9950-330

PHASE I OF THE NEAR TERM HYBRID PASSENGER VEHICLE DEVELOPMENT PROGRAM

FINAL REPORT

APPENDIX A : Mission Analysis and Performance Specification Studies

– VOLUME II : Appendices –

Prepared for

JET PROPULSION LABORATORY

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The research described in this publication represents the first of the several Tasks of the "Phase I of the Near Term Hybrid Passenger Vehicle Development Program" being carried-on by Centro Ricerche FIAT (CRF) on Contract No. 955187 from the Jet Propulsion Laboratory, California Institute of Technology.

Major part of this task has been carried on by the Illinois Institute of Technology - Research Institute (IITRI) on a subcontract from Centro Ricerche FIAT.

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SECTION A.1

APPENDICES RELATED TO SECTION 1: BACKGROUND INFORMATION

The following Appendices have been included in Volume II of this Report to provide a handy reference for JPL Minimum Requirements and Guidelines as well as some side comments on the use of the fundamental Information Source represented by the Nationwide Personal Transportation Survey.

Other data on U.S. demographic statistics and Highway speeds are also included.

Appendix A.1-1 : JPL Minimum Requirements and Guidelines

Appendix A.1-2 : Comments on NPTS use for Mission Analysis

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APPENDIX A.1-1

JPL GUIDELINES AND MINIMUM REQUIREMENTS

The JPL provided basic data delineating certain technical aspects of the Phase I - Mission Analysis. These data have been referred to as "JPL Guidelines and Minimum Requirements". Because of the fundamental nature of these data and their underlying effect on the study, this material has been incorporated in this Appendix. The inclusion of these basic data is an important facet of the report as it provides a readily available documentation of the "foundation" data base.

All four major parts of the assumptions and guidelines have been included:

(A) 1985 Travel Behavior Assumptions

(B) Estimated 1985 Fuel Prices

(C) Guidelines for Contractor Selection of Reference Conventional Vehicle

(D) Guidelines for Life Cycle Cost Estimation

Exhibit I, "Constraints, Vehicle Minimum Requirements, and Output Requirements" has been abstracted. Only the first three pages that cover the constraints and minimum requirements have been included.

NEAR TERM HYBRID PASSENGER VEHICLE
DEVELOPMENT PROGRAM - PHASE I

ASSUMPTIONS AND GUIDELINES

This package contains the items supplied by JPL to the Phase I Contractors for the Near Term Hybrid Vehicle as specified in the Contract Statement of Work. These items are:

(A) 1985 travel behavior assumptions.

(B) Estimated 1985 fuel prices (electricity, gasoline, and diesel).

(C) Guidelines for Contractor selection of reference conventional vehicle.

(D) Guidelines for life cycle cost estimation.

(A) 1985 TRAVEL BEHAVIOR ASSUMPTIONS

The 1985 travel behavior pattern is assumed to duplicate the travel pattern as described in the NATIONWIDE PERSONAL TRANSPORTATION SURVEY 1969-70, Report No. 1 through 11, U.S. Department of Transportation/Federal Highway Administration; published in 1972-74.
To complement this data base the following forecasts should be assumed:

(1) Population forecast (Table A-1)

(2) Drivers and passenger car fleet forecast (Table A-2)

(3) Average annual vehicle kilometers and vehicle miles traveled (VKT and VMT) forecast (Table A-3)

TABLE A– 1
POPULATION FORECAST FOR THE U S A
(SERIES II PROJECTIONS)

JULY 1 YEAR	POPULATION TOTAL (x 1000)	POPULATION 16 YEARS AND OLDER (x 1000)
1977	216,745	160,996
1978	218,437	163,535
1980	222,159	168,335
1985	232,880	177,607
1990	243,513	185,082
1995	252,750	191,139
2000	260,378	199,324

SOURCE: U.S. BUREAU OF THE CENSUS, U.S. DEPARTMENT OF COMMERCE: PROJECTIONS OF THE POPULATION OF THE UNITED STATES 1977 to 2050 (CURRENT POPULATION REPORTS, SERIES P-25, No.704, ISSUED JULY 1977)

TABLE A – 2

DRIVER LICENSES AND PASSENGER CAR FLEET FORECAST FOR THE U S A

JULY 1 YEAR	DRIVER LICENSES[1] (x 1000)	PASSENGER CARS [2] (x 1000)
1975[3]	128,865	95,241
1977[3]	137,901	99,904
1978	139,005	102,864
1980	143,085	107,314
1985	150,966	113,224
1990	157,320	117,990
1995	162,468	121,851
2000	169,425	127,069

1: THE PROJECTION ASSUMES A SATURATION POINT OF DRIVER LICENSES EQUAL TO 85% OF THE POPULATION 16 YEARS AND OLDER, FROM 1978.

2: THE PROJECTION ASSUMES A SATURATION POINT OF PASSENGER CARS EQUAL TO 75% OF DRIVER LICENSES TO BE REACHED IN 1980.

3: SOURCES: R.L. POLK and MOTOR VEHICLE MANUFACTURERS ASSOCIATION OF THE UNITED STATES, 1978.

TABLE A-3
AVERAGE ANNUAL
VEHICLE KILOMETERS TRAVELED (VKT) AND VEHICLE MILES TRAVELED (VMT)
FOPECAST FOR PASSENGER CARS IN THE U S A

JULY 1 YEAR	AVERAGE ANNUAL VKT PER VEHICLE (KILOMETERS)	AVERAGE ANNUAL VMT PER VEHICLE (MILES)	% INCREASE OVER THE PREVIOUS 5 YEAR PERIOD
1975	17,466[E]	10,853[E]	
1980	18,339	11,397	5.0 %
1985	19,073	11,852	4.0 %
1990	19,645	12,208	3.0 %
1995	20,038	12,452	2.0 %
2000	20,238	12,577	1.0 %

E: ESTIMATE FOR 1975 IN BASED ON A FLEET AVERAGE FUEL ECONOMY OF 13.6 mpg (SEE TABLE C-2), A FUEL CONSUMPTION OF 76,010 MILLION GALLONS AND A PASSENGER CAR FLEET OF 95.241 MILLION CARS.

SOURCES: FHWA/DOT REFERENCE ON FUEL CONSUMPTION IN MVMA MOTOR VEHICLE FACTS AND FIGURES 1977.

R.L. POLK REFERENCE ON CAR FLEET IN MVMA MOTOR VEHICLE FACTS AND FIGURES 1977.

B) ESTIMATED 1985 FUEL PRICES (Electricity, gasoline, and diesel)

The following real prices (in 1978 cents) should be assumed:

TABLE B – 1
FUEL PRICE FORECAST (1978 CENTS)

JULY 1 YEAR	GASOLINE[1] CENTS/GALLON	DIESEL[2] CENTS/GALLON	ELECTRICITY[3] CENTS/kwh
1978	72.0	67.0	4.2
1980	76.5	71.1	4.0
1985	95.5	88.8	4.2
1990	110.0	102.3	4.5

1 : ASSUMING A CONSTANT FUEL COST (IN 1978 $) of .05 $/mile AND AN AVERAGE FLEET mpg AS TABULATED IN TABLE C–2.

2 : ASSUMING THE PRICE OF DIESEL FUEL TO BE 7 % BELOW THE PRICE OF GASOLINE.

3 : SOURCE: DRI ENERGY REPORT, MARCH 1978.

(C) GUIDELINES FOR CONTRACTOR SELECTION OF REFERENCE CONVENTIONAL ICE VEHICLE

The reference conventional ICE vehicle must be representative of the vehicles expected to be used on the selected mission. As a general guideline for the selection of reference conventional ICE vehicles and the analysis of their effect on the total fleet fuel economy and consumption, the following baseline (conventional ICE technology) forecasts should be assumed:

1) New car fleet mix, weight, and fuel economy (EPA composite mpg) forecasts for 1985 (Table C-1).
2) New car fleet fuel economy and national average fuel economy (weighted for age and VMT) forecast (Table C-2).

It is assumed that the relationship between the EPA mposite mpg and the on-road mpg is as follows (based on recent DOE analysis: A Comparison of Fuel Economy Results from EPA Tests and Actual In-Use Experience, 1974-77 Model Year Cars, February 1978):

FE (on-road mpg) = .71 (EPA composite mpg) + 2.83

Table C-3 (percent of VMT versus age of vehicle) has been utilized to calculate the national average fuel economy by harmonic averaging of the various model year mpg's (on-road) weighted against the respective fraction of the total VMT or VKT.

TABLE C – 1

NEW CAR FLEET MIX AND
EPA COMPOSITE MPG FORECAST

NEW CAR FLEET MIX	1976 USA (%)	1976 FOREIGN (%)	1976 TOTAL (%)	1985 USA (%)	1985 FOREIGN (%)	1985 TOTAL (%)
SMALL	1.1	6.8	7.9	5	6	11
SUBCOMPACT	2.1	3.9	6.0	10	4	14
COMPACT	22.5	4.6	27.1	25	5	30
FULL–SIZE	37.0	0.4	37.4	29	1	30
LARGE	21.6	0.0	21.6	15	0	15
TOTAL	84.3	15.7	100	84	16	100

NEW CAR WEIGHT AND FUEL ECONOMY	1976 (mpg)	IW (lbs)	1985 (mpg)	IW (lbs)
SMALL	29.1	2218	41.5	2050
SUBCOMPACT	25.4	2590	38.0	2225
COMPACT	21.0	3253	32.0	2650
FULL–SIZE	16.1	4311	25.0	3375
LARGE	14.1	5175	21.0	4050

NEW CAR SALES–WEIGHTED FUEL ECONOMY FLEET	1976 USA (%)	1976 FOREIGN (%)	1976 TOTAL (%)	1985 USA (%)	1985 FOREIGN (%)	1985 TOTAL (%)
FLEET AVERAGE (HARMONIC MEAN)	16.8	24.9	17.7	27.6	35.9	28.7

TABLE C – 2
NEW CAR FLEET FUEL ECONOMY
AND TOTAL FLEET FUEL ECONOMY FORECASTS

YEAR	NEW CAR FLEET FUEL ECONOMY (EPA COMPOSITE) mpg	NEW CAR FLEET FUEL ECONOMY (ON–ROAD mpg)	TOTAL CAR FLEET FUEL ECONOMY (ON–ROAD mpg)
1965	15.8	14.0	14.0
66	15.8	14.0	14.0
67	15.8	14.0	14.0
68	15.4	13.8	14.0
69	15.4	13.8	13.9
1970	15.5	13.8	13.9
71	15.1	13.6	13.9
72	15.0	13.5	13.8
73	14.5	13.1	13.7
74	14.4	13.1	13.6
1975	15.6	13.9	13.6
76	17.7	15.4	13.8
77	18.6	16.0	14.1
78	19.6	16.7	14.4
79	20.6	17.5	14.9
1980	21.6	18.2	15.3
81	23.5	19.5	15.9
82	25.4	20.9	16.6
83	27.3	22.2	17.5
84	28.2	22.9	18.3
1985	28.7	23.2	19.1
1990	28.7	23.2	22.0
1995	28.7	23.2	23.0
2000	28.7	23.2	23.2

TABLE C – 3
VMT VERSUS AGE OF VEHICLE-NATIONAL AVERAGES

VEHICLE AGE (YEARS)	PERCENT OF VEH. FLEET (%)	AVERAGE VMT (10^3 mi/yr)	PERCENT OF NATIONAL VMT (%)
< 1	8.0	18.0	12.7
1 – 2	11.0	15.1	14.7
2 – 3	10.5	13.4	12.4
3 – 4	10.1	12.2	10.9
4 – 5	9.7	11.3	9.7
5 – 6	9.3	10.5	8.6
6 – 7	8.9	9.8	7.7
7 – 8	7.5	9.2	6.1
8 – 9	6.0	8.7	4.6
9 – 10	5.0	8.3	3.7
10 – 11	4.0	7.9	2.8
11 – 12	3.0	7.6	2.0
12 – 13	2.0	7.3	1.3
13 – 14	1.2	7.0	.7
14 – 15	1.0	6.7	.6
15 – 16	.8	6.5	.5
> 16	2.0	6.3	1.0
TOTAL	100.0		100.0

(D) GUIDELINES FOR LIFE CYCLE COST ESTIMATION

1) Contractors shall use a present-value method for estimating life cycle costs.

2) All vehicles including the reference conventional ICE vehicle shall be costed using the same methodology.

3) All costs shall be presented in 1978 dollars.

4) Contractors may develop their own cost estimating relationships and assumptions with the exception of the following relationships which shall be used by all contractors:

   (a) Purchase price = 2.0 x manufacturing cost (includes destination, dealer prep, and license)

   (b) Sales tax = 5%

   (c) Annual tax, license, registration = $ 33/year

   (d) Annual insurance cost = $ 125 + .01 x purchase price (first 5 years)
   $ 75 + .006 x purchase price (subsequent years)

   (e) Fuel cost as specified in para. (B) of these guidelines.

   (f) Discount rate for present value calculations:

   privetely-owned vehicles: 2%
   commercial vehicles: 10%

(g) Financing:

Privately-owned

vehicle and first battery	12% APR 4 years
replacement batteries	12% APR 3 years or battery service life whichever is less
Commercial	all cash

(5) Cost Elements

As a minimum, contractors shall include the following items in their life cycle cost estimations:

(a) Acquisition Costs

1) Manufacturing Costs

a) Chassis

b) Heat engine

c) Electric motor (s)

d) Transmission (s)

e) Controller

f) Charger

g) Battery

h) Secondary storage system (if any)

i) Vehicle assembly

2) Purchase price (= 2 x manufacturing cost)

3) Sales taxes (= .05 x purchase price)

4) Interest (for privately-owned vehicles)

5) Salvage value

(a) vehicle salvage value

(b) replacement batteries salvage value

(b) Operating Costs

(1) Routine maintenance

(2) Repairs

(3) Annual taxes, license, and registration

(4) Insurance

(5) Fuel

a) gasoline or diesel

b) electricity

c) distilled water or other battery consumables

(6) Battery replacements

(7) Sales tax on battery replacements

(8) Interest on battery replacements (for privately owned vehicles)

EXHIBIT I

NEAR TERM HYBRID VEHICLE PROGRAM

CONSTRAINTS, VEHICLE MINIMUM REQUIREMENTS,

AND OUTPUT REQUIREMENTS

Constraints

C1 Vehicle Type - On-road passenger vehicle.

C2 Fuel Sources - Must utilize two (2):

1) Wall plug electricity, battery storable within the vehicle
2) Gasoline or diesel fuel.

C3 Technology

Components and fabrication techniques must be within state-of-the art capabilities that can be developed by 1980 and must be amenable to mass production by the mid-1980's

C4 Operator Interfaces

Operation and control of speed, braking, and direction must be similar to conventional vehicles in terms of complexity and response. Displays of information required for vehicle operation must be similar to conventional vehicles.

C5 Safety

Applicable Federal Motor Vehicle Safety Standards (FMVSS) as of date of contract (Sept. '78).
Additional standards recommended by the National Highway Transportation Safety Administration (NHTSA) for electric and hybrid vehicles as of date of contract.

C6 Emissions

1981 Federal Statutory Standards.

Vehicle Minimum Requirements (*)

R1	Passenger Capacity (SAE J1100a 2.3)	5 adults		
	(SAE J833a)	Two(2)	95	percentile males
		Three(3)	50	percentile males

(*) NOTE: Terms used are in accordance with the references indicated. Reference documents are identified by code as follows:

SAE: SAE Handbook, 1977, Part 2.

COA: Liston, L.L., Sherrea, R.W., Cost of Operating an Automobile, U.S. Department of Transportation, Federal Highway Administration, April 1974.

R2 Cargo Capacity (SAE J1100a 2.3 and 9., consistent with 9.V2 and 9.V3) 0.5 m^3 (17.7ft^3)

R3 Payload Capacity (Manufacturer's rating) 520 kg (1147 lb)

R4 Speed - Continuous Cruise 90 km/h (56mph)

R5 Accelerations

R5.1 0-50 km/h (0-31 mph) in 6 sec

R5.2 0-90 km/h (0-56 mph) in 15 sec

R5.3 40-90 km/h (25-56 mph) in 12 sec

R6 Gradeability (capability to maintain a given speed on a given grade for a given distance)

	Grade	Speed	Distance
R6.1	3%	90 km/h (56 mph)	1.0 km (0.62 mi)
R6.2	8%	50 km/h (31 mph)	0.3 km (0.19 mi)
R6.3	15%	25 km/h (16 mph)	0.2 km (0.12 mi)

R7 Additional Equipment

R7.1 Charger - on-board, 120 V, 60 Hz, 15 A and 30 A

R7.2 Charger - off-board
Must interface with a 240 V and 208 V, 60 Hz, 60 amp off-board Charger

R7.3 State-of-charge meter or equivalent

R7.4 Heater ("Consistent with good industry practice")

R7.5 Air Conditioner ("Consistent with good industry practice")

R8 Environmental conditions

R8.1 Ambient temperature - vehicle must meet all minimum requirements over an ambient temperature range of -20°C to + 40°C (-4°F to + 104°F)

R8.2 Self-contained warm-up
Minimum of ten minute self-contained warm-up is allowed to reach full performance in ambient temperature range of -20°C to 0°C (-4°F to + 32°F)
Vehicle must be operable within one minute in ambient temperature range of -20°C to +40°C (-4°F to +104°F)

R9 Test Conditions-vehicle must meet all minimum requirements and performance specifications under the following test conditions

R9.1 Test Payload 140 kg (309 lb)
R9.2 Lights and Accessories On
R9.3 Air Conditioning Off

R10 Costs

R10.1	Maximum consumer purchase price	Competitive with purchase price of reference conventional Internal Combustion Engine (ICE) vehicle
R10.2	Maximum consumer life cycle costs (Acquisition and operating costs as per COA)	Same as average life cycle cost of reference vehicle

THE NATIONWIDE PERSONAL TRANSPORTATION SURVEY (NPTS)

Comments on NPTS use for Mission Analysis.

The NPTS was designed to obtain information on nationwide patterns of travel. The survey data were collected in 1969-70 by the Bureau of Census of the Department of Commerce for the Federal Highway Administration of the Department of Transportation.

The survey was based on a multi-stage probability sample of housing units located in 235 sample areas, comprising 485 counties and independent cities, representing every State and the District of Columbia. The 235 sample areas were selected by grouping all the Nation's counties and independent cities into about 1,900 primary sample units (PSU's) and further forming 235 strata containing one or more PSU's that were relatively homogeneous according to socio-economic characteristics. Within each of the strata, a single PSU was selected to represent the stratum. Within each PSU, a probability sample of housing units was selected to represent the civilian non-institutionalized population.

The households in the survey comprised two panels, each panel consisting of approximately 3,000 households. Data from the panels were expanded to the national estimates contained in the 11 published reports. One panel was interviewed in April, July, and October 1969 and January 1970; the second panel was interviewed only once, in August, 1969.

A.1-2.1 Trip Purposes

A factor of fundamental importance in the determination of patterns of passenger-car usage is the purpose served. This is clearly revealed by the data of the NPTS survey.

Trips were classified by purpose in this sample survey according to the following categories and subcategories:

P_1. Earning a living

a. Work
b. Related business

P_2. Family and personal business

a. Shopping
b. Medical and dental care
c. Other

P_3 Educational, civic, and religious activities

a. Visiting friends and relatives
b. Pleasure driving
c. Vacations
d. Other

P_5. Other and unknown.

Travel behaviour is analyzed in terms of trip purposes on the following Reports:

No. 1 - Automobile Occupancy
No. 3 - Seasonal Variations of Automobile Trips and Travel
No. 7 - Household Travel in the U.S.
No. 10 - Purposes of Automobile Trips and Travel.

Furthermore, Report No. 8 - Home to Work Trips and Travel analyzes in detail the characteristics of this specific trip purpose contributing to the overall travel related to Earning a Living.

While Report No. 3 has no significant relevance to Mission Analysis studies, the following Reports also provide valuable information on Automobile use and travel although unrelated to trip purposes:

No. 2 - Annual miles of Automobile Travel

No. 11 - Automobile Ownership

The remaining four Reports are related to School Transportation, Public Transportation & Shopping Characteristics, Mode of Transportation & Trip-Makers Characteristics (respectively Nos. 3, 4, 9) and to Licensed Drivers Characteristics (No. 6).

A.1-2.2 Annual Vehicle Miles

Annual Vehicle Miles information is available in the NPTS in terms of Annual Travel per Household and Annual Travel per Automobile.

As the Mission Quantification Methodology described in Subsection 3.2.1.3 of Volume I moves from a "per Household" approach (points d, e, f and g of said subsection), the relationship between the Household Miles Traveled (HMT) and the Vehicle Miles Traveled (VMT) is of paramount importance, taking also into account that Trip Purpose quantification is based upon the average member of cars per household.

In projecting the 1969 Travel information to the year 1985 it was found that some contraddictions existed in the available data.

All NPTS Reports provide the same total 1969 base values for

A)	Annual trips	87.3	billions
B)	Daily miles	2.12	billions
C)	Annual miles	776	billions
D)	Number of households	62.5	millions

while different numbers of vehicles are provided in Report No. 2. Annual Miles of Automobile Travel (either 62.4 or 66.8 millions) and in Report No. 11 - Automobile Ownership (either 72.3, 72.5 or 65.4 millions). The last figure is the sum of 32.5 millions vehicles purchased new and 32.9 million vehicles purchased used as provided on Table 10 of the Report No. 11. The corresponding figures provided by the Report No. 2 (Table 4) are only slightly different (33.5 and 32.8 millions respectively).

Since the rounded 72 million cars figure is the only one in agreement with the number of car resulting from the existing distribution of car ownership among the rounded 62 million household figure which would lead to an approximate average of 1.16 car/ households, we have concluded that the appropriate value to be assumed for the number of cars in the 1969 in-place fleet is slightly above 72 millions.

On the other hand it cannot be assumed that the other values (66.4 and 66.8 millions) are not referred to the total fleet but only to a fraction on which the presented averages were computed, since those averages are also based upon numbers of daily vehicle miles (respectively 2.12 and 2.13 billions) applicable to 62.5 millions households on Reports No. 7, 10 and 11 and therefore to the entire fleet of above 72 million vehicles.

The actual 1969 average annual vehicle miles should be therefore given by:

$$\frac{\text{Total annual traveled Miles}}{\text{Total fleet vehicles}} = \frac{776 \times 10^9}{72.3 \times 10^6} = 10,700 \text{ miles}$$

which compares with the value of 11,600 miles shown on Table 4 of Report No. 2 and calculated from the values of 12,500 and 10,700 miles shown on Table 11 of Report No. 11 for respectively purchased new and purchased used vehicles. Even taking into account the comment made on page 3 of Report No. 7 about the 776 billion miles figure being 74 billion miles short of the 850 billion miles figure estimated by the FHA, one should observe that, as presented, the NPTS Report data are all based upon statistics made from household residents provided information as a result of the 1969-70 survey so that the annual vehicle miles figures should not include any adjustment to account for the reported difference.

On the other hand, it must be pointed out that the overall value of 776 billion miles includes 22.5 billion vehicle miles traveled by residents of households without cars, which therefore should not be attributed to the 72.3 or 72.5 millions cars owned by only 79.4% of the 62.5 million households (49.6 millions).

Since the surveying procedure described in the Reports' appendices let us exclude the possibilities that said 22.5 billions miles (2.9% of total) are represented by rides taken on vehicle trips already accounted for by the remaining 97.1%, one should conclude that they correspond to trips made on rented cars and taxicabs or on borrowed cars. The actual average annual miles traveled by household owned cars should be then for 1969 even lower than the 10,700 figure indicated above and, excluding all vehicle miles traveled by no-car household, would reach a minimum of:

$$\frac{776 - 22.5}{72.5} \times 10^3 = 10,400 \text{ miles}$$

A.1-2.3 Taxicab trips

With reference to the issue of use of rented cars and taxicabs, while no applicable information has been found on the first type of vehicles and they have been therefore neglected; some data on use of Taxicabs can be found on NPTS Reports Nos. 8 and 9.

These data however are somewhat contraddictory in nature: on Report No. 8, Home to Work Trips and Travel, Taxi trips are included in Public Transportation data (Percent Trips and Person Miles-Tables A-10 and A-12, Trip Length-Tables A-11 and A-13 by place of residence) as well as in Private Transportation data (Percent Trips by no-car household Income-Table A-15, Commuting Time and Percent of Employed Persons using Private Transportation only by Trip Length-Table A-20 and A-18); in other instances (Percent of Employed Persons by Mode of Transportation and Annual Income-Table A-14 or Occupation-Table A-16 or Age-Table A-17) no references are made to the use of Taxicabs.

On Report No. 9, Mode of Transportation and Personal Characteristics of Tripmakers, taxicabs are only included in Public Transportation Data (Percent Trips by Age and Mode of Travel-Table A, by Sex-Table E, by Age and Race-Table I, by Age and Residence-Table M).

The most relevant data on taxicab transportation are provided on Appendix C, Table 2 of this last report where, on a base of 145 billion total Person Trips, 74.7 billion person trips are attributed to car drivers (51,4%) 48,9 billion person trips to passengers (33.7%) with a total of 123.6 billion total for person trips on automobiles. The corresponding Taxicab trips are 410 millions (0.28%).

From Report No. 11 - Automobile Ownership, on a base of 62.5 millions households, a total of 87.3 billion vehicle trips is indicated (Tables 16 and 20). From the average daily person trips per average household, 6.2, given on Table 25, the total annual number of 141 billion Automobile Person Trips can be calculated (14% higher than the 123,6 billions figure).

Such a difference should only indicate the effect of a different statistical base since the ratio of all Automobile Person Trips to Driver Person Trips (123,6/74.7 = 1.64) obtained by data published on Report No. 9 is very close to the ratio of all Vehicle Person Trips to Vehicles Trips (141/87.3 = 1.61) obtained by data published on Report No. 11 and the ratio of Taxicab Person Trips to Private Automobile Driver Person Trips (0.410/74.7 = 0.0055 or 0.55%) could therefore be used to assess the taxicab person trips to be associated the 87.3 billion Vehicle Trips base.

A 0.5% contribution by Taxicabs trips to the total trips is on the other hand rather small compared to the 3.6% of all trips made by households with no car.

With respect to this last figure the NPTS Reports do not provide information to establish how many of these trips are made by using respectively cars borrowed from car-owning household, rented cars and taxicabs.

The last two are not on the other hand precluded to car owning households so that, lacking more defined information, we have used, in estimating the 1985 mission, the simplifying conservative assumptions that 1) Rental cars are neglected, 2) Taxicab trips are excluded from households with car, 3) no-car household trips are included in Mission M4 - Taxi/Police.

APPENDIX A.1-3

DEMOGRAPHIC DATA

The 1970 U.S. Census [(1)] served as the reference for the demographic data that are briefly summarized in this section.

The total population of the U.S. in 1970 numbered 207, 976, 452. A ranking of the individual States by population density is presented in Fig. A.1-1. The average population density of the U.S. as of 1970 is 57.5 persons per square mile. The eastern States clearly have the highest population density. Figure A.1-2 ranks the States by percent of population change from 1960-1970. Almost all the States gained in population, with only four losers.

The population inside and outside the Standard Metropolitan Statistical Areas (SMSA's) is shown in Fig. A.1-3 and the percent of population in the SMSA's by States in 1970 is shown in Table A.1-1.

Almost 70% of the U.S. population was found to live in the SMSA's.

These population statistics demonstrate that the U.S. is still a growing nation with its population primarily concentrated in the urban areas. The midwestern and principally the eastern regions of the country are the most densely populated. The implication of these conclusions for the vehicle missions analysis is that an urban/suburban, relatively-high-population-density, four-season environment affects a majority of the U.S. motorists.

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(1) See REFERENCE [1] - VOLUME I, SECTION 1.

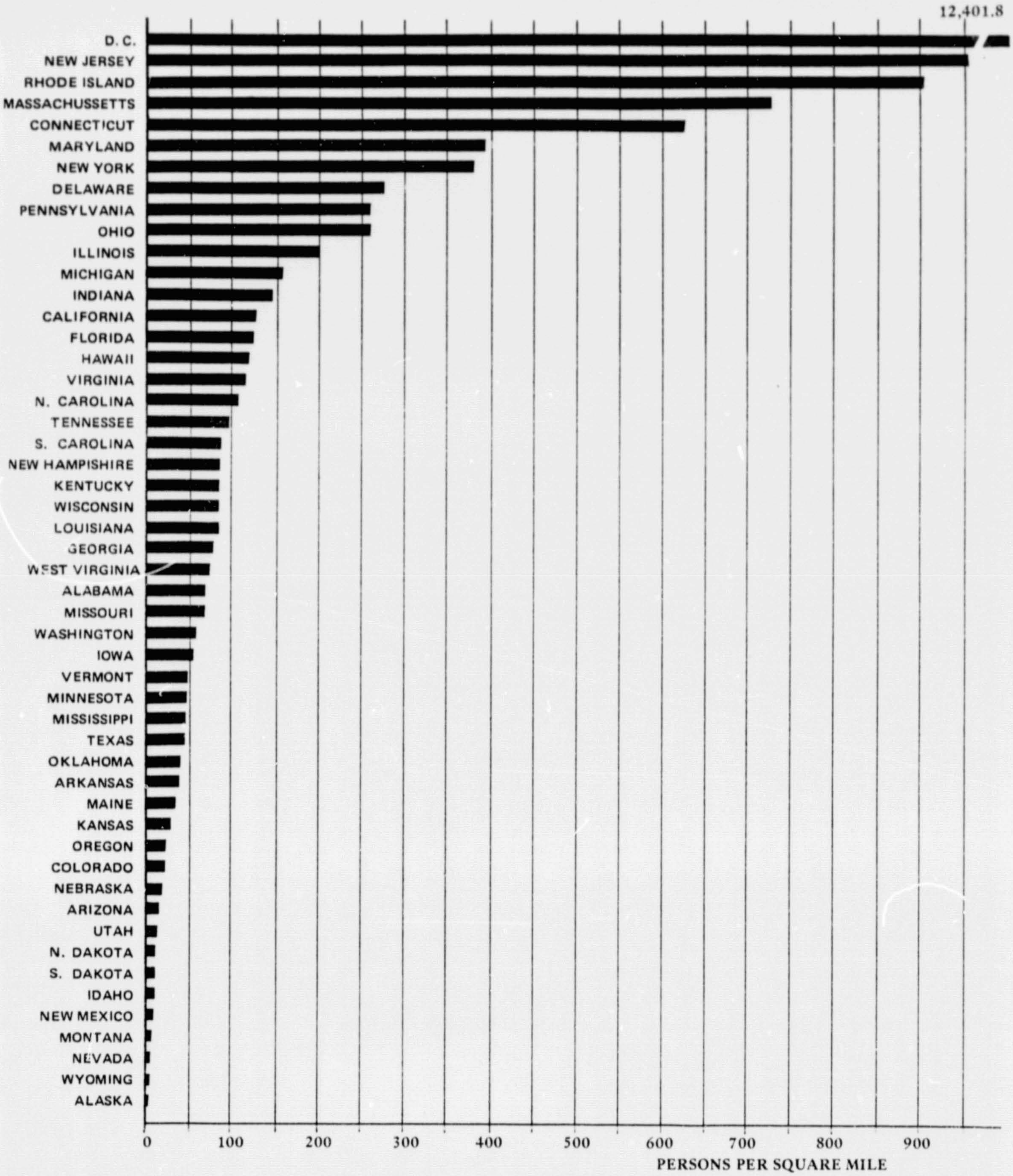


FIGURE A. 1 – 1
STATES RANKED BY POPULATION DENSITY: 1970

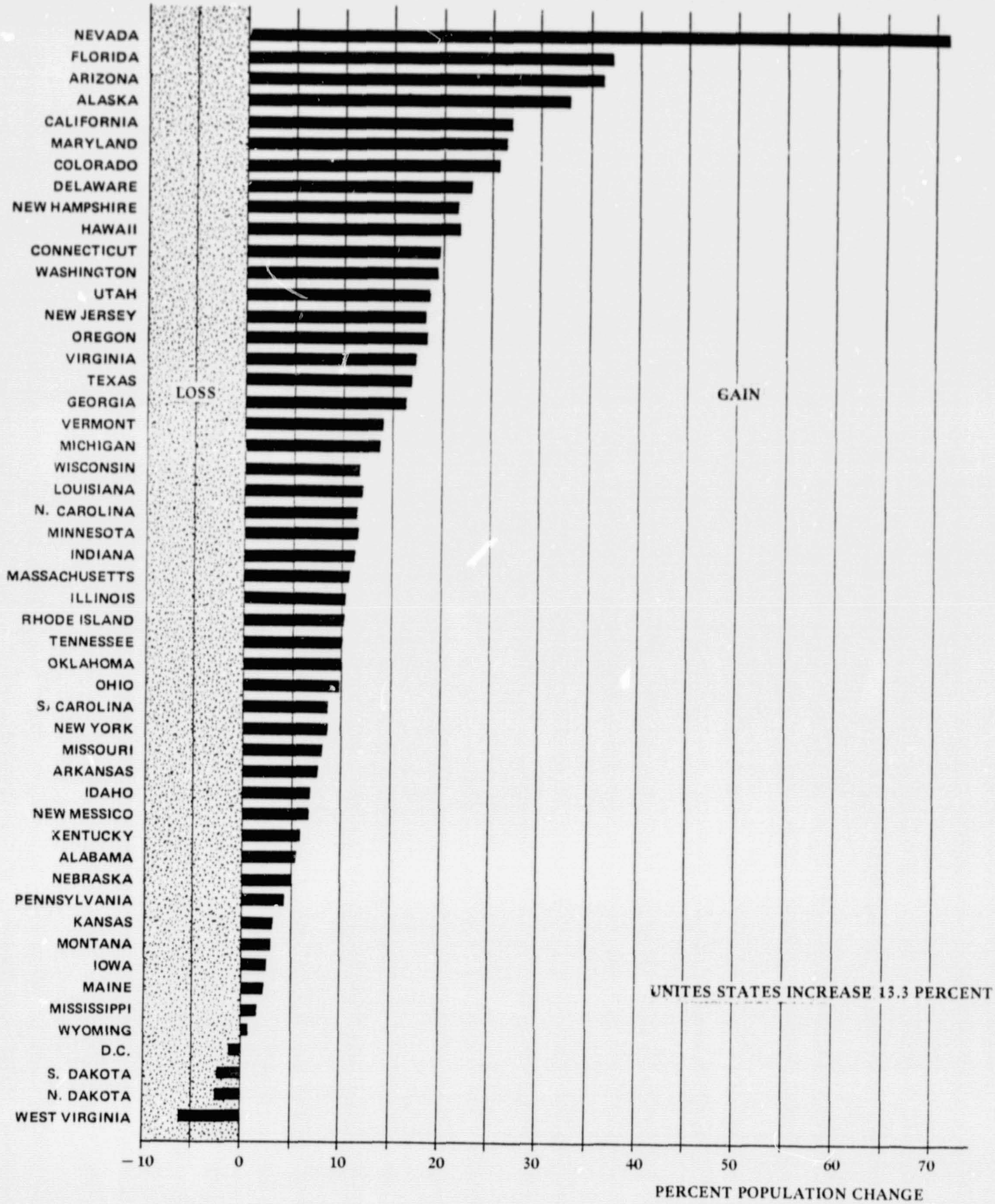


FIGURE A. 1 – 2
STATES RANKED BY PERCENT OF POPULATION CHANGE: 1960 – 1970

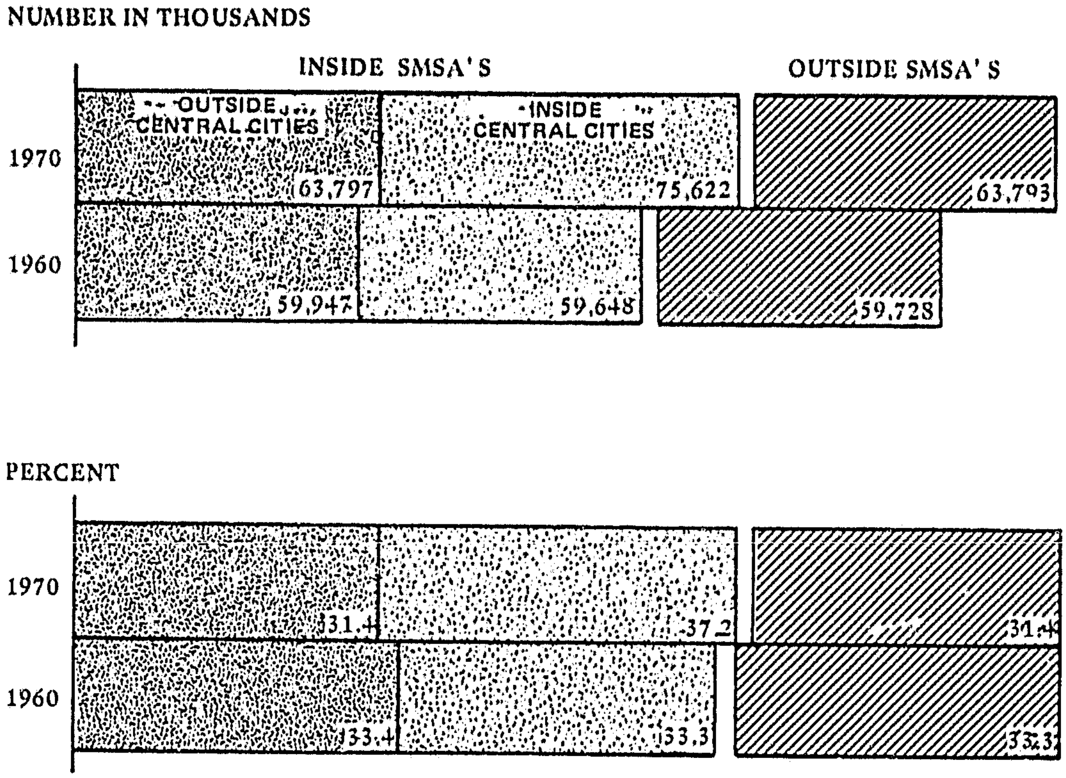


FIGURE A. 1 – 3
POPULATION INSIDE AND OUTSIDE SMSA'S: 1970 and 1960

	FAMILY MEDIAN INCOME (1976)	PERCENT OF POPULATION IN STD. METROPOLITAN STATISTICAL AREAS 1970
ALASKA	$ 12,443	—
ALABAMA	$ 7,266	52.3
ARIZONA	$ 9,187	74.5
ARKANSAS	$ 6,273	30.9
CALIFORNIA	$ 10,732	82.7
COLORADO	$ 9,555	71.7
CONNECTICUT	$ 11,811	82.6
DELAWARE	$ 10,211	70.4
DISTRICT OF COLUMBIA	$ 9,583	100
FLORIDA	$ 8,267	68.6
GEORGIA	$ 8,167	49.7
HAWAII	$ 11,554	81.9
IDAHO	$ 8,381	15.8
ILLINOIS	$ 10,959	80.1
INDIANA	$ 9,970	61.9
IOWA	$ 9,018	36.5
KANSAS	$ 8,693	42.3
KENTUCKY	$ 7,441	40.0
LOUISIANA	$ 7,530	54.8
MAINE	$ 8,205	21.6
MARYLAND	$ 11,063	84.3
MASSACHUSETTS	$ 10,835	84.7
MICHIGAN	$ 11,032	76.7
MINNESOTA	$ 9,931	56.9
MISSISSIPPI	$ 6,071	17.7
MISSOURI	$ 8,914	64.1
MONTANA	$ 8,512	24.4
NEBRASKA	$ 8,564	42.8
NEVADA	$ 10,692	80.7
NEW HAMPSHIRE	$ 9,698	27.3
NEW JERSEY	$ 11,407	76.9
NEW MEXICO	$ 7,849	31.1
NEW YORK	$ 10,617	86.5
NORTH CAROLINA	$ 7,774	37.3
NORTH DAKOTA	$ 7,838	11.9
OHIO	$ 10,313	77.7
OKLAHOMA	$ 7,725	50.1
OREGON	$ 9,489	61.2
PENNSYLVANIA	$ 9,558	79.4
RHODE ISLAND	$ 9,736	84.7
SOUTH CAROLINA	$ 7,621	39.3
SOUTH DAKOTA	$ 7,494	14.3
TENNESSEE	$ 7,447	48.9
TEXAS	$ 8,490	73.5
UTAH	$ 9,320	77.6
VERMONT	$ 8,929	—
VIRGINIA	$ 9,049	61.2
WASHINGTON	$ 10,407	66.0
WEST VIRGINIA	$ 7,415	31.3
WISCONSIN	$ 10,068	57.6
WYOMING	$ 8,943	—

TABLE A. 1 – 1
MEDIAN INCOME AND POPULATION DISTRIBUTION IN U S A

Another demographic statistic pertinent to the hybrid vehicle mission analysis is family income. The level of income will affect the American public's consumer behavior and therefore, attitude and available budget for new vehicle concepts. The U.S. 1970 Census revealed that the average family income was $ 9,590.

A breakdown of median family income by states is also given in Table A.1-1.

Net percent increase from 1959-1969 in median family income by race and region is given in Fig. A.1-4.

The most frequent single type of trip is the work trip. The census data show the growth in labor force, Fig. A.1-5. Both male and female participation in the labor force has continually increased over the last three decades. Only about 8.9% of all the 76,852,382 workers of the U.S. use public transportation for work trips. This means that a very sizable percentage of the labor force relies on the automobile for its transportation to and from work.

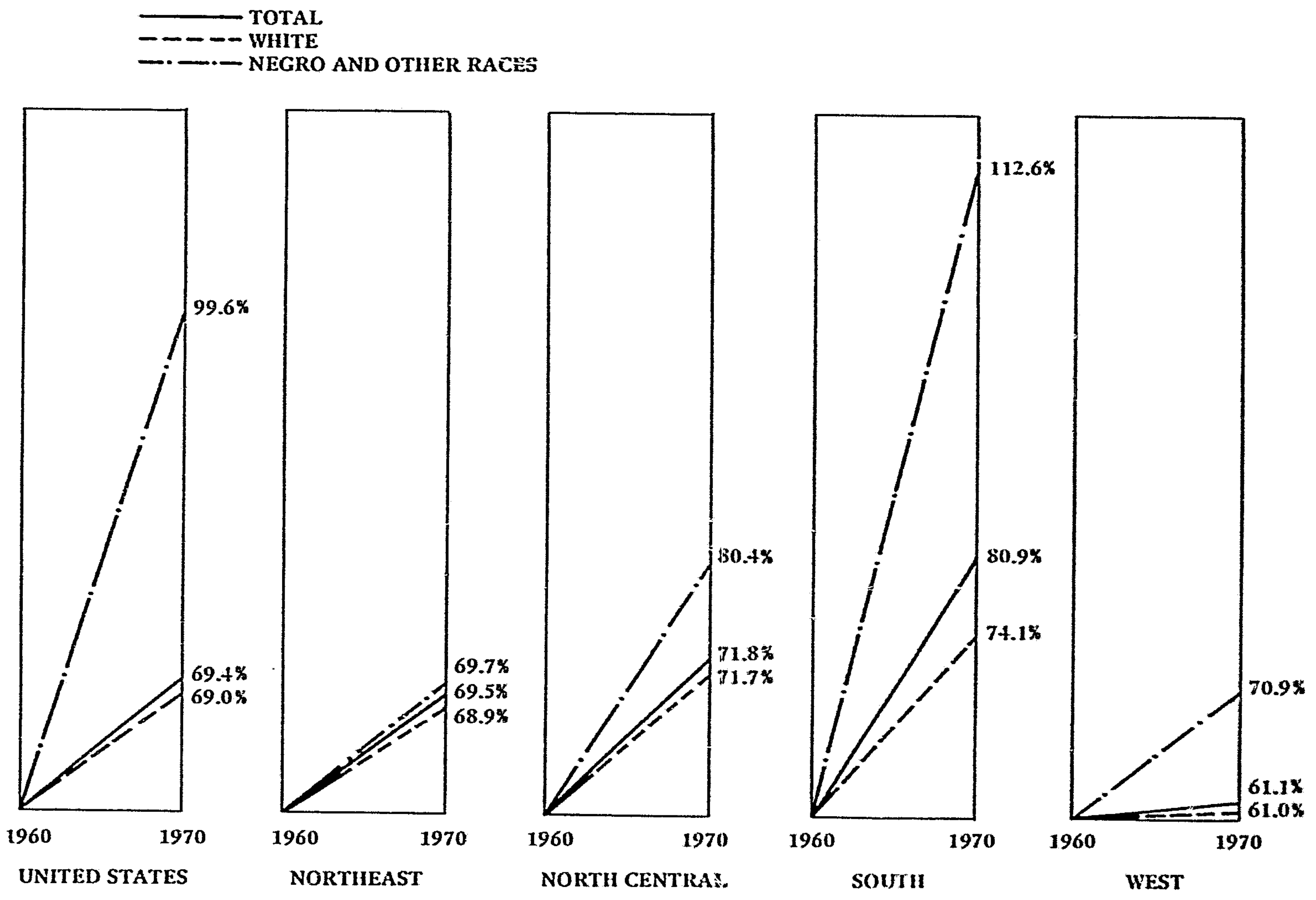


FIGURE A. 1 — 4
NET PERCENT INCREASE, 1959 — 1969, IN MEDIAN INCOME OF FAMILIES BY RANCE OF HEAD, BY REGIONS: 1960 — 1970

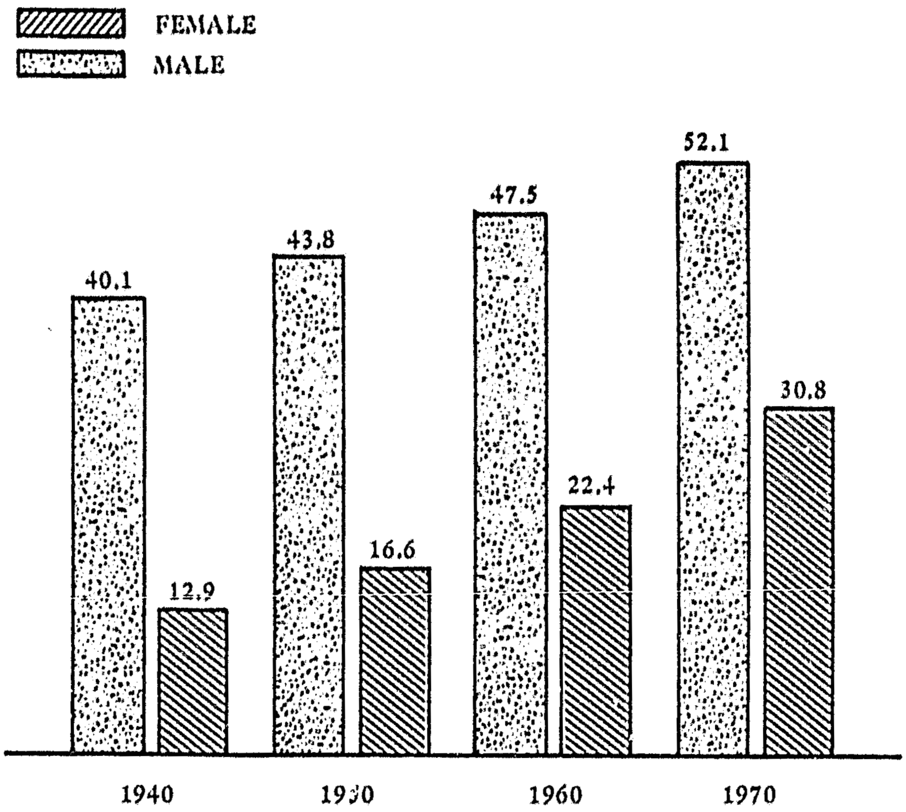


FIGURE A. 1 – 5
PERSONS 14 YEARS OLD AND OVER IN THE LABOR FORCE
(BY SEX: 1940 – 1970)

APPENDIX A.1-4

MISCELLANEOUS HIGHWAY SPEEDS DATA

The analysis performed in support of determining the cruise and top speeds for the various classes of vehicles was based on vehicle speed distributions.

A summary of the average observed highway speeds for all vehicles and for the years 1973 through 1975 is given in Table A.1-2 for the various highway systems. It shows a general speed decrease from 1973 to 1975 except than for Urban Primary Highways.

This is reflected for such Highways by a less significant decrease, during the same period, of the percent of vehicles exceeding 55, 60 and 65 mph. These percentages were, on the other hand, already much lower for the Urban Primary Highways than for any other Highway.

The variation of the percent of vehicles exceeding 55 and 65 mph is also shown in the diagrams of Fig. A.1-6; it is limited to the Rural Interstate Highways but shows the splitting between autos and trucks for the years from 1969 through 1975.

TABLE A. 1 – 2

AVERAGE SPEEDS OF FREE–MOVING VEHICLES AND PERCENTAGES OF VEHICLES EXCEEDING VARIOUS SPEEDS BY TYPE OF HIGHWAY

HIGHWAY SYSTEM	AVERAGE SPEED ALL VEHICLES (mph)			PERCENT OF VEHICLES EXCEEDING								
				55 mph			60 mph			65 mph		
	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
RURAL INTERSTATE	65.0	57.6	57.6	89	65	68	72	29	27	50	9	7
RURAL PRIMARY	57.1	53.5	54.6	58	40	47	36	14	17	19	4	5
MAIN RURAL*	60.3	55.3	55.8	70	51	55	50	21	21	31	6	6
RURAL SECONDARY	52.6	49.5	51.7	39	24	23	21	8	12	10	2	2
URBAN INTERSTATE	57.0	53.1	54.7	58	35	48	33	10	13	16	2	3
URBAN PRIMARY	41.8	42.3	42.6	13	10	11	5	3	3		1	1

* Rural Interstate and Rural Primary

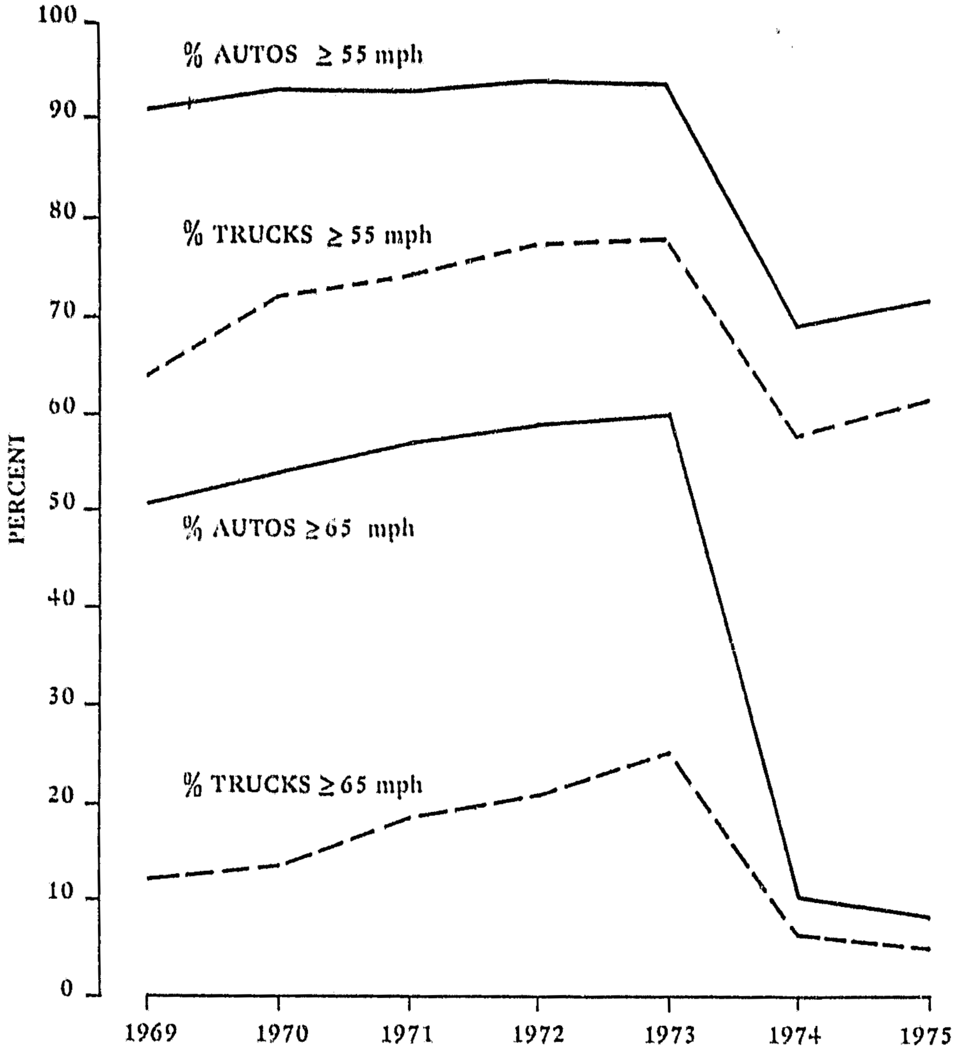


FIGURE A. 1 – 6
PERCENT OF AUTOS AND TRUCKS EXCEEDING 55 and 65 mph
ON COMPLETED RURAL INTERSTATE

SECTION A.3

APPENDICES RELATED TO SECTION 3: METHODOLOGY

The following Appendices have been included in Volume II of this Report to comply with JPL Data Description Requirement to provide Flow-diagrams and Description of Computer Models developed in defining the Methodology used for the Mission Analysis.

Appendices related to parameters and/or interim results of the Mission Quantification are attributed to Section 4 of Volume I (Interim Results) and are therefore included in the following Section A.4, while the method used to implement assumption 2.2.8 on Section 2 of Volume I has been considered related to the methodology development and therefore included in this Section.

Appendix A.3-1 : Maximum-Likelihood method for Normal Parameters evaluation

Appendix A.3-2 : Model for the synthesis of daily distance distributions

Appendix A.3-3 : Projection of car ownership distributions

APPENDIX A.3-1

METHOD AND COMPUTER PROGRAM FOR MAXIMUM-LIKELIHOOD EVALUATION OF NORMAL PARAMETERS FROM INTERVAL DATA

The objective is to compute the maximum-likelihood (ML) values of the mean μ and standard deviation σ of a normal distribution from interval data, i.e. data in which values of the variate Y are given in the form of intervals on the Y axis of varying width and weights W are associated with the intervals.

Consider a data set consisting of interval observations indexed by $i = 1, \ldots, n$. Each observation i will have numbers

Y_{1i} Lower bound of the interval on the Y axis, or $-\infty$

Y_{2i} Upper bound of the interval on the Y axis, or $+\infty$

W_i Weight associated with the interval

For computational convenience, standardized variate values (lower-case symbol) are defined in one-to-one correspondence with the original variate values. The generic definition is

$$y = (Y - \mu)/\sigma \qquad \text{(A.3-1)}$$

with specific correspondences $y_{1i} = (Y_{1i} - \mu)/\sigma$, etc.

Weight W_i might be, for example, the percentage of individuals in a random sample from a specified population that have measured values Y of some quantitative property lying in the interval from Y_{1i} to Y_{2i} (equivalently, values of y lying in the interval from y_{1i} to y_{2i}).

Depending on the nature of the lower and upper bounds, there are three types of observations; these are illustrated by the three standardized normal density curves of Fig. A.3-1. The top curve represents an upper-bound observation; the interval on the y axis has a definite upper bound but no definite lower bound.

The middle curve represents a lower-bound observation; the interval has a definite lower bound but no definite upper bound. The bottom curve represents a range observation; the interval has both a definite lower bound and a definite upper bound.

The ML values of μ and σ are computed from the data by a Newton-Raphson iterative method [(1)]. The quantity that is actually maximized by the numerical procedure is the support, S, which is the logarithm of the likelihood, L:

$$S = \text{Ln}\ (L) = \sum_i S_i \qquad \text{(A.3-2)}$$

For each observation i the contribution S_i to the support S and also the contributions to the first and second partial derivatives of S with respect to the parameters μ and σ are required.

The algebraic expressions for all these contributions are given in Table A.3-1 (the subscript i is omitted to shorten the expressions).

Definitions of the algebraic symbols used in both Table A.3-1 and Fig. A.3-1 are, per interval observation:

- y_1 Lower bound of the interval on the y axis
- y_2 Upper bound of the interval on the y axis
- z_1 Ordinate of the normal density function at y_1
- z_2 Ordinate of the normal density function at y_2
- p_1 Integral of the normal density function from $-\infty$ to y_1

(1) See REF. [3] VOLUME I - SECTION 1, 1.3.2 Mission Analysis.

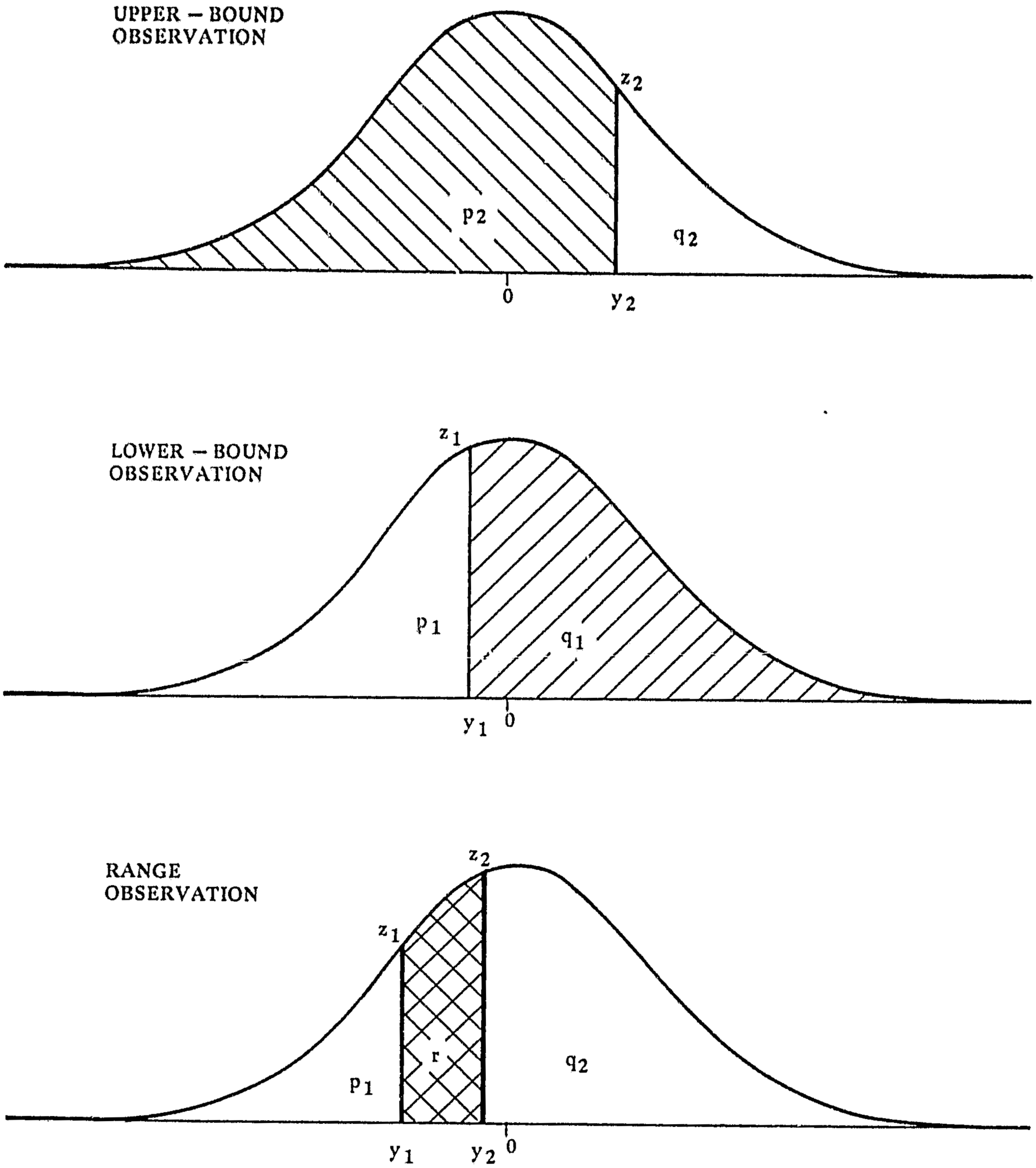


FIGURE A.3 – 1
THREE TYPES OF OBSERVATIONS ON A STANDARDIZED
NORMALLY DISTRIBUTED VARIABLE , Y.

TABLE A. 3 – 1

CONTRIBUTIONS PER INTERVAL OBSERVATION TO THE NATURAL LOGARITHM OF THE LIKELIHOOD (= SUPPORT, S) AND TO ITS FIRST AND SECOND PARTIAL DERIVATIVES WITH RESPECT TO THE MEAN μ AND STANDARD DEVIATION σ OF A NORMAL DISTRIBUTION

QUANTITY	ALGEBRAIC FORMULA FOR WEIGHTED CONTRIBUTION PER INTERVAL OBSERVATION
S	$W \left[\mathrm{Ln}(r) \right]$
$\partial S / \partial \mu$	$\left[\frac{z_1 - z_2}{\sigma r} \right]$
$\partial S / \partial \sigma$	$W \left[\frac{z_1 y_1 - z_2 y_2}{\sigma r} \right]$
$\partial^2 S / \partial \mu^2$	$W \left[\frac{r(z_1 y_1 - z_2 y_2) - (z_1 - z_2)^2}{\sigma^2 r^2} \right]$
$\partial^2 S / \partial \sigma^2$	$W \left[\frac{r(z_1 y_1 (y_1^2 - 2) - z_2 y_2 (y_2^2 - 2)) - (z_1 y_1 - z_2 y_2)^2}{\sigma^2 r^2} \right]$
$\partial^2 S / \partial \mu \, \partial \sigma$	$W \left[\frac{r(z_1 (y_1^2 - 1) - z_2 (y_2^2 - 1)) - (z_1 - z_2)(z_1 y_1 - z_2 y_2)}{\sigma^2 r^2} \right]$

p_2	Integral of the normal density function from $-\infty$ to y_2
q_1	$1 - p_1$
q_1	$1 - p_2$
r	$p_2 - p_1$
w	Weight of the observation

The symbols p_1, p_2, q_1, q_2, and r denote probabilities.

A range observation has positive values of z_1, z_2, p_1, and q_2, and $r = p_2 - p_1$

In an upper-bound observation y_1 is treated as if at $-\infty$; hence $z_1 = p_1 = 0$ and $r = p_2$.

In a lower-bound observation y_2 is treated as if at $+\infty$; hence $z_2 = q_2 = 0$ and $r = q_1$.

The algorithm for computing the ML values of the normal parameters μ and σ from a set of interval observations on a variate Y consists of the following principal steps, executed in the indicated sequence.

Step 1. Specify the value of the stopping criterion, $\varepsilon > 0$. Zero the iteration counter, k. Make initial rough estimates μ_0 and σ_0 of the values of μ and σ. Take step 2.

Step 2. Using current values μ_k and σ_k compute the standardized values y_{i1} and y_{i2} from the given values Y_{i1} and Y_{i2} for each observation $i = 1, \ldots, n$ (Eq. A.3-1). Then compute and sum the weighted contributions per observation to the support S and to its first and second partial derivatives with respect to μ and σ (Table A.3-1). Solve the resulting Newton-Raphson equations for adjustments $\Delta\mu$ and $\Delta\sigma$ (1). Take step 3.

(1) See cited REF. [3].

Step 3. Increment k by 1. Then set $\mu_k = \mu_{k-1} + \Delta\mu$ and $\sigma_k = \sigma_{k-1} + \Delta\sigma$. If ratios $\Delta\mu/\mu_k$ and $\Delta\sigma/\sigma_k$ are both less than ε, stop; μ_k and σ_k are the required ML values of μ and σ. Otherwise, take step 2.

Computer program HYBRID-1 implements the algorithm in the FORTRAN language. It was applied to derive ML values of the normal parameters μ and σ from highly aggregated NPTS data, the variates being Ln (trip length), Ln (annual vehicle distance), and Square-root (number of vehicle occupants per trip). In all three instances the weights were reported percentage occurrences in the NPTS sample suryey, associated with a few broad class intervals.

The HYBRID - 1 Flow Diagram is shown in Fig. A.3-2, which the following Block List applies to:

1. READ INTERVAL DATA
   $Y_1(i)$, $Y_2(i)$, $W(i)$ $i = 1, N$
   READ INITIAL PARAMETER VALUES $\mu(0)$, $\sigma(0)$
   READ STOPPING CRITERION, ε

2. $K = 0$

3. $y_1(i) = (Y_1(i) - \mu(K))/\sigma(K)$
   $y_2(i) = (Y_2(i) - \mu(K))/\sigma(K)$
   $i = 1$ THROUGH N

4. COMPUTE $\delta\mu$ AND $\delta\sigma$ BY NEWTON-RAPHSON PROCEDURE

5. $K = K+1$

6. $\mu(K) = \mu(K-1) + \delta\mu$
   $\sigma(K) = \sigma(K-1) + \delta\sigma$

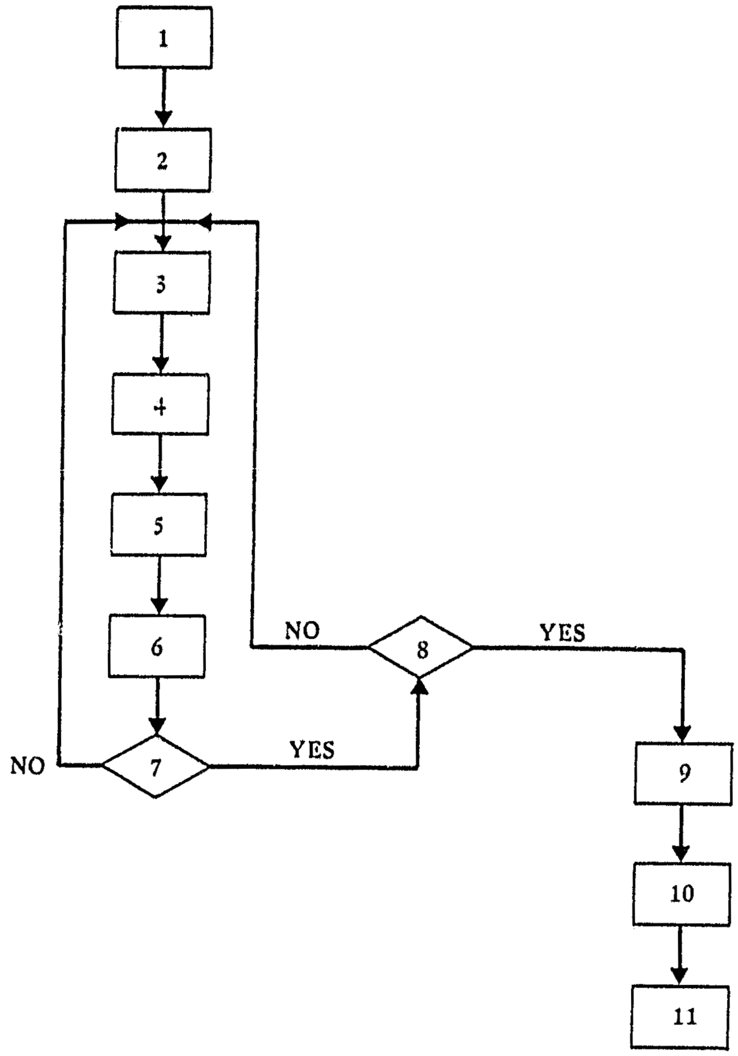
7. $\delta\mu/\mu(K)$.LT.ε

8. $\mu = \mu(K)$, $\sigma = \sigma(K)$

10. WRITE μ, σ

11. STOP

FIGURE A. 3 – 2
FLOW CHART OF PROGRAM
HYBRID – 1



APPENDIX A.3-2

SYNTHESIS OF VEHICLE-DAILY-DISTANCE DISTRIBUTIONS

The assumptions underlying the algorithm used to synthesize distributions of daily vehicle distance for the various passenger-car missions are stated in Section 2.4.5.1.

The inputs to the algorithm for each mission are the maximum likelihood values of the parameters of two normal distributions:

μ_1 Mean of variable Y_1 = Ln (Annual vehicle distance, miles)

σ_1 Standard deviation of Y_1

μ_2 Mean of variable Y_2 = Ln (trip length, miles)

σ_2 Standard deviation of Y_2

The principal steps of the algorithm, in sequential order, are as follows.

Step 1. Generate a sequence of 31 equal intervals on the Y_2 axis covering the range from μ_2-$3\sigma_2$ to $\mu_2 + 3\sigma_2$. Extend the sequence to a total of 81 intervals, indexed by $i = 1, \ldots, 81$.

Compute the probability density $P_2(i)$ associated with each interval. Compute the sequence of distances in miles, $D_2(i)$, $i = 1, \ldots, 82$, corresponding to the successive end points of the intervals on the Y_2 axis.

Step 2. Generate a sequence N(j) of number of trips per day ranging from 0 to 35 and indexed by j = 1,...,36.

Step 3. Construct matrix M having 81 rows and 36 columns, the entry in cell (i,j) being the probability P(i,j) of N(j) trips having total distance in the interval from D_2 (i) to D_2(i+1). The entries in column 1 are 0. The entries in column 2 are the probabilities P_2(i) computed in step 1. The entries in column j, j = 3,...,36, are computed by multiplying each entry P(i,j-1), i = 1,...,81 in column j-1 by the vector of probabilities P(i,2) in column 2 and in each instance adding the product probability to the entry in column j of M for which the sum of distances is in the correct interval.

Step 4. Generate a sequence of 31 equal intervals on the Y_1 axis covering the range from $\mu_1 - 3\sigma_1$ to $\mu_1 + 3\sigma_1$ and indexed by k = 1,31. Compute the probability density $P_1(k)$ associated with each interval. Compute the sequence of distances in miles, $D_1(k)$, k = 1,...,31, corresponding to the successive midpoints of the intervals on the Y_1 axis.

Step 5. Compute the mean trip length

$$m_2 = \exp\ (\mu_2 + \sigma_2^2)$$

Step 6. For each value of k in turn compute the mean number of trips per day,

$$\lambda\ D_1\ (k)/365m_2,$$

then use λ as the parameter of a Poisson distribution to derive the probability P(m) of n trips per day,

$n = 0,1,\ldots,31$. For each value of n, multiply the entries $M(i,n+1)$, $i = 1, 81$, in column n+1 of matrix M by P(n) and in each instance add the product probability to the entry in cell i of the daily distance probability vector, V. Computer program HYBRID-2, written in the FORTRAN language, implements the algorithm. It was applied to synthesize the distributions of daily vehicle distance for missions M_1 through M_4 reported in Section 3.

The HYBRID - 2 Flow Diagram is shown in Fig. A.3-3 which the following Block List applies to:

1. READ PARAMETER VALUES μ_1, σ_1, μ_2, σ_2

2. GENERATE TRIP-LENGTH DISTRIBUTION
   B_2 (i), i = 1 TO 82
   P_2 (i), i = 1 TO 81
   μ_2 (i), i = 1 TO 81

3. COMPUTE PROBABILITIES PM(i,j),
   i = 1 TO 81, j = 1 TO 36, of DAILY DISTANCES
   IN THE INTERVAL $B_2(i)$ TO $B_2(i+1)$
   GIVEN THERE ARE N = j - 1 TRIPS

4. GENERATE ANNUAL-DISTANCE DISTRIBUTION
   $P_1(k)$, k = 1 TO 31
   $\mu_1(k)$, k = 1 TO 31

5. COMPUTE MEAN TRIP LENGTH, m_2

6. ZERO THE DAILY-DISTANCE PROBABILITY, PD

7. k = 1

8. $L = V_1(k)/(365 + m_2)$

9. ; = z

10. N = j-1, $P_3(j)$ = NATURAL e TO THE EXPONENT (-λ) TIMES λ TO THE EXPONENT (N) DIVIDED BY (N) FACTORIAL

11. i = 1

12. PD(i) = PD(i) + PM (i,j) P_3 (j) P_1 (k)

13. i = i+1

14. i. EQ.81

15. j = j+1

16. j. EQ.36

17. k = k+1

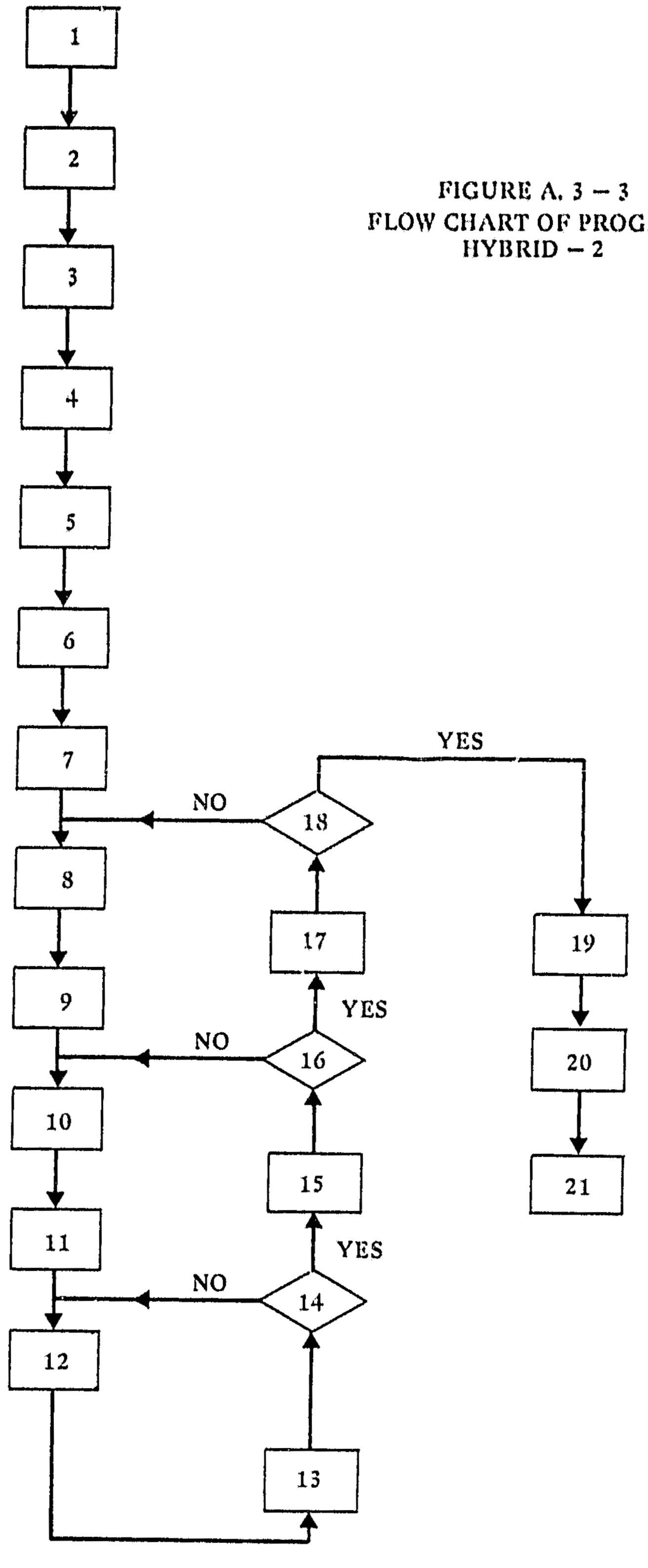
18. k. EQ . 31

19. NORMALIZE PD ARRAY, COMPUTE MEAN DISTANCE

20. WRITE RESULTS

21. STOP

FIGURE A. 3 – 3
FLOW CHART OF PROGRAM
HYBRID – 2



APPENDIX A.3-3

PROJECTION OF CAR OWNERSHIP DISTRIBUTIONS

The car ownership distribution for 1969 households is provided by the NTPS Report No. 11 and shows the following figures:

a) Average number of cars/household $= \frac{73.2 \times 10^6}{65.5 \times 10^6} = 1.17$

b) Households with

0	1	2	3 or more	cars/household
20.6	48.4	26.4	4.6	% of all households.

Assuming that the increase in the number of households in the U.S. from 1969 through 1985 corresponds to the projected population increase, the projected number of households in 1985 shall be 71.5 millions.

The resulting average number of cars/household projected to 1985 shall be

$$\frac{113.2 \times 10^6}{71.5 \times 10^6} = 1.58$$

If a curve is fitted to the data given above at b) in such a way that, according to assumption 2.28 of Volume I - Subsection 2.2, the intersections made with the curve itself by the

$$x = i \qquad (i = 0,1,2,3.....)$$

axis transleted as shown by a given amount Δ satisfy to the following conditions:

$$\sum^{1\to} y\,(i + \Delta) = 100$$

$$\sum_{i}^{i\to} i \cdot y(i + \Delta) = 1,17 + \Delta$$

$$(i = 0,1,2,3...)$$

being Δ the difference between the projected value of the number of car per household and the curve reference value of 1.17 related to 1969, the curve shown in Fig. A.3-4 is obtained.

Being for 1985 Δ = 0,41, the following car ownership distribution is obtained:

Households with:

0	1	2	3 or more	cars/households
12.6	32.6	41.3	13.4	% of all households

The values so obtained have been used to perform the Trip Purpose/Mission Combination described in Subsection 3.2.1.5 of Volume I.

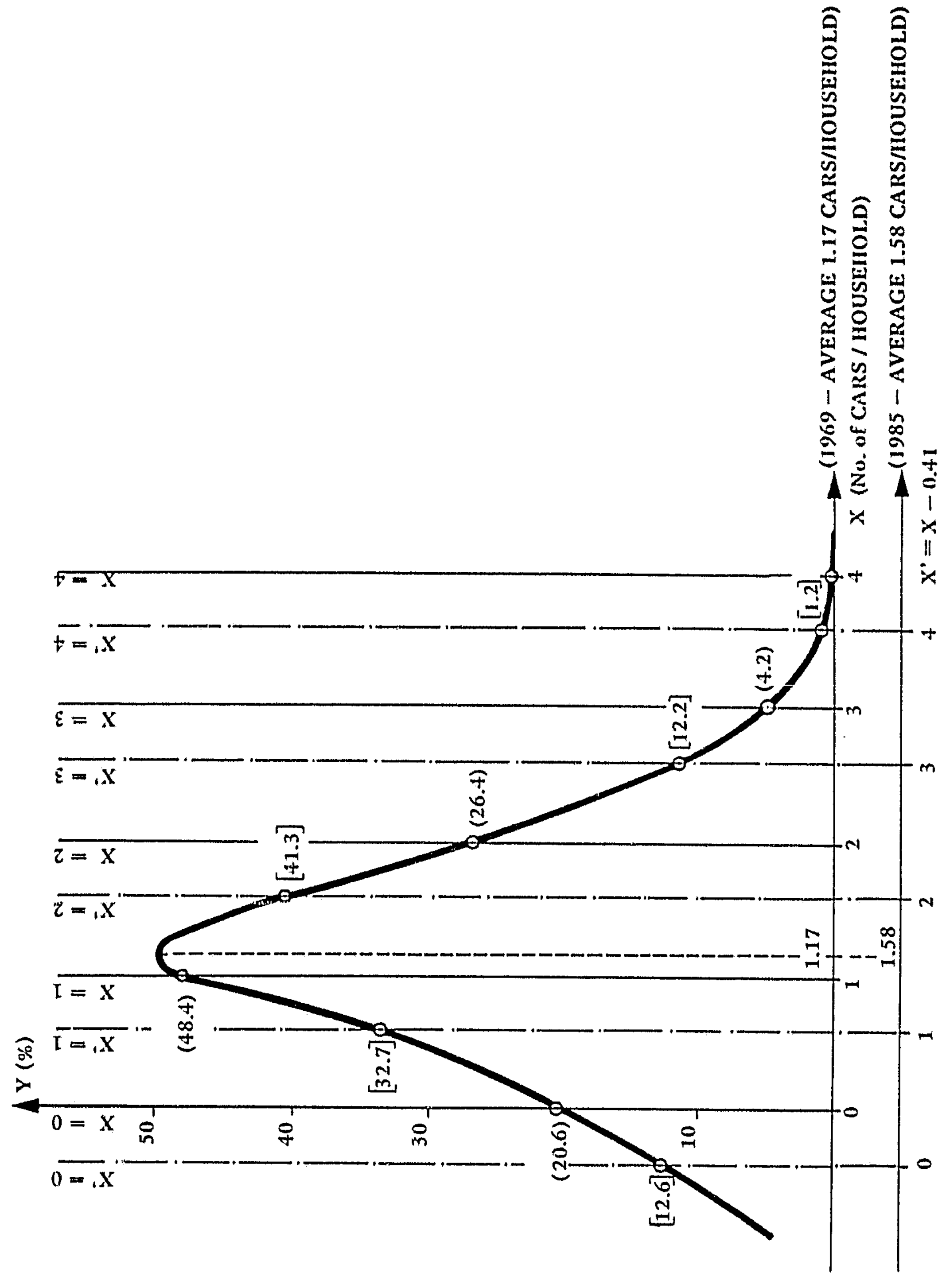


FIGURE A. 3 – 4
CAR OWNERSHIP DISTRIBUTION CURVE

S E C T I O N   A.4

APPENDICES RELATED TO SECTION 4 INTERIM RESULTS

APPENDIX A.4-1

SYNTHESIS OF TENTATIVE MISSION QUANTIFICATION RESULTS

As a preliminary stage of mission quantification the various travel parameters were tentatively defined for the various missions by aggregating the travel parameters (trip length, occupancy etc) provided by the NTPS for the various trip purposes using the % of trips on a given purpose for the average household (all missions) as a weight.

Annual distances per mission were defined as aggregation of the average annual distances given by the NTPS for the various purposes and adjusted to match the 1985 vehicle Miles Traveled (VMT) value provided by JPL using the fleet mix attributed to the various missions.

Underlying the natural concept of vehicle usage specialization according to mission requirements, smaller vehicles were attributed to less demanding missions and larger vehicles to more demanding missions.

The corresponding Mission Quantification results are shown in Tables A.4-1.1 and A.4-1.2

A review of these results has pointed out that, to obtain results consistent with the original NPTS data and therefore match the "all missions" trip purpose distribution thereby provided, the weights had to be adjusted in accordance to an assumed distribution of each trip purpose among the various missions.

The fleet mix for the various missions also had to be defined according to criteria other than the vehicle class by size distribution which, being an independent variable, could not assure the required matching with the % of traveled miles for the various trip purposes provided by the NPTS data.

TABLE A. 4 – 1.1
TENTATIVE MISSION QUANTIFICATION RESULTS

MISSION	DESCRIPTION	VEHICLE CLASS	% FLEET	ANNUAL DISTANCE MILES		DAILY DISTANCE MILES	
				MEAN	95 %	MEAN	95 %
M1	INTRAURBAN / LOCAL	K1	10.2	4,100	10,900	11.2	51
M2	URBAN/SUBURBAN COMMUTING	K2,K3,K4	67.3	11,330	30,300	31.0	109
M3	GENERAL PURPOSE	K5	22.0	16,910	45,200	43.5	149
M4	TAXI / POLICE	K6	0.4	20,000	53,400	54.5	129

TABLE A. 4 – 1.2
TENTATIVE MISSION QUANTIFICATION RESULTS

MISSION	DESCRIPTION	DAILY TRIPS	TRIP LENGTH MILES		CAR OCCUPANCY	
		MEAN	MEAN	95 %	MEAN	95 %
M1	INTRAURBAN / LOCAL	2.7	5.4	17.5	2.1	4.2
M2	URBAN/SUBURBAN COMMUTING	4.3	7.7	24.7	1.8	3.8
M3	GENERAL PURPOSE	5.2	8.9	30.6	1.9	4.0
M4	TAXI / POLICE	8.6	5.4	17.5	2.1	4.2

APPENDIX A.4-2

SYNTHESIS OF INTERMEDIATE MISSION QUANTIFICATION RESULTS

The quantitative assumptions about Trip Purpose Distributions among the various missions are shown on Table A.4-2.1.

While 100% of Social and Recreational Trips (P_4) have been attributed to Mission M_3, the Earning a Living Trips (P_1) have been split between Mission M_2 (as primary purpose) and Mission M_3 (as secondary purpose) on a 60/40 % (minimum specialization) to 80/20 % (maximum specialization) basis.

Family Business (P_2) and Social, Civil & Religious (P_3) Trips have been similarly split among Mission M_1 (as primary purpose) and Mission M_2, M_3 (as secondary purpose) on a 50/30/20 % (minimum specialization) to 70/20/10 % (maximum specialization) basis.

Other and Unknown Trips have been split among the three missions using an opposite distribution with respect to the previous ones, on the assumption that the higher the specialization level the higher should be the percentage of "other" (i.e. unspecialized) trips made on a General Purpose Mission.

The calculated trip parameters for the high and low boundaries of the Trip Purpose distribution Range are shown on Tables A.4-2.2 and A.4-2.3.

The methodology used to calculate all the parameters shown on Table A.4-2.2 follows the one described on Volume I, Section 3.

The Annual Distances shown on Table A.4-2.2 were however calculated differently with respect to the values corresponding to the Final Mission Quantification, lacking acceptable criteria to assign the number of cars used by the households contributing to a given mission.

TABLE A. 4 – 2.1

CORRESPONDENCE BETWEEN PASSENGER–CAR MISSION AND TRIP PURPOSES

PASSENGER– CAR MISSION	GENERIC TRIP PURPOSE				
	EARNING A LIVING P1	FAMILY BUSINESS P2	EDUCATIONAL CIVIC, AND RELIGIOUS P3	SOCIAL AND RECREATIONAL P4	OTHER AND UNKNOWN P5
M_1 INTRAURBAN/LOCAL	—	50 – 70 %	50 – 70 %	—	20 – 10 %
M_2 URBAN/SUBURBAN COMMUTING	60 – 80 %	30 – 20 %	30 – 20 %	—	30 – 20 %
M_3 GENERAL PURPOSE	40 – 20 %	20 – 10 %	20 – 10 %	100 %	50 – 70 %
M_4 TAXI / POLICE	√	√	√	—	—

TABLE A. 4 – 2.2
INTERMEDIATE MISSION QUANTIFICATION RESULTS

MISSION	DESCRIPTION	VEHICLE CLASS	% FLEET	ANNUAL DISTANCE MILES		DAILY DISTANCE MILES		BOUNDARY LEVEL (1)
				MEAN	95 %	MEAN	95 %	
M1	INTRAURBAN / LOCAL	APPROPRIATE MIX OF ALL CLASSES (2)	20.3	7,120	(2)	19.5	(2)	LOW
			28.1	7,090	(2)	19.4	(2)	HIGH
M2	URBAN/SUBURBAN COMMUTING	APPROPRIATE MIX OF ALL CLASSES (2)	34.4	11,200	(2)	30.7	(2)	LOW
			37.1	12,030	(2)	32.9	(2)	HIGH
M3	GENERAL PURPOSE	APPROPRIATE MIX OF ALL CLASSES (2)	44.9	14,180	(2)	38.8	(2)	LOW
			34.4	15,500	(2)	42.5	(2)	HIGH
M4	TAXI / POLICE	K6	0.4	20,000	53,400	46.3	129	—

(1) REFERS TO THE LOW / HIGH LEVEL OF SPECIALIZATION IDENTIFIED BY THE TRIP PURPOSE / MISSION DISTRIBUTION RANGES SHOWN ON TABLE A. 4 – 2.1

(2) UNDEFINED BECAUSE THE INTERMEDIATE MISSION QUANTIFICATION WAS NOT COMPLETED

TABLE A. 4 – 2.3
INTERMEDIATE MISSION QUANTIFICATION RESULTS

MISSION	DESCRIPTION	DAILY TRIPS	TRIP LENGTH MILES		CAR OCCUPANCY		BOUNDARY LEVEL (1)
		MEAN	MEAN	95 %	MEAN	95 %	
M1	INTRAURBAN / LOCAL	3.6	5.43	(2)	2.1	(2)	LOW
		3.6	5.41	(2)	2.1	(2)	HIGH
M2	URBAN/SUBURBAN COMMUTING	3.6	8.49	(2)	1.6	(2)	LOW
		3.6	9.15	(2)	1.5	(2)	HIGH
M3	GENERAL PURPOSE	3.6	10.8	(2)	2.1	(2)	LOW
		3.6	11.5	(2)	2.2	(2)	HIGH
M4	TAXI / POLICE	6.4	7.2	22.3	2.1	4.2	––

(1) REFERS TO THE LOW / HIGH LEVEL OF SPECIALIZATION IDENTIFIED BY THE TRIP PURPOSE / MISSION DISTRIBUTION RANGES SHOWN ON TABLE A. 4 – 2.1

(2) UNDEFINED BECAUSE THE INTERMEDIATE MISSION QUANTIFICATION WAS NOT COMPLETED

Upon calculating the Annual Miles Traveled per Household and Mission as average Annual Trips per Household on a given Mission times the average Trip Length per Mission, it was assumed that, on the average, vehicles would perform the same number of trips in the various missions, that is, if a vehicle is used on a specialized mission, its number of specialized trip for the mission's trip purpose should exceed the average number of trips made for the same trip purposes by the average household. With such an assumption the percent of vehicles on a given mission (as shown on the table) would correspond to the corresponding percent of trips if the number of vehicle trips per average household performing each mission is kept constant and identical to the number of vehicle trips per average household. While attributing all trips in one mission only to the vehicles of a group of households segregated from the households "performing" the other missions represents indeed a distorsion of the reality, as more than one mission will often be performed by the members of a single household, this "unnaturale" forcement of reality does not alter the validity of the abtained results as long as the constant numbers of trips/vehicle assumption is accepted.

The Daily Distances shown for the various missions on the last column of Table A.4-2.3 were, on the other hand, calculated according to the same methodology already used for the Tentative and Final Mission Quantification as described in Subsection 3.2.1.4 of Volume I.

APPENDIX A.4-3

SYNTHESIS OF MISSION QUANTIFICATION PARAMETERS

The specific numerical values, calculated for the various trip parameters and for the various missions according to the methodology described in Volume I, Section 3 of this Report, are collected and presented in this appendix to serve as a reference in evaluating the Summary of Mission Quantification Data (Volume I, Table 3.2-10, page 3-49) and the M_3, K_5 Mission Specifications (Volume I, Table 5-1, page 5-11).

The maximum likelihood parameter values are shown on Table A.4-3.1 for the distributions of the varous trip parameters according to the NPTS data referred to 1969 averages for all 1969 households.

The mean one-way trip lengths calculated for the 1985 M_1, M_2, M_3 missions and referred to all households with cars, are shown on Table A.4-3.2 together with the corresponding values of μ.

Mission M_4 trip length has been assumed to be the same as of Mission M_2.

The mean number of car occupants calculated for the 1985 M_1, M_2, M_3 missions and referred to all households with cars are shown on Table A.4-3.3 together with the corresponding values of μ.

Mission M_4 mean car occupancy has been assumed coincident with that of mission M_1, because most of the taxi travel is performed with at least one passenger in addition to the driver; the same would apply to police patrol cars.

The percentiles of the distribution of car occupants are shown, for the same missions, on Table A.4-3.4.

TABLE A. 4 – 3.1

MAXIMUM–LIKELIHOOD PARAMETER VALUES FOR DISTRIBUTIONS OF ANNUAL DISTANCE, TRIP LENGTH, AND NUMBER OF OCCUPANTS OF PASSENGER CARS *

DISTRIBUTION	DATA SOURCE	MODEL	TRANSFORMED VARIATE	PARAMETER VALUES	
				MEAN μ	ST.DEV. σ
ANNUAL DISTANCE, ALL PASSENGER CAR	NPTS (1970)	LOG–NORMAL	LN (ANNUAL DISTANCE, MILES)	9.0508	0.7838
TRIP LENGTH, ALL PASSENGER–CAR TRIPS	NPTS (1970)	LOG–NORMAL	LN (TRIP LENGTH, MILES)	1.3150	1.2438
OCCUPANCY, ALL PASSENGER–CAR TRIPS	NPTS (1970)	SQUARE–ROOT NORMAL	SQUARE ROOT (No. OF OCCUPANTS)	0.9837	0.6188

* AVERAGES FOR ALL 1969 HOUSEHOLDS

TABLE A. 4 – 3.2
MEAN 1 – WAY TRIP LENGTH BY MISSION
AND CORRESPONDING VALUES OF THE PARAMETER μ

1985 MISSION	MEAN TRIP LENGTH, MILES (*)	μ
M_1 INTRAURBAN / LOCAL	5.70	0.9702
M_2 URBAN/SUBURBAN COMMUTING	9.74	1.5045
M_3 GENERAL PURPOSE	11.00	1.624
M_4 TAXI / POLICE	9.74	0.9702

(*) ALL HOUSEHOLDS WITH CARS

TABLE A. 4 – 3.3
MEAN NUMBER OF CAR OCCUPANTS BY MISSION
AND CORRESPONDING VALUES OF THE PARAMETER ν

1985 MISSION	MEAN No. OF OCCUPANTS PER TRIP	ν
M_1 INTRAURBAN / LOCAL	2.1	1.0512
M_2 URBAN / SUBURBAN COMMUTING	1.6	0.8793
M_3 GENERAL PURPOSE	2.0	1.0231
M_4 TAXI / POLICE	2.1	1.0512

TABLE A. 4 – 3.4
PERCENTILES OF THE DISTRIBUTION OF NUMBER OF OCCUPANTS
PER PASSENGER CAR PER TRIP, BY TYPE OF MISSION

1985 MISSIONS	CUMULATIVE PERCENT OF TRIPS			
	80	90	95	99
M_1 INTRAURBAN / LOCAL	2.4	3.4	4.3	6.2
M_2 URBAN / SUBURBAN COMMUTING	2.1	3.0	3.6	5.4
M_3 GENERAL PURPOSE	2.3	3.2	4.0	6.0
M_4 TAXI / POLICE	2.4	3.4	3.6	5.2

The values shown in parenthesis for the 90th 95th ad 99th percentiles of mission M_4 indicates the assumption that a lower occupancy should occur at higher percentages to compensate the higher occupancy at low percentages.

The mean annual distance traveled by passenger cars calculated for the 1985 M_1, M_3 and M_3 missions and referred to all households with cars are shown on Table A.4-3.5. These values correspond to the mean annual distance per passenger car for the same missions shown on Table A.4-3.6 multiplied by 1.78 (average number of cars per household with car, projected to 1985).

In addition to the corresponding values for the Taxi-Police M_4 mission and the "combined" mission (i.e. for all missions) the values of the percent of vehicle fleet/mission and the μ parameter related to the annual vehicle distance are also shown on the same Table.

Finally the percentiles of the synthesized distribution of passenger car daily distances calculated for the 1985 missions M_1, M_2 and M_3 for 1985 missions and referred to all households with cars, are shown on Table A.4-3.7 together with the corresponding values for mission M_4. It is worth noticing that, while Mission M_4 has higher daily traveled distances than any other mission at lower percentiles, at the highest percentiles the daily traveled distance is closer to the mission M_2 values and lower than mission's M_3.

TABLE A. 4 – 3.5
MEAN ANNUAL PASSENGER – CAR DISTANCE
PER HOUSEHOLD BY MISSION (*)

1985 MISSION	MEAN ANNUAL VEHICLE MILES PER HOUSEHOLD
M_1 INTRAURBAN / LOCAL	13,780
M_2 URBAN/SUBURBAN COMMUTING	20,010
M_3 GENERAL PURPOSE	23,650

(*) ALL HOUSEHOLDS WITH CARS

TABLE A 4 – 3.6
MEAN ANNUAL DISTANCE PER PASSENGER CAR BY TYPE OF MISSION
ESTIMATED AS OF 1985, AND CORRESPONDING VALUES
OF THE PARAMETER

1985 MISSION	PERCENT OF VEHICLES	MEAN ANNUAL DISTANCE, MILES	μ
M_1 INTRAURBAN/LOCAL	14.6	7,180	8.5677
M_2 URBAN/SUBURBAN COMMUTING	29.3	11,170	9.0140
M_3 GENERAL PURPOSE	55.7	13,300	9.1886
M_4 TAXI / POLICE	0.4	20,000	9.5963
COMBINED	100	11,850	

TABLE A. 4 – 3.7

PERCENTILES OF THE SYNTHESIZED DISTRIBUTIONS OF DAILY PASSENGER–CAR DISTANCES BY TYPE OF MISSION, 1985

1985 MISSIONS	DISTANCE UNITS	CUMULATIVE PERCENT OF DAYS				
		50	80	90	95	99
M_1 INTRAURBAN / LOCAL	MILES	11	33.5	52	76	141
M_2 URBAN / SUBURBAN COMMUTING	MILES	17	52	84	122	179
M_3 GENERAL PURPOSE	MILES	20	62	100	142	218
M_4 POLICE / TAXI	MILES	34.8	75.3	103	129	181

APPENDIX A.4-4

1985 IN-PLACE FLEET FUEL ECONOMY DATA

The fuel economy data upon which the fleet analysis was based is presented in this appendix. The data are presented in the form of six tables; one for each vehicle size class, except that two tables have been prepared for large-size vehicles, K_5 and K_6, as representative of privately owned and Taxi-police cars respectively.

EPA fuel economy data were available for the years of 1975 through and including 1979. This information established one "anchor point" in the analysis. A second anchor point was established by the fuel economy data, for the in-place fleet, by JPL.

Finally, the SAE fuel economy was based upon ratios obtained from data available at CRF.

The fuel economy for the years not covered by EPA data were estimated by appropriate extrapolations. The composite fuel economies were calculated by uniformly incrementing the base line figures for each vehicle size class so as to match the miles per gallon (mpg) change in the total fleet.

TABLE A. 4 – 4.1
MINICOMPACT VEHICLE FLEET FUEL ECONOMY MATRIX

MODEL YEAR	FUEL ECONOMY, mpg				1985 IN-PLACE FLEET		
	EPA VALUES			S A E	NUMBER OF CARS		% OF TOTAL FLEET FUEL CONSUMPTION
	COMBINED	CITY	HIGHWAY		THOUSANDS	% OF FLEET	
≤ 69	22.4	19.2	28.0	16.6	186	0.16	0.04
70	22.4	19.2	28.0	16.6	76	0.07	0.02
71	22.0	18.9	27.5	16.3	94	0.08	0.03
72	22.0	18.6	28.5	16.0	107	0.09	0.03
73	21.5	18.3	27.3	15.7	177	0.16	0.06
74	20.7	17.3	27.4	14.9	415	0.37	0.09
75	21.9	19.1	26.8	16.4	486	0.43	0.12
76	25.6	22.4	31.1	19.3	548	0.48	0.13
77	27.4	23.7	33.8	20.4	622	0.55	0.15
78	28.0	24.3	34.4	20.9	800	0.71	0.20
79	28.9	25.1	35.5	21.6	980	0.87	0.24
80	29.7	25.8	36.5	22.2	1051	0.93	0.26
81	31.5	27.3	38.7	23.5	1127	1.00	0.28
82	33.2	28.8	40.8	24.8	1208	1.07	0.30
83	35.0	30.4	43.0	26.1	1289	1.14	0.32
84	35.8	31.1	44.0	26.7	1384	1.22	0.37
85	36.7	31.8	45.1	27.3	1033	0.91	0.31
	HARMONIC MEAN				TOTALS		
	30.0	26.0	37.0	22.4	11583	10.24	2.95

TABLE A.4 – 4.2
SUBCOMPACT VEHICLE FLEET FUEL ECONOMY MATRIX

MODEL YEAR	FUEL ECONOMY, mpg				1985 IN–PLACE FLEET		
	EPA VALUES				NUMBER OF CARS		% OF TOTAL FLEET FUEL CONSUMPTION
	COMBINED	CITY	HIGHWAY	S A E	THOUSANDS	% OF FLEET	
≤ 69	20.0	17.2	25.0	13.6	576	0.51	0.25
70	20.0	17.2	25.0	13.6	235	0.21	0.12
71	19.6	16.9	24.5	13.4	292	0.26	0.15
72	19.6	16.5	25.4	13.0	326	0.29	0.18
73	19.1	16.3	24.2	12.9	547	0.48	0.33
74	18.3	15.3	24.2	12.1	993	0.88	0.54
75	19.5	17.0	23.8	13.4	1219	1.08	0.70
76	22.4	19.6	27.2	15.5	1216	1.07	0.80
77	24.7	21.4	30.4	16.9	1281	1.13	0.91
78	25.3	22.0	31.1	17.4	1649	1.46	1.18
79	26.2	22.7	32.2	17.9	2008	1.77	1.44
80	27.0	23.4	33.2	18.5	2157	1.91	1.56
81	28.8	25.0	35.4	19.8	2312	2.04	1.64
82	30.5	26.5	37.5	20.9	2466	2.18	1.74
83	32.3	28.0	39.7	22.1	2632	2.33	1.88
84	33.1	28.7	40.7	22.7	2816	2.49	2.17
85	33.5	29.1	41.2	23.0	2102	1.86	1.85
	HARMONIC MEAN				TOTALS		
	26.8	23.2	33.1	18.3	24827	21.95	17.44

TABLE A. 4 – 4.3
COMPACT VEHICLE FLEET FUEL ECONOMY MATRIX

MODEL YEAR	FUEL ECONOMY, mpg				1985 IN–PLACE FLEET		
	EPA VALUES				NUMBER OF CARS		% OF TOTAL FLEET FUEL CONSUMPTION
	COMBINED	CITY	HIGHWAY	SAE	THOUSANDS	% OF FLEET	
≤ 69	16.5	14.2	20.6	10.3	154	0.14	0.28
70	16.6	14.2	20.7	10.3	63	0.06	0.14
71	16.2	13.9	20.2	10.1	78	0.07	0.17
72	16.2	13.7	21.0	10.0	109	0.10	0.20
73	15.7	13.4	19.9	9.8	156	0.14	0.38
74	14.9	12.4	19.7	9.1	282	0.25	0.62
75	16.1	14.0	19.7	10.2	653	0.58	0.79
76	18.0	15.7	21.8	11.5	1170	1.03	0.93
77	19.0	16.5	23.4	12.0	1192	1.05	1.40
78	19.6	17.0	24.1	12.4	1581	1.40	1.41
79	20.5	17.8	25.2	13.0	1988	1.76	170
80	21.3	18.5	26.2	13.5	2188	1.93	1.83
81	23.1	20.0	28.4	14.5	2400	2.12	1.90
82	24.8	21.5	30.5	15.7	2627	2.32	1.99
83	26.6	23.1	32.7	16.9	2858	2.52	2.11
84	27.4	23.8	33.7	17.4	3127	2.76	2.43
85	27.8	24.1	34.2	17.6	2374	2.10	2.07
	HARMONIC MEAN				TOTALS		
	22.7	19.7	27.9	14.4	23000	20.34	20.04

TABLE A. 4 – 4.4
MIDSIZE VEHICLE FLEET FUEL ECONOMY MATRIX

MODEL YEAR	FUEL ECONOMY, mpg				1985 IN–PLACE FLEET		
	EPA VALUES				NUMBER OF CARS		% OF TOTAL FLEET FUEL CONSUMPTION
	COMBINED	CITY	HIGHWAY	S A E	THOUSANDS	% OF FLEET	
≤ 69	14.0	12.1	17.5	8.1	549	0.48	0.40
70	14.1	12.1	17.6	8.1	224	0.20	0.20
71	13.7	11.8	17.1	7.9	278	0.25	0.25
72	13.7	11.6	17.7	7.8	325	0.29	0.29
73	13.2	11.3	16.7	7.6	606	0.54	0.55
74	12.4	10.3	16.4	6.9	915	0.81	0.93
75	13.6	11.8	16.6	7.9	1133	1.00	1.15
76	15.7	13.7	19.0	9.2	1527	1.35	1.32
77	17.0	14.7	21.0	9.8	1973	1.74	1.52
78	17.6	15.3	21.6	10.3	2387	2.11	1.94
79	18.5	16.1	22.7	10.8	2734	2.42	2.33
80	19.4	16.8	23.8	11.3	2757	2.44	2.49
81	21.2	18.4	26.1	12.3	2763	2.44	2.56
82	23.0	20.0	28.3	13.4	2775	2.45	2.65
83	24.8	21.5	30.5	14.4	2763	2.44	2.80
84	25.5	22.1	31.3	14.8	2779	2.45	3.23
85	25.9	22.5	31.8	15.1	1930	1.70	2.74
	HARMONIC MEAN				TOTALS		
	19.3	16.7	23.8	11.2	28418	25.11	27.35

TABLE A. 4 – 4.5
K5 VEHICLE FLEET FUEL ECONOMY MATRIX

MODEL YEAR	FUEL ECONOMY, mpg				1985 IN–PLACE FLEET		
	EPA VALUES				NUMBER OF CARS		% OF TOTAL FLEET FUEL CONSUMPTION
	COMBINED	CITY	HIGHWAY	S A E	THOUSANDS	% OF FLEET	
≤ 69	13.1	11.3	16.4	7.2	750	0.66	0.47
70	13.2	11.3	16.5	7.2	306	0.27	0.23
71	12.8	11.0	16.0	7.6	380	0.34	0.29
72	12.8	10.8	16.6	7.5	483	0.43	0.33
73	12.3	10.5	15.6	7.2	769	0.68	0.64
74	11.5	9.6	15.2	6.6	780	0.69	1.04
75	12.7	11.1	15.5	7.7	1018	0.90	1.36
76	14.0	12.2	17.0	8.4	1175	1.04	1.64
77	16.4	14.2	20.2	9.8	1688	1.49	1.72
78	17.0	14.8	20.9	10.2	2032	1.80	2.20
79	17.9	15.5	22.0	10.7	2324	2.05	2.63
80	18.7	16.2	23.0	11.2	2330	2.06	2.83
81	20.5	17.8	25.2	12.3	2331	2.06	2.91
82	22.3	19.4	27.4	13.4	2316	2.05	3.01
83	24.0	20.8	29.5	14.4	2300	2.03	3.18
84	24.8	21.5	30.5	14.8	2296	2.03	3.65
85	25.2	21.9	31.0	15.1	1589	1.40	3.10
	HARMONIC MEAN				TOTALS		
	18.2	15.7	22.5	10.8	24867	21.98	31.23

TABLE A.4 – 4.6

K6 VEHICLE FLEET FUEL ECONOMY MATRIX

MODEL YEAR	FUEL ECONOMY, mpg				1985 IN-PLACE FLEET		
	EPA VALUES				NUMBER OF CARS		% OF TOTAL FLEET FUEL CONSUMPTION
	COMBINED	CITY	HIGHWAY	SAE	THOUSANDS	% OF FLEET	
≤ 69	14.0	12.0	17.9	9.1	15	0.01	0.01
70	14.1	12.0	18.0	9.1	6	0.01	0.01
71	13.7	11.7	17.4	7.1	8	0.01	0.01
72	13.7	11.4	18.1	7.9	10	0.01	0.01
73	13.2	11.1	17.0	7.7	16	0.01	0.02
74	12.3	10.2	16.6	7.0	16	0.01	0.04
75	13.7	11.8	16.9	8.1	21	0.02	0.04
76	14.9	12.9	18.5	8.9	24	0.02	0.05
77	17.6	15.1	22.0	10.4	34	0.03	0.06
78	18.3	15.7	22.8	10.8	41	0.04	0.07
79	19.1	16.4	24.0	11.3	47	0.04	0.09
80	20.0	17.2	25.1	11.9	47	0.04	0.09
81	22.0	18.9	27.5	13.0	47	0.04	0.10
82	24.0	20.6	29.9	14.2	47	0.04	0.10
83	25.7	22.0	32.2	15.2	47	0.04	0.11
84	26.5	22.8	33.2	15.7	47	0.04	0.12
85	27.0	23.2	33.8	16.0	32	0.03	0.10
	HARMONIC MEAN				TOTALS		
	19.4	16.6	24.5	11.5	505	0.44	1.03