Per Vehicle	Total Vehicle-Miles (Automobiles) (Billions)	Miles Per Gallon	Total Gasoline Consumption (Billion gals)	Gallons Per Vehicle
1972						
Standard	63.0	10,370	653.3	12.0	54.3	
Compact	22.0	10,000	220.0	16.0	13.7	
Economy	13.9	9,500	132.1	22.0	5.1	755
Total	99.9	10,157	995.4	13.4	73.1	
1980						
Standard	57.1	9,700	554.1	13.1	42.3	
Compact	30.9	10,100	312.1	17.0	18.4	
Economy	29.5	9,700	286.2	23.0	12.4	622
Total	117.5	9,800	1,152.4	15.8	73.1	
1985						
Standard	36.8	11,400	420.9	14.5	27.3	
Compact	40.2	11,100	446.2	17.5	25.5	
Economy	29.5	10,000	295.0	24.0	12.3	574
Total	106.5	10,833	1,162.1	18.0	65.1	
1990						
Standard	21.8	12,825	279.8	16.0	17.5	
Compact	40.7	12,100	492.3	18.0	27.3	
Economy	73.8	11,500	848.1	24.2	35.0	502
Total	136.3	11,825	1,620.2	21.7	80.3	
1990/1972	+40.7%	+18.2%	(2.9% compound- ed annually)	+51.7%	+10.0%	

Table B-6. Estimated Vehicles, Travel, and Gasoline Consumption Assumption Number 5 1/