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PHASE I OF THE NEAR TERM HYBRID PASSENGER VEHICLE DEVELOPMENT PROGRAM

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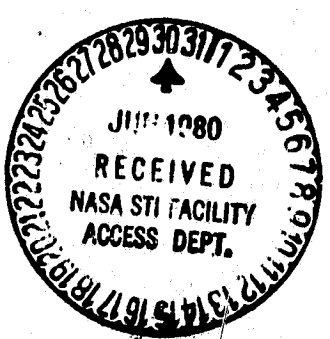
FINAL REPORT

APPENDIX D: SENSITIVITY ANALYSIS



Prepared for

JET PROPULSION LABORATORY

by

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The research described in this publication represents the fourth 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.

Turin, July 3, 1979

This Report, prepared by:

M. Traversi of CRF

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FOREWORD AND ACKNOWLEDGEMENTS

This Report on the "Sensitivity of Mission Analysis and Trade-off Studies" provides an analysis of the sensitivity of the "Mission Analysis and Performance Specification Studies" and the "Trade-off Studies" results to the possible variations of the values of some significant paramenters as projected to the year 1985 according to JPL Guidelines.

The Author wish to express his appreciation to Messrs. Frondaroli and Piccolo of CRF and their Staffs who made the essential contribution to the study development as well as to Mrs. Floreani and Mr. Vercelli and their Staff for their fine work in the conclusive typing and editing effort of the Report preparation in compliance with JPL's Data Requirement Description.

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S E C T I O N 1

BACKGROUND INFORMATION : SOURCES AND REFERENCES

1.1 Data Sources

The only data sources utilized in the Sensitivity Analysis Studies which are supplemental to those listed in Volume I of the "Mission Analysis and Performance Specification Studies" Report and in Volume I of the "Trade-off Studies" Report are, in addition to the relevant results presented in the Reports themselves, the Boundary Values provided by JPL as page 9 of Exhibit I.

S E C T I O N 2

SIGNIFICANT ASSUMPTIONS

No significant assumptions have been made and used in the Sensitivity Analysis Studies which are supplemental to those listed in the Reports mentioned above in Section 1.

S E C T I O N 3

METHODOLOGY DESCRIPTION

3.1 SENSITIVITY OF "MISSION ANALYSIS AND PERFORMANCE SPECIFICATION STUDIES" RESULTS

3.1.1 Mission Analysis

3.1.1.1 Sensitivity to the number of Passenger Cars

Variations in the number of Passenger Cars result in different car ownership distributions which, in turn, result in different distributions of the various trip parameters among the various trip purposes and therefore missions.

The Subsections:

3.2.1.1* Usage Characterization
3.2.1.2* Mission Definition by Trip Purpose Combination
3.2.1.3* Mission Quantification
3.2.1.4* Synthesis of Combination of Driving Cycles

of Volume I of the "Mission Analysis and Performance Specification Studies" Report will entirely apply to the Sensitivity Analysis without any modification, together with the corresponding Appendices included in Volume II of the same Report which all the following references to either Volume I or II made in this Subsection 3.1 are referred to[1].

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(1) The single asterisk * after a Subsection No. indicates its inclusion in the "Mission Analysis and Performance Specification Studies" Report, Volumes I and II.

The Subsection 3.2.1.5*, Trip Purpose/Mission Combination would also apply in terms of the methodology that have been used, but, as the variations in the projected number of Passenger Cars would affect the average number of car/household distributions, the sensitivity of Mission Analysis Results to such a variable started at STEP 1 of said Subsection 3.2.1.5* (page 3-47 of Volume I) with the calculation of the corresponding average number of car/household.

Based upon the same assumption used thereby, the corresponding distributions were determined for the two cases using the methodology described on Appendix A.3-3* and the following results were obtained:

	(-7%)	(+7%)
a) Average number of car per household	1.47	1.69

b) Households with

0	1	2	3 or more	Cars/household
(-7%) 15.7	35.0	38.5	11.0	% of all household
(+7%) 9.0	31.0	45.0	15.0	% of all household

Steps 2, 3 and 4 were then performed for either case as described in said page 3-47.

The adjustments on the annual vehicle miles on each mission required to match the projected low/high boundary values of the 1985 average annual vehicle miles/vehicle according to JPL guidelines (STEP 4) resulted in an increase of 14.5% (-7%) and 17.4% (+7%).

A summary of the Mission Quantification Data per Household and Vehicle have been more properly included in the following Section 4, Interim Results.

On the basis of the obtained average annual trips and trip length/mission values, the corresponding annual trips and trip lengths/mission percentile distributions were obtained according to the methodology previously described.

The daily distance distribution was accordingly calculated using the methodology described on Subsection 3.2.1.3.e)* of volume I and the corresponding driving cycles were determined using the methodology described on the following Subsection 3.2.1.4*.

The resulting data for the trip parameters related to the various mission quantifications are outlined in Section 4 Interim Results, of this report.

3.1.1.2 Sensitivity to the number of Annual Vehicle Miles

Variations in the number of Annual Vehicle Miles do not result in different car ownership distributions, since the actual adjustment to the projected 1985 figures takes place, according to the methodology thas has been developed and used, after the distribution of the trip parameters among the various missions has been completed.

The calculation of the Mission Sensitivity to the number of Annual Vehicle miles started at STEP 4 of Subsection 3.2.1.5*, Trip Purpose/Mission Combination, on the data obtained from steps 1 through 3.

The resulting annual vehicle miles/vehicle on each mission were therefore adjusted to match respectively $\mp$ 7% of the 1985 average vehicle miles/vehicle provided by the JPL Guidelines, resulting in an increase of 7.3% (-7%) and 22.9% (+7%) with respect to the values

obtained on the basis of the 1969 number of trips and trips lengths per household group.

A summary of the Mission Quantification Data per Household and Vehicle have again been more properly included in the following Section 4. Interim Results.

3.1.2 Vehicle Characteristics

The methodology described on Subsection 3.2.2*, Vehicle Characteristics, will entirely apply to the Sensitivity Analysis without any modification, together with the corresponding Appendices.

Moreover, since the variations in the assumptions relative to trevel behavior do not affect the new car fleet mix, weight and fuel economy forecasts for 1985 provided by JPL (Table C-1 of JPL Guidelines, Appendix A.1-1, page A.1-9 of the Mission Analysis Report, Volume II) and the Mission Specifications require the computation only of the estimated annual fuel consumption of mission performed entirely by reference ICE vehicles, said variations influence, in terms of Mission Specifications and Mission Related Vehicle Characteristics, the results of the Lyfe Cycle Costs computation only, performed as described on (sub-) Subsection i) of Subsection 3.2.2.3*, Candidate Reference Vehicle Characterization.

While, in fact, the Mission Analysis and Performance Specification Studies provide a detailed analysis of the in-place Fleet Characterization (fleet mix, size and fuel economy) from 1969 till 1985, said analysis was required to verify the correspondence between the figures provided by the JPL guidelines (as related to car weight Classes) and the figures we had considered the most appropriate in estabilishing the relationship between vehicle classes and missions (as related to EPA internal volume criteria).

The parameter variations to be analyzed by the Sensitivity Analysis would not therefore affect the projected 1985 in-place Fleet Mix and Fuel Economy figures, since variations in the projected Fleet size or Vehicle Miles Traveled (VMT) should not be reflected in a variation of the % of vehicle Fleet as function of Vehicle Age as shown on Table C-3 of said JPL Guidelines.

As a result none of the data provided by the Mission Analysis Report on % fleet mixes should be affected by the parameter variations now being considered, nor any of the fuel economy data thereby obtained, since these same variations should not modify the baseline forecasts (conventional ICE technology: tables C-1 and C-2 of the same JPL Guidelines) to be assumed for the selection of reference conventional ICE vehicles.

It is worth pointing out on this subject that, while the specific wording of the JPL Guidelines ("The reference conventional ICE vehicle must be representative of the vehicles expected to be used on the selected mission") could apply to a "median year model" of vehicle by mission, according to the definition used by in the NPTS Reports, this "statistical" approach to reference vehicle selection was not used in the Mission Analysis. It had not, in fact, appeared appropriate to compare the projected life cycle costs (in 1978 U.S. $) and fuel economies of 1982 conventional ICE and 1985 hybrid vehicles, nor require the maximum consumer purchase price of a 1985 Hybrid Vehicle to be competitive with the purchase price of a 1982 "reference" conventional ICE vehicle.

The effect of the parameter variations being considered on the 1985 reference conventional ICE vehicle life cycle costs is reflected, on the basis of the developed methodology, on the operating costs only and specifically on:

a) annual taxes, license, registration and insurance as a result of the variations in either the number of vehicles (2nd order effect) or the annual miles which affect the total years of vehicle life (<10).

b) fuel cost as a result of the variations in either the number of vehicles (2nd order effect) or the annual miles (which affect the amount of gallons consumed at a given purchase price) and, obviously, in the fuel purchase price.

It must be also pointed out that the fuel economy used on subsection 3.2.2.3.i)*, while defined as "on-the-road", has not been calculated according to the formula given at page 7 of the JPL Guidelines since the formula itself was assumed to apply to the EPA Composite MPG only on the basis of actual fuel consumption data.

Considering that:

1) the M_3 General Purpose Mission 'composition' in terms of standard driving cycles (4 U + 10 H, that is 0,285 U + 0,715 H) is rather different from the EPA Composite cycle (0.45 U + 0.55 H);

2) the formula penalizes more heavily the cars with higher fuel economies due to the effect of the 71% coefficient with respect to the 2.83 constant; while this could be explained for conventional cars by the fact that, being the higher the fuel economy the smaller the car size, smaller cars operation, optimized for standard cycle consumption, is more sensitive than larger cars operation to the different on-the-road actual driving conditions. This should not be true for the 1985 hybrid vehicle which, while using a small conventional engine like today's smaller cars should very little resent of actual driving conditions due to its sophisticated control logic and to the electric motor taking care of most, otherwise fuel consuming, accelerations;

it was decided to compare the convential and hybrid vehicle fuel economy's impact on the operating costs on the basis of standard cycles performance alone, lacking experimental data on actual on-the-road fuel economy of advanced hybrid vehicles.

It has furthermore been noted in calculating the life cycle cost sensitivity that attributing an interest charge equal to four times the 12% annual percentage rate (APR) applied to the purchase price should result in an unrealistic inflation of the total acquisition costs since car loans are usually paid back to the banks by means of monthly installments which would result in a reduction of the total interest charge by approximatelly 50%.

While this would significantly affect the sentivity of life cycle cost to the gasoline price variations it was decided not to alter the basic methodology used during Tasks 1 and 2.

3.2 SENSITIVITY OF"TRADE-OFF STUDIES" RESULTS

The same considerations presented on the previous subsection 3.1.2 Vehicle Characteristics apply to the "Trade-off Studies" Results.

The sensitivity of such results to the expected parameter variations is reflected on the operating costs only with the same limitations and assumptions presented on said Subsection.

The methodology described on Subsection 3.2.3.6 ** will therefore entirely apply to this subsection.

SECTION 4

INTERIM RESULTS

4.1 SENSITIVITY OF MISSION ANALYSIS RESULTS

4.1.1 Trip Purpose/Mission Combination

Summaries of Mission Quantification Data per Household as well as per Vehicle are shown on Tables 4.1.2 through 4.1-5; the corresponding data for nominal conditions (Table 3.2-10 on Subsection 3.2.1.5*) are shown for convenience on Table 4.1-1.

In terms of sensitivity to the various parameters, the annual travel variations only have on obvious proportional effect on vehicle annual miles assumed to be evenly split between the number of trips and the trip lengths; the fleet size variation on the other hand only have second order effects which may also tend to compensate each other especially for mission M_3.

Considering in fact the percentages of all trips performed in all households with car the -7% Δ(Fleet) condition results in a -6, -5 and +3,5% variation for mission M_1, M_2 and M_3 respectively with respect to the nominal condition. The corresponding +7% Δ(Fleet) condition results in a +2.8, +3.2 and -2% variation for the same missions.

For the average trip length the corresponding variations are +1, -1 and +1% (-7%) and -5, +.5 and less than .1% (+7%) for the three missions M_1, M_2 and M_3.

The variations of the percentage of all fleet cars in each mission are:

Mission M_1 - 5.6 (-7%) and + 2.8 (+7%)
Mission M_2 - 3.3 (-7%) and + 2.6 (+7%)
Mission M_3 + 3.3 (-7%) and - 2.0 (+7%)

TABLE 4.1 — 1

SUMMARY OF MISSION QUANTIFICATION DATA PER HOUSEHOLD / VEHICLE
(NOMINAL CONDITIONS)

CAR OWNERSHIP		1 CAR HOUSEHOLDS				2 CAR HOUSEHOLDS				3 OR MORE HOUSEHOLDS				ALL HOUSEH. WITH CARS				COMBINED (ALL MISSIONS)		
PARAMETER		M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS.	CAR OWN. HOUSE-HOLDS (1)	NO CAR HOUSE-HOLDS (2)	ALL HOUSE HOLDS
TRIP. PURP.	CAR/MISS DIST.	0.05	—	0.95	1.0	0.2	0.8	1.0	2.0	1.0	1.0	1.2	3.2				1.58			
	%of HOUSEHOLD	32.6 (37.3)				41.3 (47.4)				13.4 (15.3)				87.4 (100)				87.4	12.6	100
P_1	No.of TRIPS/HH	—	—	423	423	—	436	436	872	—	1049	117	1166	—	367	382	749	604	92	713
	% P1 TRIPS	—	—	100	100	—	50	50	100	—	90	10	100	—	49	51	100	98.4	1.6	100
	% ALL TRIPS	—	—	7.8	7.8	—	10.2	10.2	20.4	—	7.9	0.9	8.8	—	18.1	18.9	37.0	36.3	0.6	36.9
	TRIP LENGTH	—	—	9.5	9.5	—	10.7	10.7	10.7	—	11.4	11.4	11.4	—	10.7	9.91	10.3	11.4	7.6	11.3
P_2	No.of TRIPS/HH	40	—	357	397	214	286	214	714	715	84	42	841	226	148	241	615	660	71	685
	% P2 TRIPS	10	—	90	100	30	40	30	100	85	10	5	100	36.7	24.1	39.2	100	98.5	1.5	100
	% ALL TRIPS	0.7	—	6.6	7.3	6.0	6.7	6.0	16.7	5.2	0.6	0.3	6.3	11.1	7.3	11.9	30.3	29.8	0.5	30.3
	TRIP LENGTH	5.6	—	5.6	5.6	5.6	5.6	5.6	5.6	5.3	5.3	5.3	5.3	5.45	5.68	5.59	5.54	5.9	5.4	5.9
P_3	No.of TRIPS/HH	10	—	91	101	68	91	68	227	284	35	17	346	81	48	69	198	212	26	189
	% P3 TRIPS	10	—	90	100	30	40	30	100	85	10	5	100	40.9	24.2	34.9	100	98.3	1.7	100
	% ALL TRIPS	0.2	—	1.7	1.9	1.6	2.1	1.6	6.3	2.2	0.3	0.1	2.6	4.0	2.4	3.4	9.8	9.6	0.2	9.8
	TRIP LENGTH	4.1	—	4.1	4.1	5.4	5.4	5.4	5.4	4.3	4.3	4.3	4.3	4.75	5.28	4.72	4.87	5.2	3.9	5.1
P_4	No.of TRIPS/HH	—	—	285	285	—	—	477	477	—	—	718	718	—	—	442	442	476	71	42
	% P4 TRIPS	—	—	100	100	—	—	100	100	—	—	100	100	—	—	100	100	97.8	2.2	100
	% ALL TRIPS	—	—	5.2	5.2	—	—	11.2	11.2	—	—	5.4	5.4	—	—	21.8	21.8	21.4	0.5	21.9
	TRIP LENGTH	—	—	12.6	12.6	—	—	13.6	13.6	—	—	14.3	14.3	—	—	13.53	13.53	14.5	11.6	14.4
P_5	No.of TRIPS/HH	1.3	—	11.7	13	8	11	8	27	1.5	3	26.5	31	4.4	5.6	12.0	22.0	24	2	21
	% P5 TRIPS	10	—	90	100	30	40	30	100	5	10	85	100	20.1	25.4	54.5	100	98.9	1.1	100
	% ALL TRIPS	—	—	0.2	0.2	0.1	0.2	0.1	0.4	—	—	0.5	0.5	0.2	0.3	0.6	1.1	1.1	—	1.1
	TRIP LENGTH	9.4	—	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	10.1	10.1	10.1
ALL PURP.	No.of TRIPS/HH	55	—	1252	1307	311	884	1290	2485	1083	1257	987	3327	334	611	1230	2175	2175	262	1944
	% ALL TRIPS	0.9	—	21.5	22.4	6.8	19.3	28.1	54.2	7.6	6.8	7.0	23.4	15.3	28.1	56.6	100	98.2	1.8	100
	TRIP LENGTH	5.75	—	9.15	9.0	6.07	8.92	11.4	9.86	5.37	10.87	14.92	10.52	5.70	9.74	10.97	9.82	9.8	7.7	9.8
ALL PURP.	ANNUAL MILES/CAR $\times 10^3$	6.3	—	12.1	11.75	9.43	9.87	14.67	12.25	5.82	14.45	12.25	10.93	7.18	11.2	13.3	11.77	11.77	20.0	11.85
	% OF CAR	1.0	—	19.6	20.6	5.83	20.92	24.19	52.3	8.47	8.47	10.2	27.14	14.7	29.4	55.9	100	99.6	0.4	100

A) CONDITIONS: • No of TRIPS AND TRIP LENGTH PER GROUP OF HOUSEHOLDS FROM 1969 NPTS DATA. COMBINED DATA ARE RELATED TO 1985 CAR/HOUSEHOLD
• No of CARS/HOUSEHOLD AND ANNUAL MILES/CAR ADJUSTED IN LINE WITH 1985 JPL FORECASTS.

B) SIMPLIFYING ASSUMPTIONS: • TAXI CAB AND RENTAL CAR TRIPS EXCLUDED FROM HOUSEHOLDS WITH CARS (1)
• NO-CAR HOUSEHOLD TRIP INCLUDED IN MISSION M4 -- TAXI/POLICE (2)

TABLE 4.1 – 2

SUMMARY OF MISSION QUANTIFICATION DATA PER HOUSEHOLD / VEHICLE – Δ (FLEET) – 7 %

CAR OWNERSHIP		1 CAR HOUSEHOLDS				2 CAR HOUSEHOLDS				3 OR MORE HOUSEHOLDS				ALL HOUSEH. WITH CARS				COMBINED (ALL MISSIONS)		
PARAMETER		M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS	CAR OWN. HOUSE-HOLDS (1)	NO CAR HOUSE-HOLDS (2)	ALL HOUSE HOLDS
TRIP PURP.	CAR/MISS DIST.	0.05	—	0.95	1.0	0.2	0.8	1.0	2.0	1.0	1.0	1.2	3.2				1.74			
	%of HOUSEHOLD	35.0 (41.4)				38.5 (45.6)				11.0 (13.0)				84.3 (100)				84.3	15.7	100
P_1	No. of TRIPS/HH	—	—	423	423	—	436	436	872	—	1049	117	1166	—	335	389	724	775	92	668
	% P1 TRIPS	—	—	100	100	—	50	50	100	—	90	10	100	—	46.3	53.7	100	97.8	2.2	100
	% ALL TRIPS	—	—	8.9	8.9	—	10.1	10.1	20.2	—	6.9	0.8	7.7	—	17.0	19.8	36.8	36.1	0.8	36.9
	TRIP LENGTH	—	—	9.5	9.5	—	10.7	10.7	10.7	—	11.4	11.4	11.4	—	11.0	10.2	10.6	11.3	7.6	11.2
P_2	No. of TRIPS/HH	40	—	357	397	214	286	214	714	715	84	42	841	207	141	251	599	641	70	551
	% P2 TRIPS	10	—	90	100	30	40	30	100	85	10	5	100	34.6	23.5	41.9	100	98.0	2.0	100
	% ALL TRIPS	0.8	—	7.5	8.3	5.0	6.6	5.0	16.6	4.7	0.6	0.3	5.6	10.5	7.2	12.8	30.5	29.8	0.6	30.4
	TRIP LENGTH	5.6	—	5.6	5.6	5.6	5.6	5.6	5.6	5.3	5.3	5.3	5.3	5.5	5.6	5.6	5.5	5.9	5.4	5.9
P_3	No of TRIPS/HH	10	—	91	101	68	91	68	227	284	35	17	336	72	46	71	189	202	26	174
	% P3 TRIPS	10	—	90	100	30	40	30	100	85	10	5	100	381	243	376	1000	97.7	2.3	100
	% ALL TRIPS	0.2	—	1.9	2.1	1.6	2.1	1.6	5.3	1.9	0.2	0.1	2.2	3.7	2.3	3.6	9.6	9.4	0.2	9.6
	TRIP LENGTH	4.1	—	4.1	4.1	5.4	5.4	5.4	5.4	4.3	4.3	4.3	4.3	4.8	5.3	4.7	4.9	5.2	3.9	5.2
P_4	No of TRIPS/HH	—	—	285	285	—	—	477	477	—	—	718	718	—	—	429	429	459	70	398
	% P4 TRIPS	—	—	100	100	—	—	100	100	—	—	100	100	—	—	100	100	97.2	2.8	100
	% ALL TRIPS	—	—	6.0	6.0	—	—	11.1	11.1	—	—	4.72	4.72	—	—	21.8	21.8	21.3	0.6	21.9
	TRIP LENGTH	—	—	12.6		—	—	—	13.6	—	—	—	14.3	—	—	13.5	13.5	14	11.6	13.9
P_5	No of. TRIPS HH	1.3	—	11.7	13	8	11	8	27	1.5	3	26.5	31	4.4	5.4	11.9	21.7	23	3	20
	% P5 TRIPS	10	—	90	100	30	40	30	100	5	10	85	100	20.3	24.9	54.8	100	97.6	2.4	100
	% ALL TRIPS	—	—	0.2	0.2	0.2	0.2	0.2	0.6	—	—	0.2	0.2	0.2	0.2	0.6	1.0	1.1	0	1.1
	TRIP LENGTH	9.4	—	9.4	9.4	9.4	9.4	9.4	9.4	—	—	—	9.4	9.4	9.4	9.4	9.4	10.0	9.8	10.0
ALL PURP.	No. of TRIPS/HH	54.9	—	1249	1301	310	802	1287	2479	1070	1253	985	3309	304	564	1232	2100	2102	261	1813
	% ALL TRIPS	1	—	24.5	25.5	6.8	19	28	53.8	6.6	7.7	5.1	20.4	14.4	26.7	58.6	100	97.7	2.3	100
	TRIP LENGTH	5.67	—	9.25	9.11	6.06	8.91	10.63	9.44	5.36	11.49	14.08	10.28	5.75	9.67	10.82	9.75	9.75	7.7	9.75
ALL PURP.	ANNUAL MILES / CAR $\times 10^3$	5.7	—	12.9	11.8	9.65	9.8	13.75	11.7	5.7	14.2	11.5	10.5	7.2	11.1	13.2	11.76	11.76	20.0	11.79
	% OF CAR	1.2	—	22.6	23.8	5.2	20.9	26.1	52.2	7.5	7.5	9	24	13.9	28.4	57.7	100	99.6	0.4	100

A) CONDITIONS :
- No. of TRIP - AND TRIP LENGTH PER GROUP OF HOUSEHOLDS FROM 1969 NPTS DATA. COMBINED DATA ARE RELATED TO 1985 CAR / HOUSEHOLD.
- No. of CARS / HOUSEHOLD AND ANNUAL MILES / CAR ADJUSTED IN LINE WITH 1985 JPL FORECASTS

B) SIMPLIFYING ASSUMPTIONS :
- TAXI CAB AND RENTAL CAR TRIPS EXCLUDED FROM HOUSEHOLDS WITH CARS (1)
- NO – CAR HOUSEHOLD TRIPS INCLUDED IN MISSION M4 – TAXI / POLICE (2)

TABLE 4.1 – 3

SUMMARY OF MISSION QUANTIFICATION DATA PER HOUSEHOLD / VEHICLE $-\Delta$(FLEET) + 7 %

CAR OWNERSHIP		1 CAR HOUSEHOLDS				2 CAR HOUSEHOLDS				3 OR MORE HOUSEHOLDS				ALL HOUSEH. WITH CARS				COMBINED (ALL MISSIONS)		
PARAMETER		M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS	CAR OWN. HOUSE-HOLDS (1)	NO CAR HOUSE-HOLDS (2)	ALL HOUSE HOLDS
TRIP PURP.	CAR/MISS DIST.	0.05		0.95	1.0	0.2	0.8	1.0	2.0	1.0	1.0	1.2	3.2				1.86			
	%of HOUSEHOLD	31 (34.1)				45 (49.4)				15 (16.5)				(91 (100)				91.0	9.0	100
P_1	No. of TRIPS/HH	—	—	423	423	—	436	436	872	—	1049	117	1166	—	388	379	767	331	93	765
	% P1 TRIPS	—	—	100	100	—	50	50	100	—	90	10	100	—	50.6	49.4	100	98.9	1.1	100
	% ALL TRIPS	—	—	7.0	7.0	—	10.4	10.4	20.8	—	8.4	0.9	9.3	—	18.8	18.3	37.1	36.6	0.4	37
	TRIP LENGTH	—	—	9.5	9.5	—	10.7	10.7	10.7	—	11.4	11.4	11.4	—	11.0	10.3	10.6	11.5	7.7	11.7
P_2	No. of TRIPS/HH	40	—	357	397	214	286	214	714	715	84	42	841	237	156	234	627	679	71	624
	% P2 TRIPS	10	—	90	100	30	40	30	100	85	10	5	100	37.8	24.9	37.3	100	99.0	1.0	100
	% ALL TRIPS	0.6	—	5.9	6.5	5.1	6.8	5.1	17.0	5.7	0.7	0.3	6.7	11.4	7.5	11.4	30.3	29.9	0.3	30.2
	TRIP LENGTH	5.6	—	5.6	5.6	5.6	5.6	5.6	5.6	5.3	5.3	5.3	5.3	5.45	5.6	5.6	5.6	5.9	5.4	5.9
P_3	No of TRIPS/HH	10	—	91	101	68	71	68	227	284	35	17	346	85	51	68	204	221	26	203
	% P3 TRIPS	10	—	90	100	30	40	30	100	85	10	5	100	41.7	25	33.3	100	99.0	1.0	100
	% ALL TRIPS	0.2	—	1.5	1.7	1.6	2.2	1.6	5.4	2.3	0.3	0.1	2.7	4.1	2.5	3.2	9.8	9.7	0.1	9.8
	TRIP LENGTH	4.1	—	4.1	4.1	5.4	5.4	5.4	5.4	4.3	4.3	4.3	4.3	4.7	5.3	4.7	4.85	5.3	3.9	5.3
P_4	No of TRIPS/HH	—	—	285	285	—	—	477	477	—	—	718	718	—	—	451	451	489	71	451
	% P4 TRIPS	—	—	100	100	—	—	100	100	—	—	100	100	—	—	100	100	98.7	1.3	100
	% ALL TRIPS	—	—	4.7	4.7	—	—	11.4	11.4	—	—	5.7	5.7	—	—	21.8	21.8	21.5	0.3	21.8
	TRIP LENGTH	—	—	12.6	12.6	—	—	13.6	13.6	—	—	14.3	14.3	—	—	13.6	13.6	14.7	11.7	14.6
P_5	No of. TRIPS HH	1.3	—	11.7	13	8	11	8	27	1.5	3	26.5	31	5	6	12	23	25	3	24
	% P5 TRIPS	10	—	90	100	30	40	30	100	5	10	85	100	21.7	26.1	52.2	100	95.0	5.0	100
	% ALL TRIPS		—	0.2	0.2	0.2	0.2	0.2	0.7	—	—	0.2	0.2	0.2	0.2	0.6	1.0	1.1	0.1	1.2
	TRIP LENGTH	9.4	—	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	10.2	10	10.2
ALL. PURP.	No. of TRIPS/HH	55.6	—	1271	1327	3142	893	1303	2510	1089	1269	997	3365	354	651	1239	2245	2245	264	2067
	% ALL TRIPS	0.8	—	19.3	20.1	6.9	19.6	28.7	55.2	8	9.4	7.3	24.7	15.7	29	55.3	100	98.8	1.2	100
	TRIP LENGTH	5.6	—	8.86	8.69	5.98	8.92	11.5	9.89	5.43	11.62	11.26	10.42	5.42	9.81	10.95	9.75	9.75	7.8	9.7
ALL. PURP.	ANNUAL MILES / CAR $\times 10^3$	6.8	—	11.9	11.5	9.4	9.9	15.0	11.95	5.9	14.8	11.8	10.9	6.8	11.4	13.4	11.78	11.78	20.00	11.81
	% OF CAR	0.9	—	17.4	18.3	5.3	21.3	26.6	53.2	8.9	8.9	10.7	28.5	15.1	30.2	54.7	100	99.3	0.7	100

A) CONDITIONS :
- No. of TRIP - AND TRIP LENGTH PER GROUP OF HOUSEHOLDS FROM 1969 NPTS DATA. COMBINED DATA ARE RELATED TO 1985 CAR / HOUSEHOLD.
- No. of CARS / HOUSEHOLD AND ANNUAL MILES / CAR ADJUSTED IN LINE WITH 1985 JPL FORECASTS

B) SIMPLIFYING ASSUMPTIONS :
- TAXI CAB AND RENTAL CAR TRIPS EXCLUDED FROM HOUSEHOLDS WITH CARS (1)
- NO – CAR HOUSEHOLD TRIPS INCLUDED IN MISSION M4 – TAXI / POLICE (2)

TABLE 4.1 – 4
SUMMARY OF MISSION QUANTIFICATION DATA PER HOUSEHOLD / VEHICLE – Δ (ANNUAL TRAVEL) – 7 %

CAR OWNERSHIP		1 CAR HOUSEHOLDS				2 CAR HOUSEHOLDS				3 OR MORE HOUSEHOLDS				ALL HOUSEH. WITH CARS				COMBINED (ALL MISSIONS)		
PARAMETER		M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS.	CAR OWN. HOUSE-HOLDS (1)	NO CAR HOUSE-HOLDS (2)	ALL HOUSE HOLDS
TRIP PURP.	CAR/MISS DIST.	0.05	—	0.95	1.0	0.2	0.8	1.0	2.0	1.0	1.0	1.2	3.2				1.78			
	%of HOUSEHOLD	32.6 (37.3)				41.3 (47.4)				13.4 (15.3)				87.4 (100)				87.4	12.6	100
P_1	No. of TRIPS/HH	—	—	423	423	—	436	436	872	—	1049	117	1166	—	367	382	749	776	89	689
	% P1 TRIPS	—	—	100	100	—	50	50	100	—	90	10	100	—	49	51	100	98.4	1 6	100
	% ALL TRIPS	—	—	7.8	7.8	—	10.2	10.2	20.4	—	7.9	0.9	8.8	—	18.1	18.9	37.0	36.3	0.6	
	TRIP LENGTH	—	—	9.5	9.5	—	10.7	10.7	10.7	—	11.4	11.4	11.4	—	10.7	9.91	10.3	10.7	7.3	10.6
P_2	No. of TRIPS/HH	40	—	357	397	214	286	214	714	715	84	42	841	226	148	241	615	637	68	565
	% P2 TRIPS	10	—	90	100	30	40	30	100	85	10	5	100	36.7	24.1	39.2	100	98.5	1.5	100
	% ALL TRIPS	0.7	—	6.6	7.3	6.0	6.7	6.0	16.7	5.2	0.6	0.3	6.3	11.1	7.3	11.9	30.3	29.8	0.5	
	TRIP LENGTH	5.6	—	5.6	5.6	5.6	5.6	5.6	5.6	5.3	5.3	5.3	5.3	5.45	5.58	.59	5.54	5.7	5.2	5.7
P_3	No of TRIPS/HH	10	—	91	101	68	91	68	227	284	35	17	346	81	48	69	198	20.5	25	182
	% P3 TRIPS	10	—	90	100	30	40	30	100	85	10	5	100	40.9	24.2	34.9	100	98.3	1.7	100
	% ALL TRIPS	0.2	—	1.7	1.9	1.6	2.1	1.6	6.3	2.2	0.3	0.1	2.6	4.0	2.4	3.4	9.8	9.6	0.2	
	TRIP LENGTH	4.1	—	4.1	4.1	5.4	5.4	5.4	5.4	4.3	4.3	4.3	4.3	4.75	5.28	4.72	4.87	5.0	3.7	5.0
P_4	No of TRIPS/HH	—	—	285	285	—	—	477	477	—	—	718	718	—	—	442	442	45.8	6 9	409
	% P4 TRIPS	—	—	100	100	—	—	100	100	—	—	100	100	—	—	100	100	97.9	2.1	100
	% ALL TRIPS	—	—	5.2	5.2	—	—	11.2	11.2	—	—	5.4	5.4	—	—	21.8	21.8	21.5	0 4	21.9
	TRIP LENGTH	—	—	12.6	12.6	—	—	13.6	13.6	—	—	14.3	14.3	—	—	13.53	13.53	14.0	11.2	13.9
P_5	No of. TRIPS HH	1.3	—	11.7	13	8	11	8	27	1.5	3	26.5	31	4.4	5.6	12.0	22.0	23	3	29
	% P5 TRIPS	10	—	90	100	30	40	30	100	5	10	85	100	20.1	25.4	54.5	100	98.2	1.8	100
	% ALL TRIPS	—	—	0.2	0.2	0.1	0.2	0.1	0.4	—	—	0.5	0.5	0.2	0.3	0.6	1.1	1.1		
	TRIP LENGTH	9.4	—	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.7	9.5	9.7
ALL PURP.	No. of TRIPS/HH	53	—	1210	1263	300	853	1246	2399	1047	1213	954	3214	323	859	1187	2099	2099	233	1866
	% ALL TRIPS	0.9	—	21.5	22.4	6.8	19.3	28.1	54.2	7.6	8.8	7.0	23.4	15.3	28.1	56.6	100	98.3	1.7	100
	TRIP LENGTH	5.5	—	8.84	8.71	5.86	8.62	11.01	9.51	5.39	11.3	14.4	10.18	5.51	9.41	10.6	9.5	9.5	7.5	9.5
ALL PURP.	ANNUAL MILES / CAR $\times 10^3$	5.8	—	11.3	11.0	8.8	9.2	13.7	11.4	5.4	13.5	11.4	10.2	6.7	10.4	12.4	11.0	11.0	18.6	11.03
	% OF CAR	1.0	—	19.6	20.6	5.83	20.92	24.15	52.3	8.47	8.47	10.2	27.14	14.7	29.4	55.9	100	99.6	0 4	100

A) CONDITIONS :
- No. of TRIP - AND TRIP LENGTH PER GROUP OF HOUSEHOLDS FROM 1969 NPTS DATA. COMBINED DATA ARE RELATED TO 1985 CAR / HOUSEHOLDS
- No. of CARS / HOUSEHOLD AND ANNUAL MILES / CAR ADJUSTED IN LINE WITH 1985 JPL FORECASTS

B) SIMPLIFYING ASSUMPSIONS:
- TAXI CAB AND RENTAL CAR TRIPS EXCLUDED FROM HOUSEHOLDS WITH CARS (1)
- NO CAR HOUSEHOLD TRIPS INCLUDED IN MISSION M4 -- TAXI / POLICE (2)

TABLE 4.1 – 5

SUMMARY OF MISSION QUANTIFICATION DATA PER HOUSEHOLD / VEHICLE –
Δ (ANNUAL TRAVEL) +- 7%

CAR OWNERSHIP		1 CAR HOUSEHOLDS				2 CAR HOUSEHOLDS				3 OR MORE HOUSEHOLDS				ALL HOUSEH. WITH CARS				COMBINED (ALL MISSIONS)		
PARAMETER		M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS.	M_1	M_2	M_3	ALL MISS.	CAR OWN. HOUSE-HOLDS (1)	NO CAR HOUSE-HOLDS (2)	ALL HOUSE-HOLDS
TRIP PURP.	CAR/MISS DIST.	0.05	—	0.95	1.0	0.2	0.8	1.0	2.0	1.0	1.0	1.2	3.2				1.78			
	%of HOUSEHOLD	32.6 (37.3)				41.3 (47.4)				13.4 (15.3)				87.4 (100)				87.4	12.6	100
P_1	No. of TRIPS/HH	—	—	423	423	—	436	436	872	—	1049	117	1166	—	367	382	749	830	95	737
	% P1 TRIPS	—	—	100	100	—	50	50	100	—	90	10	100	—	49	51	100	98.4	1.6	100
	% ALL TRIPS	—	—	7.8	7.8	—	10.2	10.2	20.4	—	7.9	0.9	8.8	—	18.1	18.9	37.0	36.3	0.6	36.9
	TRIP LENGTH	—	—	9.5	9.5	—	10.7	10.7	10.7	—	11.4	11.4	11.4	—	10.7	9.91	10.3	11.4	7.9	11.5
P_2	No. of TRIPS/HH	40	—	357	397	214	286	214	714	715	84	42	841	226	148	241	615	682	73	605
	% P2 TRIPS	10	—	90	100	30	40	30	100	85	10	5	100	36.7	24.1	39.2	100	98.5	1.5	100
	% ALL TRIPS	0.7	—	6.6	7.3	6.0	6.7	6.0	16.7	5.2	0.6	0.3	6.3	11.1	7.3	11.9	30.3	29.8	0.5	30.3
	TRIP LENGTH	5.6	—	5.6	5.6	5.6	5.6	5.6	5.6	5.3	5.3	5.3	5.3	5.45	5.58	.59	5.54	6.1	5.5	6.1
P_3	No of TRIPS/HH	10	—	91	101	68	91	68	227	284	35	17	346	81	48	69	198	219	27	195
	% P3 TRIPS	10	—	90	100	30	40	30	100	85	10	5	100	40.9	24.2	34.9	100	98.2	1.8	100
	% ALL TRIPS	0.2	—	1.7	1.9	1.6	2.1	1.6	6.3	2.2	0.3	0.1	2.6	4.0	2.4	3.4	9.8	9.6	0.2	9.8
	TRIP LENGTH	4.1	—	4.1	4.1	5.4	5.4	5.4	5.4	4.3	4.3	4.3	4.3	4.75	5.28	4.72	4.87	5.4	4.0	5.4
P_4	No of TRIPS/HH	—	—	285	285	—	—	477	477	—	—	718	718	—	—	442	442	490	73	437
	% P4 TRIPS	—	—	100	100	—	—	100	100	—	—	100	100	—	—	100	100	97.9	2.1	100
	% ALL TRIPS	—	—	5.2	5.2	—	—	11.2	11.2	—	—	5.4	5.4	—	—	21.8	21.8	21.5	0.4	21.9
	TRIP LENGTH	—	—	12.6	12.6	—	—	13.6	13.6	—	—	14.3	14.3	—	—	13.53	13.53	15.0	12.0	14.9
P_5	No of. TRIPS HH	1.3	—	11.7	13	8	11	8	27	1.5	3	26.5	31	4.4	5.6	12.0	22.0	24	3	21
	% P5 TRIPS	10	—	90	100	30	40	30	100	5	10	85	100	20.1	25.4	54.5	100	98.2	1.8	100
	% ALL TRIPS	—	—	0.2	0.2	0.1	0.2	0.1	0.4	—	—	0.5	0.5	0.2	0.3	0.6	1.1	1.1		1.1
	TRIP LENGTH	9.4	—	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	10.4	10.2	10.4
ALL PURP.	No. of TRIPS/HH	57	—	1294	1351	321	914	1334	2562	1120	1288	1020	3498	346	630	1270	2246	2246	251	1997
	% ALL TRIPS	0.9	—	21.5	22.4	6.8	19.3	28.1	54.2	7.6	8.8	23.4	7.6	8.3	7.0	234		98.3	1.7	100
	TRIP LENGTH	5.94	—	9.46	9.32	6.27	9.22	11.78	10.18	5.55	11.91	13.1	10.89	5.90	10.06	11.34	10.15	10.15	8.0	10.1
ALL PURP.	ANNUAL MILES / CAR $\times 10^3$	6.6	—	12.9	12.6	10.1	10.5	15.7	13.1	6.2	15.5	13.1	11.7	7.65	11.95	14.2	12.6	12.6	21.4	12.63
	% OF CAR	1.0	—	19.6	20.6	5.83	20.22	24.45	52.3	8.47	8.47	10.2	27.14	14.7	29.4	55.9	100	99.6	0.4	100

A) CONDITIONS : ● No. of TRIP - AND TRIP LENGTH PER GROUP OF HOUSEHOLDS FROM 1969 NPTS DATA. COMBINED DATA ARE RELATED TO 1985 CAR / HOUSEHOLD.
● No. of CARS / HOUSEHOLD AND ANNUAL MILES / CAR ADJUSTED IN LINE WITH 1985 JPL FORECASTS

B) SIMPLIFYING ASSUMPTIONS : ● TAXI CAB AND RENTAL CAR TRIPS EXCLUDED FROM HOUSEHOLDS WITH CARS (1)
● NO – CAR HOUSEHOLD TRIPS INCLUDED IN MISSION M4 – TAXI / POLICE (2)

The corresponding variations of the annual miles per vehicle are on the other hand:

Mission M_1 <.1 (-7%) and - 5.5 (-7%)
Mission M_2 -1 (-7%) and + 2.0 (+7%)
Mission M_3 -.8 (-7%) and +.8 (+7%)

The sensitivity of daily distance distribution to the various travel parameters is summarized on Table 4.1-6; as the composition in terms of driving cycles was assumed not to be dependent on the daily driving range as a result of the average speed and stops per mile being independent from the range itself, the daily distance variations at the various percentiles levels are only reflected in a different percentile corresponding to the nominal daily distance resulting from the driving cycle combination which best fits the assumed values for the average speed and numbeer of stops per mile.

4.1.2 Vehicle fleet/mission distribution and fuel consumption

Assuming that small variations in the annual travel do not affect the vehicle fleet mix, the fleet/mission distribution are only affected by the vehicle fleet variation as a result of the different vehicle distributions in the various missions, as given below:

	M_1	M_2	M_3	
Δ(Fleet) -7%	13.9	28.4	57.7	%
Nominal	14.6	29.3	55.7	%
Δ(Fleet))7%	15.0	30.0	54.6	%

The resulting vehicle class distributions are shown on Tables 4.1-7 through 4.1-9; the corresponding fuel consumptions for the

TABLE 4.1 – 6

SUMMARY OF DAILY DISTANCE AND DRIVING CYCLES SENSITIVITY

MISSION		DAILY DISTANCE (MILES)			DRIVING CYCLES					
		PERCENTILE			COMPOSITION	SEQUENCE	DAILY DISTANCE		AVER. SPEED (MPH)	STOPS PER MILE
		50	90	95			(PERCENTILE)	(MILES)		
M1	A	11	52	76	4S, 4 U	(1S, U, 4S, U, U, 4S, U, 1S)	90.0	52.4	17.7	2.5
	B	11	54	77.5			89.5			
	C	10.5	51	73			91.0			
	D	9	50	72			91.0			
	E	12	57	82			87.0			
M2	A	17	84	122	4S, 6U, 2H	(U, H, 2U, 2S, 2S, 2U, H, U,)	91.0	88	24.2	1.6
	B	16	83	121			91.0			
	C	17	86	124			91.0			
	D	13	80	115			92.0			
	E	17	80	129			91.0			
M3	A	20	100	142	4U, 10H	(H, U, 4H, U, U, 4H, U, H,)	95.5	147	34.9	0.67
	B	20	99	141.5			95.5			
	C	20	101	144			95.0			
	D	18	94	136			96.0			
	E	22	107	153			94.5			

A = NOMINAL.
B = (FLEET) – 7 %
C = (FLEET) + 7 %
D = (ANNUAL TRAVEL) – 7 %
E = (ANNUAL TRAVEL) + 7 %

TABLE 4.1 – 7
VEHICLE / MISSION DISTRIBUTIONS – Δ (FLEET) – 7 %

MISSION	DISTRIBUTION	K1		K2		K3		K4		K5		TOTAL
		% K1	% FLT.	% K2	% FLT.	% K3	% FLT.	% K4	% FLT.	% K 5	% FLT.	% FLT.
M1	TENTATIVE	83	8.67	50	10.95	30	6.12	20	5.02	5	1.10	31.96
	FINAL	58.8	6.0	19.6	4.3	9.3	1.9	5.2	1.3	10	0.2	13.9
M2	TENTATIVE	10	1.02	30	6.58	40	8.16	30	7.53	10	2.20	25.49
	FINAL	23.6	2.4	40.2	8.8	42.6	8.7	27.1	6.8	7.3	1.6	28.4
M3	TENTATIVE	5	0.51	20	4.37	30	6.12	50	12.55	85	18.70	42.25
	FINAL	17.6	1.8	40.2	8.8	48.1	9.8	67.7	17.0	91.7	20.2	57.7
ALL MISSIONS		100	10.2	100	21.9	100	20.4	100	25.1	100	22.0	99.6

Note : MISSION M4 (TAXI/POLICE – 0,4 % OF FLEET) NOT INCLUDED – VEHICLES CLASS EQUIVALENT TO K5

TABLE 4.1 – 8

VEHICLE / MISSION DISTRIBUTIONS

(NOMINAL CONDITIONS)

MISSION	DISTRIBUTION	K1		K2		K3		K4		K5		TOTAL
		% K1	% FLT.	% K2	% FLT.	% K3	% FLT.	% K4	% FLT.	% K5	% FLT.	% FLT.
M1	TENTATIVE	85	8.67	50	10.95	30	6.12	20	5.02	5	1.10	31.86
	FINAL	60.8	6.2	21.0	4.6	10.2	2.1	5.6	1.4	1.4	0.3	14.6
M2	TENTATIVE	10	1.02	30	6.58	40	8.16	30	7.53	19	2.20	25.49
	FINAL	23.5	2.4	41.1	9.0	44.2	9.0	28.7	7.2	7.6	1.7	29.3
M3	TENTATIVE	5	0.51	20	4.37	30	6.12	50	12.55	85	18.70	42.25
	FINAL	15.7	1.6	37.9	8.3	45.6	9.3	65.7	16.5	91.0	20.0	55.7
ALL MISSIONS		100	10.2	100	21.9	100	20.4	100	25.1	100	22.0	99.6

Note : MISSION M4 (TAXI / POLICE – 0,4% OF FLEET) NOT INCLUDED – VEHICLED CLASS EQUIVALENT TO K5

TABLE 4.1 – 9
VEHICLE / MISSION DISTRIBUTIONS – Δ (FLEET) + 7%

MISSION	DISTRIBUTION	K1		K2		K3		K4		K5		TOTAL	
		% K1	% FLT.	% K2	% FLT.	% K3	% FLT.	% K4	% FLT.	% K5	% FLT.		% FLT.
M1	TENTATIVE	83	8.67	50	10.95	30	6.12	20	5.02	5	1.10		31.86
	FINAL	61.8	6.3	21.9	4.8	10.3	2.1	6.0	1.5	1.0	0.2		15.0
M2	TENTATIVE	10	1.62	30	6.58	40	8.16	30	7.53	10	2.20		25.49
	FINAL	23.5	2.4	42.0	9.2	45.6	9.3	29.5	7.4	9.2	1.8		30.0
M3	TENTATIVE	[illegible]	0.51	20	4.37	30	6.12	50	12.55	85	18.70		42.25
	FINAL	14.7	1.5	36.1	7.9	44.1	9.0	64.5	16.2	90.8	20.0		54.6
ALL MISSIONS		100	10.2	100	21.9	100	20.4	100	25.1	100	22.0		99.6

Note : MISSION M4 (TAXI / POLICE – 0.4 % OF FLEET) NOT INCLUDED – VEHICLES CLASS EQUIVALENT TO E5

various missions and 1985 reference new vehicles representative of each class, calculated according to the previously defined driving cycles and to the fuel economies calculated as described on Subsection 3.2.2.2.* are shown on Tables 4.1-10 through 4.1-12.

The fuel consumptions resulting from annual travel variations are shown on Tables 4.1-13 and 4.1-14.

With respect to the fuel consumption under nominal conditions, the following fuel consumption variations may be accordingly expected as a result of vehicle fleet variations:

	All Vehicle Classes & Missions	K_5 Vehicle M_3 Mission
Δ(Fleet) -7%	- 4.9%	- 6.0%
Δ(Fleet) +7%	+ 7.3%	- 7.7%

Annual miles variations obviously result in identical percent variation in the corresponding fleet fuel consumptions.

These Interim Results on Mission Analysis Sensitivity do not appreciably alter the conclusions made at the end of Subsection 3.2.1.6* so that the K_5 vehicle tailored to perform M_3 type general purpose mission shall be mantained as the reference conventional vehicle.

In the design of the corresponding hybrid vehicle, vehicle sizing close to the lower end of the projected K_5 class should provide a better fitting to the expected market trends as well as the highest potential in terms of achievable fuel savings both on a per vehicle basis and in terms of attainable market penetration.

TABLE 4.1 –10
MISSION AND VEHICLE CLASS FUEL CONSUMPTIONS, BILLIONS OF GALLONS
(%OF VEHICLE CLASS, MISSION, FLEET CONSUMPTIONS)
Δ (FLEET) – 7%

MISSION	VEHICLE CLASS						
	K1 % % FLT.	K2 % % FLT.	K3 % % FLT.	K4 % % FLT.	K5 % % FLT.	K6 % % FLT.	ALL CLASSES % FLT.
M1 % % FLT.	1.47 (50.5) (38.0) (3.2)	1.18 (15.0) (30.5) (2.7)	0.64 (7.0) (16.5) (1.3)	0.49 (3.7) (12.7) (1.1)	0.09 (0.8) (2.9) (0.2)		3.87 (100) (8.7)
M2 % % FLT.	0.82 (28.1) (6.7) (1.8)	3.30 (12.1) (27.1) (7.4)	3.95 (43.4) (32.4) (8.8)	3.32 (25.3) (27.2) (7.4)	0.79 (7.1) (6.5) (1.8)		12.18 (100) (27.3)
M3 % % FLT.	0.63 (21.6) (2.2) (1.4)	3.36 (42.9) (12.0) (7.5)	4.5 (46.9) (16.0) (10.0)	9.33 (71.0) (33.2) (21.0)	10.28 (92.1) (36.6) (23.2)		28.10 (100) (63.0)
M4 % % FLT.						0.45 (100) (100) (1.0)	0.45 (100) (1.0)
ALL MISSIONS % FLT.	2.92 (100) (6.5)	7.84 (100) (17.8)	9.07 (100) (20.5)	13.14(100) (29.5)	11.16 (100) (25.1)	0.45 (100) (100)	44.6 (100 (100)

TABLE 4.1 – 11
MISSION AND VEHICLE CLASS FUEL CONSUMPTIONS, BILLIONS OF GALLONS
(% OF VEHICLE CLASS, MISSION, FLEET CONSUMPTIONS)

(NOMINAL CONDITIONS)

MISSION	VEHICLE CLASS						
	K1 % % FLT.	K2 % % FLT.	K3 % % FLT.	K4 % % FLT.	K5 % % FLT.	K6 % % FLT.	ALL CLASSES % FLT.
M1 % FLT.	1.63 (51.1) (36.9) (3.5)	1.35 (16.0) (30.6) (2.9)	0.74 (7.6) (16.8) (1.6)	0.58 (4.4) (13.2) (1.2)	0.11 (0.9) (2.5) (0.2)		4.41 (100) (9.4)
M2 % % FLT.	0.88 (28.3) (6.4) (1.9)	3.67 (43.5) (26.8) (7.8)	4.42 (45.3) (32.2) (9.4)	3.80 (28.9) (27.8) (8.1)	0.93 (7.8) (6.8) (2.0)		13.70 (100) (29.2)
M3 % FLT.	0.61 (19.6) (2.2) (1.3)	3.40 (40.4) (12.0) (7.3)	4.59 (47.1) (16.3) (9.8)	8.77 (66.7) (31.0) (18.7)	10.94 (91.3) (38.5) (23.3)		28.31 (100) (60.4)
M4 % % FLT.						0.45 (100) (100) (1.0)	0.45 (100) (1.0)
ALL MISSIONS % FLT.	3.12 (100) (6.7)	8.42 (100) (18.0)	9.75 (100) (20.8)	13.15 (100) (28.0)	11.98 (100) (25.5)	0.45 (100) (1.0)	46.87 (100)

TABLE 4.1 – 12
MISSION AND VEHICLE CLASS FUEL CONSUMPTIONS, BILLIONS OF GALLONS
(% OF VEHICLE CLASS, MISSION, FLEET CONSUMPTIONS)
Δ (FLEET) + 7%

MISSION	VEHICLE CLASS						
	K1	K2	K3	K4	K5	K6	ALL CLASSES
	% % FLT.	% % FLT.	% % FLT.	% % FLT.	% % FLT.	% % FLT	% FLT.
M1 % % FLT.	1.68 (51.5) (36.9) (3.4)	1.42 (15.7) (30.9) (2.8)	0.78 (7.4) (16.9) (1.6)	0.61 (4.3) (13.3) (1.2)	0.11 (0.8) (2.4) (0.2)		4.6 (100) (9.2) (9.2)
M2 % % FLT.	0.96 (28.4) (6.2) (1.9)	4.08 (45.2) (26.5) (8.4)	4.96 (47.0) (32.3) (9.9)	4.3 (3.04) (28.0) (8.6)	1.07 (8.3) (7.0) (2.1)		15.37 (100) (30.5)
M3 % FLT.	0.62 (19.1) (2.1) (1.2)	3.52 (39.1) (11.7) (7.0)	4.81 (45.6) (16.1) (9.5)	9.25 (65.3) (30.8) (18.4)	11.78 (90.9) (39.3) (23.4)		29.9 (100) (59.4)
M4 % % FLT.						0.15 (100) (100) (0.8)	0.45 (100) (0.8)
ALL MISSIONS % FLT.	3.26 (100) (6.5)	9.02 (100) (17.9)	10.53 (100) (21.0)	14.16 (100) (28.1)	12.96 (100) (25.7)	0.45 (100) (8.8)	50.32 (100)

TABLE 4.1 — 13
MISSION AND VEHICLE CLASS FUEL CONSUMPTIONS, BILLIONS OF GALLONS
(%OF VEHICLE CLASS, MISSION, FLEET CONSUMPTIONS)
Δ (ANNUAL TRAVEL) — 7 %

MISSION	VEHICLE CLASS						
	K1	K2	K3	K4	K5	K6	ALL CLASS
	% % FLT.	% % FLT.	% % FLT.	% % FLT	% % FLT.	% % FLT	% FLT.
M1 % % FLT.	1.51 (51.1) (36.9) (3.5)	1.56 (16.0) (30.6) (2.9)	0.69 (7.6) (16.8) (1.6)	0.54 (4.4) (13.2) (1.2)	0.11 (0.9) (2.5) (0.2)		4.11 (100) (9.4)
M2 % % FLT.	0.82 (28.3) (6.4) (1.9)	3.41 (43.5) (26.8) (7.8)	4.11 (45.3) (32.2) (9.4)	3.53 (28.9) (27.8) (8.1)	0.86 (7.8) (6.8) (2.0)		12.73 (100) (29.2)
M3 % % FLT.	0.57 (19.6) (2.2) (1.3)	3.16 (40.4) (12.0) (7.3)	4.27 (47.1) (16.3) (9.8)	8.16 (66.7) (31.0) (18.7)	10.17(91.3) (38.5) (23.3)		26.33 (100) (60.4)
M4 % % FLT.						0.42 (100) (100) (1.0)	0.42 (100) (1.0)
ALL MISSIONS % FLT.	2.90 (100) (6.7)	7.83 (100) (18.0)	9.07 (100) (20.8)	12.23(100) (28.0)	11.14 (100) (25.5)	0.42 (100) (1.0)	43.59 (100)

TABLE 4.1 – 14

MISSION AND VEHICLE CLASS FUEL CONSUMPTIONS, BILLIONS OF GALLONS
(% OF VEHICLE CLASS, MISSION, FLEET CONSUMPTIONS)
△ (ANNUAL TRAVEL) + 7 %

MISSION	VEHICLE CLASS						
	K1	K2	K3	K4	K5	K6	ALL CLASSES
	% % FLT.	% % FLT.	% % FLT.	% % FLT.	% % FLT.	% % FLT.	% FLT.
M1 % % FLT.	1.74 (51.1) (36.9) (3.5)	1.44 (16.0) (30.6) (2.9)	0.79 (7.6) (16.8) (1.6)	0.62 (4.4) (13.2) (1.2)	0.12 (0.9) (2.5) (0.2)		4.71 (100)
M2 % % FLT.	0.94 (28.3) (6.4) (1.9)	(3.93 (43.5) (26.8) (7.8)	4.73 (45.3) (32.2) (9.4)	4.07 (28.9) (27.8) (8.1)	1.00 (7.8) (6.8) (2.0)		14.66 (100) (29.2)
M3 % % FLT.	0.65 (19.6) (2.2) (1.3)	5.64 (40.4) (12.0) (7.3)	4.91 (47.1) (16.3) (9.8)	9.38 (66.7) (31.0) (18.7)	11.70 (91.3) (38.5) (23.3)		30.38 (100) (60.4)
M4 % % FLT.						0.48 (100) (100) (1.0)	0.48 (100) (1.0)
ALL MISSIONS % FLT.	3.33 (100) (6.7)	9.00 (100) (18.0)	10.43 (100) (20.8)	14.07 (100) (28.0)	12.82 (100) (25.5)	0.48 (100) (1.0)	50.15 (100)

4.2 SENSITIVITY OF VEHICLE CHARACTERISTICS RESULTS

As previously discussed an Subsection 3.1.2 the assigned parameter variations only affect the vehicle operating costs and its resulting life cycle cost.

It has been shown that such a conclusion applies to both the existing conventional vehicles and the hybrid vehicles being designed.

It has therefore appeared appropriate to present in the same subsection the results of Vehicle Characteristics sensitivity to parameter variations for both conventional and hybrid vehicles.

4.2.1 Conventional reference vehicle Life Cycle Cost

The results of the Life Cycle Cost sensitivity analysis are shown for the 1985 average new conventional K_5 vehicle on Table 4.2-1.

The values for nominal conditions, shown for reference on the first column, do not correspond for the fuel cost figure to the values shown on Table 3.2-29, Subsection 3.2.2.2.i)* to account for a mistake made during the computation of the total fuel cost leading to a $51 excess difference on the Fuel, Operating Costs and Life Cycle Cost figures.

None of the parameter variations are expected to affect the vehicle acquisition cost, at least under the existing assumptions.

The annual taxes, licence and registration as well as the insurance figures only decrease in the case of the +7% variation in the annual travel due to the limitation of the vehicle life to its seventh year.

The fuel cost which represented 30.2% of the vehicle operating cost under nominal condition varies from 36.1% to 23.2% of said operating cost as the gasoline price varies from +30% to -30%.

TABLE 4.2 – 1

K5 CONVENTIONAL VEHICLE LIFE CYCLE COSTS – 1978 $ VALUE (1)
SENSITIVITY TO HIGH/LOW BOUNDARY PARAMETER VALUES

	NOMINAL	Δ (FLEET)		Δ (ANNUAL TRAVEL)		Δ (GASOLINE PRICE)	
		+7%	−7%	+7%	−7%	+7%	−7%
PURCHASE PRICE, $	9036	9036	9036	9036	9036	9036	9036
SALE TAX, $	452	452	452	452	452	452	452
INTEREST, $	4337	4337	4337	4337	4337	4337	4337
SALVAGE VALUE, $	0	0	0	0	0	0	0
A – ACQUISITION COST, $	13,825	13,825	13,825	13,825	13,825	13,825	13,825
TIRES, REPAIRS AND ROUTINE MAINTENANCE, $	6471	6471	6471	6471	6471	6471	6471
ANNUAL TAXES, LICENSE AND REGISTRATION, $	240	240	240	213	240	240	240
INSURANCE, $	1343	1343	1343	1237	1343	1343	1343
FUEL, $	3468	3469	3468	3472	3457	4508	2428
B – OPERATING COSTS, $	11,522	11,523	11,522	11,393	11,511	12,562	10,482
C – LIFE CYCLE COST, $ (A+B)	25,347	25,348	25,347	25,218	25,336	26,387	25,307
D – LIFE – YEARS AT 100,000 MILES	7.52	7.52	7.52	7.03 ≅ 7.0	8.04 ≅ 8.0	7.52	7.52
COST / YEAR, $	3371	3371	3371	3603	3167	3509	3232
COST / MILE, $	25.3	25.3	2 25.3	25.3	25.5	26.4	24.3
COST / KILOMETER, $	15.8	15.8	15.8	15.7	15.7	16.4	15.1
E – ON–THE ROAD FUEL ECONOMY, mpg	27.7	27.7	27.7	27.7	27.7	27.7	27.7

With reference to the life cycle cost said gasoline price variations results in ±4% variations; the fuel cost incidence on the life cycle cost (13.7% under nominal conditions) varies from 17.1% (+30%) to 10% (-30%).

The other parameters have minor influence on the vehicle life cycle cost: negligible influence in the case of vehicle fleet variations and in the order of .3% or less in the case of annual travel variations (as a result of the difference in the average fuel price over the vehicle life).

4.2.2 Hybrid vehicle Life Cycle Cost

The results of the Life Cycle Cost sensitivity analysis are shown for the 1985 K_5 hybrid vehicles on Tables 4.2-2 through 4.2-5.

On the "Trade-off Studies" report the Life Cycle Costs were evaluated for Configurations No. 2 and 3 and for two battery types (Sodium-Sulphur and Lead-Acid); the sensitivity analysis was therefore performed for these 4 alternatives.

The same considerations made for the conventional vehicles with respect to acquisition cost sensitivity and annual taxes license, registration as well as the insurance figures apply to the hybrid vehicle.

The fuel cost, which under nominal conditions represented a variable percentage of the vehicle operating cost ranging from 18.1 to 19.6% (Configuration No. 3 with Na-S and Lead-Acid battery respectively) would range, for the same alternatives, from 22.3 to 24.1% (gasoline price +30%) and from 13.4 to 14.7% (gasoline price -30%).

The same fuel cost, expressed as a percentage of the vehicle life cycle cost, while ranging for said alternatives and under nominal conditions between 6.5 and 7.9%, would correspondingly range from 8.3 to 10.0% (gasoline price +30%) and from 4.8 to 5.7% (gasoline price -30%).

TABLE 4.2 – 2

K 5 HYBRID VEHICLE LIFE CYCLE COSTS – 1978 $ VALUE (1)

SENSITIVITY TO HIGH/LOW BOUNDARY PARAMETER VALUES

CONFIGURATION No. 2 WITH Na–S BATTERY

ITEM	NOMINAL & ± 7% Δ(FLEET)	Δ (ANNUAL TRAVEL)		Δ (GASOLINE PRICE)		Δ (ELECTRIC. PRICE)	
		+ 7 %	– 7%	+ 30%	– 30%	+ 30 %	– 10 %
PURCHASE PRICE (1)	12,150	12,150	12,150	12,150	12,150	12,150	12,150
SALES TAX (1)	607	607	607	607	607	607	607
INTEREST (1)	5,818	5,818	5,818	5,818	5,818	5,818	5,818
SALVAGE VALUE (1)	—	—	—	—	—	—	—
A – ACQUISITION COST	18,575	18,575	18,575	18,575	18,575	18,575	18,575
TIRES, REPAIRS AND ROUTINE MAINTENANCE	6,500	6,500	6,500	6,500	6,500	6,500	6,500
ANNUAL TAXES, LICENSE, AND REGISTRATION (1)	240	213	240	240	240	240	240
INSURANCE (1)	1,540	1,419	1,540	1,540	1,540	1,540	1,540
FUEL (GASOLINE)	2,536	1,953	1,948	2,536	2,536	2,536	2,536
ELECTRICITY	288	288	288	288	288	299	296
BATTERY REPLACEMENT REPAIRS, SALES TAX & INTEREST	—	—	—	—	—	—	—
B – OPERATING COSTS	10,458	10.313	10,556	11,044	9,874	10,529	10,458
C– LIFE CYCLE COST (A+B)	29,033	28,888	29,131	29,619	28,449	29,104	29,011
D – VEHICLE LIFE:	100,000 MILES						
YEARS OF LIFE	7,5	7,0	8,0	7,5	7,5	7,5	7,5
MILES / YEAR	13,300	14,230	12,430	13,300	13,300	13,300	13,300
COST / YEAR	3,861	4,127	3,641	3,939	3,783	3,871	3,858
COST / MILES, ¢	29,0	28,9	29,1	29,6	28,4	29,1	29,0
COST / KILOMETER, ¢	18,0	17,95	18,1	18,4	17,7	18,1	18,0

(1) SAME CONDITIONS AS ON TABLE 4,3 – 10 –"TRADE- OFF STUDIES REPORT, VOLUME I

ALL COSTS IN $ UNLESS OTHERWISE NOTED

TABLE 4.2 – 3
K 5 HYBRID VEHICLE LIFE CYCLE COSTS – 1978 $ VALUE (1)
SENSITIVITY TO HIGH/LOW BOUNDARY PARAMETER VALUES
CONFIGURATION No. 2 WITH LEAD ACID BATTERY

ITEM	NOMINAL & ± 7% Δ(FLEET)	Δ(ANNUAL TRAVEL)		Δ(GASOLINE PRICE)		Δ (ELECTRIC. PRICE)	
		+ 7%	– 7%	+ 30%	– 30%	+ 30%	– 10%
PURCHASE PRICE (1)	10,215	10,215	10,215	10,215	10,215	10,215	10,215
SALES TAX (1)	511	511	511	511	511	511	511
INTEREST (1)	4,891	4,891	4,891	4,891	4,891	4,891	4,891
SALVAGE VALUE (1)	—	—	—	—	—	—	—
A – ACQUISITION COST	15,617	15,617	15,617	15,617	15,617	15,617	15,617
TIRES, REPAIRS AND ROUTINE MAINTENANCE	6,500	6,500	6,500	6,500	6,500	6,500	6,500
ANNUAL TAXES, LICENSE, AND REGISTRATION (1)	240	213	240	240	240	240	240
INSURANCE (1)	1,419	1,282	1,419	1,419	1,419	1,419	1,419
FUEL (GASOLINE)	1,959	1,953	1,948	2,536	1,950	1,950	1,950
ELECTRICITY	181	181	181	181	181	237	164
BATTERY REPLACEMENT REPAIRS, SALES TAX & INTEREST	—	—	—	—	—	—	—
B – OPERATING COSTS	10,290	10,156	10,290	10,976	9,706	10,346	10,273
C– LIFE CYCLE COST (A+B)	25,907	25,773	25,907	26,493	25,323	25,963	25,890
D – VEHICLE LIFE:	100,000 MILES						
YEARS OF LIFE	7,5	7,0	8,0	7,5	7,5	7,5	7,5
MILES / YEAR	13,300	14,230	12,430	13,300	13,300	13,300	13,300
COST / YEAR	3,445	3,682	3,239	3,523	3,368	3,453	3,443
COST / MILES, ¢	25,9	25,2	25,9	26,5	25,3	26,0	25,9
COST / KILOMETER, ¢	16,1	16,0	16,1	16,5	15,7	16,1	16,1

(1) SAME CONDITIONS AS ON TABLE 4.3 – 10 – "TRADE-OFF STUDIES REPORT, VOLUME I

ALL COSTS IN $ UNLESS OTHERWISE NOTED

TABLE 4.2 – 4

K 5 HYBRID VEHICLE LIFE CYCLE COSTS – 1978 $ VALUE (1)
SENSITIVITY TO HIGH/LOW BOUNDARY PARAMETER VALUES
CONFIGURATION No. 3 WITH Na–S BATTERY

ITEM	NOMINAL & ± 7% Δ(FLEET)	Δ(ANNUAL TRAVEL) +7%	Δ(ANNUAL TRAVEL) −7%	Δ (GASOLINE PRICE) +30%	Δ (GASOLINE PRICE) −30%	Δ (ELECTRIC. PRICE) +30%	Δ (ELECTRIC. PRICE) +10%
PURCHASE PRICE (1)	12,024	12,024	12,024	12,024	12,024	12,024	12,024
SALES TAX (1)	601	501	601	601	601	601	601
INTEREST (1)	5,757	5,757	5,757	5,757	5,757	5,757	5,757
SALVAGE VALUE (1)	—	—	—	—	—	—	—
A – ACQUISITION COST	18,382	18,382	18,382	18,382	18,382	18,382	18,382
TIRES, REPAIRS AND ROUTINE MAINTENANCE	6,500	6,500	6,500	6,500	6,500	6,500	6,500
ANNUAL TAXES, LICENSE, AND REGISTRATION (1)	240	213	240	240	240	240	240
INSURANCE (1)	1,530	1,382	1,530	1,530	1,530	1,530	1,530
FUEL (GASOLINE)	1,865	1,869	1,864	2,427	1,307	1,866	1,866
ELECTRICITY	187	187	187	187	187	245	169
BATTERY REPLACEMENT REPAIRS, SALES TAX & INTEREST	—	—	—	—	—	—	—
B – OPERATING COSTS	10,323	10,178	10,321	10,884	9,764	10,305	
C– LIFE CYCLE COST (A+B)	28,705	28,660	28,703	29,266	28,146	28,763	28,687
D – VEHICLE LIFE:	100,000 MILES						
YEARS OF LIFE	7,5	7,0	8,0	7,5	7,5	7,5	7,5
MILES / YEAR	13,300	14,230	12,430	13,300	13,300	13,300	13,300
COST / YEAR	3,817	4,094	3,588	3,892	3,743	3,825	3,815
COST / MILES, ¢	28,7	28,7	28,7	29,3	28,1	28,8	28,7
COST / KILOMETER, ¢	17,8	17,8	17,8	18,2	17,5	17,9	17,8

(1) SAME CONDITIONS AS ON TABLE 4.3 – 10 –"TRADE OFF STUDIES REPORT, VOLUME I

ALL COSTS IN $ UNLESS OTHERWISE NOTED

TABLE 4.2 – 5

K 5 HYBRID VEHICLE LIFE CYCLE COSTS – 1978 $ VALUE (1)
SENSITIVITY TO HIGH/LOW BOUNDARY PARAMETER VALUES
CONFIGURATION No. 3 WITH LEAD ACID BATTERY

ITEM	NOMINAL & 7 (FLEET)	(ANNUAL TRAVEL)		(GASOLINE PRICE)		(ELECTRIC. PRICE)	
		– 7	– 7	– 30	– 30	– 30	– 10
PURCHASE PRICE (1)	10,089	10,089	10,089	10,089	10,089	10,089	10,089
SALES TAX (1)	504	504	504	504	504	504	504
INTEREST (1)	4,830	4,830	4,830	4,830	4,830	4,830	4,830
SALVAGE VALUE (1)	—	—	—	—	—	—	—
A – ACQUISITION COST	15,423	15,423	15,423	15,423	15,423	15,423	15,423
TIRES, REPAIRS AND ROUTINE MAINTENANCE	6,500	6,500	6,500	6,500	6,500	6,500	6,500
ANNUAL TAXES, LICENSE, AND REGISTRATION (1)	240	213	240	240	240	240	240
INSURANCE (1)	1,413	1,302	1,413	1,413	1,413	1,413	1,413
FUEL (GASOLINE)	2,035	2,038	2,033	2,646	1,425	2,035	2,035
ELECTRICITY	167	167	167	167	167	218	151
BATTERY REPLACEMENT REPAIRS, SALES TAX & INTEREST	—	—	—	—	—	—	—
B – OPERATING COSTS	10,355	10,220	10,353	10,966	9,745	10,406	10,339
C– LIFE CYCLE COST (A–B)	25,778	25,643	25,776	26,389	25,168	25,829	25,762
D – VEHICLE LIFE:	100,000 MILES						
YEARS OF LIFE	7,5	7,0	8,0	7,5	7,5	7,5	7,5
MILES / YEAR	13,300	14,230	12,430	13,300	13,300	13,300	13,300
COST / YEAR	3,428	3,663	3,222	3,509	3,427	3,435	3,426
COST / MILES, c	25,8	25,6	25,2	26,4	25,2	25,8	25,8
COST / KILOMETER, c	16,0	15,9	16,0	16,4	15,6	16,0	16,0

(1) SAME CONDITIONS AS ON TABLE 4.3 – 10 – "TRADE- OFF STUDIES REPORT, VOLUMEII

ALL COSTS IN $ UNLESS OTHERWISE NOTED

The electricity cost, which under nominal conditions ranged between .6 and .8% of the vehicle life cost and between 1.6 and 2.2% of the vehicle operating cost, would range between .8 and 1% of the vehicle life cycle cost and between 2.1 and 2.9% of the vehicle operating cost as a results of a 30% increase in the electricity price.

A -10% variation in the electricity price would result in the electricity cost ranging between .6 and .8% of the vehicle life cycle cost and between 1.4 and 1.9 of the vehicle operating cost.

It is worth noting that the optimization of the vehicle propulsion system, to be performed during the preliminary design, should results in a further reduction of the hybrid vehicle fuel consumption with respect to the conventional vehicle at the expense of a higher consumption of electricity.

If the most energy efficient solution is considered (configuration No. 3 with Na-S battery), it appears that, for the nominal conditions, against $ 3,519 of the conventional vehicle fuel cost over the operating life (100,000 miles) the gross fuel savings are $ 1,653 (46.5%) to be obtained by means of an additional electricity cost of $ 187 (that is to provide the same amount of useful energy at the vehicle wheels an 88.7% cost savings could be obtained if electric energy instead of fuel energy is used).

The corresponding figures for ±30% fuel price and +30, -10% electricity price are (always for configuration No. 3 with Na-S battery):

		Fuel price		Electricity Pric	
		+30%	-30%	+30%	-10%
Fuel cost for Conventional Vehicles,	$	4,560	2,460	3,519	3,519
Fuel cost for Hybrid Vehicle,	$	2,427	1,307	1,866	1,866
Fuel savings for Hybrid Vehicle.	$	2,130	1,150	1,653	1,653
Electricity cost for Hybrid Vehicle,	$	187	187	245	169
Cost saving of Electric vs. Fuel Energy	%	91.2	83.8	85.2	89.8

These results show the limits of the fuel cost savings as a result of an optimal hybrid vehicle operation: they would correspond to an essentially pure electric operation of the hybrid vehicle, over the vehicle operation life, the hybrid operation capability being justified by occasional vehicle operation beyond the pure electric driving range so that the fuel consumption over the vehicle life can be neglected.

If a 20/80% ratio of hybrid to pure electric operation is assumed together with the least favorable cost saving factor of Electric versus Fuel energy (Fuel price -30%), the total fuel cost would be $ 261 instead of $ 1,307 and the total electricity cost would be $ 37 (instead of $ 187 of the hybrid operation) and $ 356 (for the pure electric operation) instead of the corresponding $ 2,200 of fuel cost of the conventional vehicle.

The total energy cost would then be $ 261 (fuel) plus $ 393 (electricity) for a total of $ 654 to be compared with $ 2,460 for the conventional vehicle (73.5% saving).

The corresponding figures for the most favorable case (Fuel price +30%) are: $ 486 (fuel) plus $ 393 (electricity) for a total of $ 879 to be compared with $ 4,560 for the conventional vehicle (80.7% saving).

These results show that, to obtain the same life cycle cost under the existing assumptions (average vehicle usage, zero salvage value, 100,000 miles operating life, etc), the sum of purchase price related costs (purchase price, sales tax, interest, repairs and maintenance, insurance) of the hybrid vehicle should not exceed the savings in fuel cost with respect to the conventional vehicle, which, for the assumed parameter variation ranges, vary between 70 and 80% of the conventional vehicle fuel cost themselves.

Excluding therefore extraordinary variations in the assumed sales tax and/or financing conditions or parameter (fuel price) variations far beyond the sensitivity analysis boundaries, the possibility for the hybrid vehicle to meet the life cycle cost minimum requirement are confined to the possibility of identifying a more suitable approach to life cycle cost evaluation which could identify a vehicle usage sector where the K_5 hybrid vehicle could be more cost effective than the average K_5 conventional vehicle.

SECTION 5

FINAL RESULTS

The final results of the sensitivity analysis of Mission Analysis and Design Trade-off Studies results are summarized in this section to provide a comprehensive review of the impact on the Mission Specifications and vehicle characteristics and Performance Specifications of the parameter variations considered.

5.1 SENSITIVITY OF MISSION ANALYSIS RESULTS

The significant data on the sensitivity of Mission Analysis results to the boundary values given in Attachment 1 for Number of passenger cars, (Fleet), and Average Annual Vehicle Miles traveled per car, (Annual Travel) are presented on Table 5-1.

While reference is made to the Item Nos. referred to on Exhibit I, only the actually affected items are included.

The daily travel (M1) sensitivity to fleet variations is negligible at the 50th percentile level and is in the order of 1% or less at the 95th percentile level. The corresponding sensitivity to annual travel variations is respectively ± 10% (50th percentile) and +8%, -4% (95th percentile).

The daily trip characteristics (M3) are affected in a different manner by the fleet and annual travel variations: while both the trip length and frequency slightly decrease for either an increase or a decrease in the number of passenger cars, the sensitivity to the annual travel variations resulted to be approximately +3%, -4% for the trip length and +.5%, -6% for the frequency. The difference in the last two figures, as obtained from the calculations, does not seem reasonable as variations in daily travel are assumed to be evenly split between trip length and trip frequency so that the +.5% variation corresponding to +7% variation of annual travel should be likely revised as +5%.

The annual travel (M5) sensitivity to the fleet variations is within ±1% while the number of passenger cars (M6) sensitivity to annual travel is negligible under the existing assumptions. Due to the impact of the vehicle fleet variations on the fleet mix per mission, there is a sensitivity of the number of K5 vehicle in use on M_3 mission, which is approximately .2% (+7%) and +.8% (-7%).

TABLE 5 – 1
M3, K5 MISSION SPECIFICATION SENSITIVITY

No.	PARAMETER	NOMINAL	Δ (FLEET) +7%	Δ (FLEET) −7%	Δ (ANNUAL TRAVEL) +7%	Δ (ANNUAL TRAVEL) −7%
M1	DAILY TRAVEL, MILES (50 th PERCENTILE) (1)	20	20	20	22	18
	MILES (95 th PERCENTILE) (1)	142	144	141.5	153	136
M3	TRIP LENGTH, MILES (MEAN ONE-WAY)	11.0	10.95	10.8	11.3	10.6
	TRIP FREQUENCY, TRIP PER DAY (MEAN PER VEHICLE)	3.4	3.35	3.35	3.42	3.20
M4	DRIVING CYCLES PERCENTILE (4U + 10H = 149 MILES) REFERRED TO DAILY TRAVEL	95.5	95.0	95.5	94.5	96.5
M5	ANNUAL TRAVEL, MILES (MEAN PER VEHICLE)	13,300	13,400	13,200	14,200	12,400
	MILES (95 th PERCENTILE)	35,500	35,800	35,250	37,900	33,100
M6	VEHICLE IN USE, MILLIONS OF VEHICLES (TOTAL FLEET)	113.2	121.1	104.3	113.2	113.2
	MILLIONS OF VEHICLES (K5 CLASS)	24.9	26.6	22.9	24.9	24.9
	MILLIONS OF VEHICLES (M3, K5 CLASS)	22.6	24.2	21.0	22.6	22.6
	(% OF FLEET)	(20.0)	(20.0)	(20.0)	(20.0)	(20.0)
	(% OF K5 CLASS)	(91.0)	(90.8)	(91.7)	(91.0)	(91.0)
M7	ANNUAL FUEL CONSUMPTION (GALLONS PER VEHICLE)	480	484	476	513	448
	FLEET (ALL REF. VEHICL., ALL MISSIONS) GALLONS x 10^9	46.8	50.3	44.6	50.15	43.6
	FLEET (ALL REF. VEHICL., M3 MISSION) GALLONS x 10^9	28.2	29.9	28.1	30.4	26.3
	(% OF TOTAL)	(60.7)	(59.4)	(63.0)	(60.4)	(60.4)
	FLEET (K5 REF. VEHICL., M3 MISSION) GALLONS x 10^9	10.9	11.8	10.3	11.7	10.2
	(% OF TOTAL)	(23.5)	(23.4)	(23.2)	(23.3)	(23.3)

(1) CUMULATIVE PERCENT OF DAYS
(2) CUMULATIVE PERCENT OF K5 VEHICLE ON M3 MISSION

The fuel consumption (M7) sensitivity to the fleet variations is approximately +8% (+7%) and 5% (-7%) and does not vary significantly beyond the expected calculation results tolerance for either the whole fleet or the K5 vehicle on the M_3 missions.

If all the vehicles on the M_3 missions are considered, the calculated sensitivity is +6% (+7%) and .3% only (-7%) while there is a possibility that, under the existing assumptions, the resulting different distribution of vehicle sizes on the M_3 mission would provide an overall compensation, the significant difference existing between the .3% and 5% figures seems to favor the hypothesis of a cumulative error in the various steps of the required calculations.

Finally the Fuel Consumption sensitivity to the annual travel variations is as expected a quite straight forward ±7%.

5.2 SENSITIVITY OF VEHICLE CHARACTERISTICS AND PERFORMANCE SPECIFICATIONS

As outlined in the previous Section 4 - Interim Results, the Vehicle Characteristics and Performance Specifications are analyzed together for both conventional and hybrid vehicles: the sensitivity of the corresponding results for both the Mission Analysis and the Trade-off Studies are therefore considered and presented on Table 5-2.

The first item, vehicle range (V2), is by definition identical to the daily travel (M1) previously analyzed on Subsection 5.1 and therefore needs no further consideration.

The Cost Constraints (V3) do not vary under the existing assumptions for the initial and total acquisition costs. The operating cost sensitivity is negligible for fleet variations; it is in the order of -1% for a 7% increase in the annual travel due to the shorter vehicle life, assumed to be constant at 100,000 miles and in the order of -.1% for a 7% decrease in the same parameter. The operating cost sensitivity to gasoline price variation is on the other hand at approximately ±10% for a ±30% variation.

The minimum non refueled ranges (P1), as defined during the Mission Analysis and Performance Specifications Studies, are not related to the actual vehicle range capabilities but to the mission (M_3) daily range requirements. They express, therefore, the estimated non refueled ranges in the various standard driving cycles of a conventional ICE vehicle which has in each cycle the fuel economy defined in said Mission Analysis and Performance Specification Studies[1] and the "unusual" mission range capability defined above as V2. The sensitivity of the minimum non refueled ranges corresponds in percentage to that of the mission daily range as it results from fuel tank minimum capacity varying proportionally to said mission daily range. Since the actual vehicle tank capacity will exceed such minimum values, the actual minimum non

[1] See: Subsection 3.2.2.2* pages 3-63 through 3-66.

TABLE 5-2

SENSITIVITY OF M3 MISSION RELATED K5 VEHICLE CHARACTERISTICS & PERFORMANCE SPECIFICATIONS

	PARAMETER	NOMINAL	Δ(FLEET)		Δ (ANNUAL TRAVEL		Δ (GASOLINE) PRICE		Δ (ELECTR. PRICE)	
			+7%	−7%	+7%	−7%	+30%	−30%	+30%	−10%
V2	RANGE (DAILY 95 TH PERCENTILE), MILES	142	144	141.5	153	136	142	142	142	142
V3	COST CONSTRAINTS, 1978 $									
	INITIAL (PURCH. PR.+SLS TAX)	9,488	9,488	9,488	9,488	9,488	9,488	9,488	9,488	9,488
	ACQUISITION	13,825	13,825	13,825	13,825	13,825	13,825	13,825	13,825	13,825
	OPERATING	11,522	11,523	11,522	11,393	11,511	12,562	10,482	11,522	11,522
P1	MINIMUM NON REFUELED RANGE, MILES									
	P 1.1 FHDC	168	170	167	181	161	168	168	168	168
	P 1.2 FUDC	118	120	118	127	113	118	118	118	118
	P 1.3 J227 a (B)	90	91	90	97	86	90	90	90	90
P8	CONSUMER COSTS, 1978 $									
	P 8.1 CONSUMER PURCH. PRICE	9,500	9,500	9,500	9,500	9,500	9,500	9,500	9,500	9,500
	P 8.2 CONSUMER LIFE CYCL. COST (1)	15.8	15.8	15.8	15.7	15.8	16.4	15.1	15.8	15.8
P8A	CONSUMER COSTS (HYBRID VEHICLE), 1978 $									
	CONSUMER PURCH. PRICE									
	(Na−S BATT.)	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
	(LEAD−AC. BATT.)	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
	CONSUMER LIFE CYCLE COSTS									
	(Na−S BATT.)	17.8	17.8	17.8	17.8	17.8	18.2	17.5	17.9	17.8
	(LEAD−AC. BATT.)	16.0	16.0	16.0	15.9	16.0	16.4	15.6	16.0	16.0

(1) ¢ / km

refueled ranges will only depend on the actual fuel tank capacity and vehicle fuel economies in the various cycles, none of which has any sensitivity to the parameter variations being considered.

The consumer costs (P8) of the conventional vehicle are not affected by the above parameter variations as far as the projected consumer purchase price (P.8.1) is concerned. With reference to the consumer life cycle cost (P.8.2) of the Mission Analysis parameters, only the +7% variation of the annual travel results an appreciable variation (-.6%) due to the lower insurance, license and registration costs because of the vehicle life not exceeding the seventh year. The ±30% gasoline price variations, on the other hand, result in life cycle cost variations of ±4.1% (the 16.4 and 15.1 figures are rounded off to the next decimal).

For the Hybrid Vehicles, it has appeared appropriate to indicate a separate Consumer Purchase Price for the two solutions considered in the Design Trade-off studies.

While the operating conditions considered in the evaluation of the operating costs were not optimized to fully exploit the two batteries' different capabilities, two different purchase prices are shown for the two solutions to account for the actual difference in the manufacturing costs. While the figures shown, as rounded off to the next decimal, do not exactly represent the actual sensitivity of the life cycle cost to all the parameter variations (but the gasoline price) it can be stated that they are within ±.5%.

The sensitivity to the ±30% variation of the gasoline price is, for the hybrid vehicle, reduced to ±2% as a result of both the higher acquisition cost and the reduced gasoline fuel consumption. It is worth noting, however, that while the life cycle cost increase of the hybrid vehicle over the conventional vehicle is about 13% for the solution with the Sodium Sulphur battery and only 1.7% for the solution with the Lead-Acid battery, with respect to the gasoline price variations the corresponding life cycle cost increases are +11% (+30%) and +15.8% (-30%) for the Sodium-Sulphur battery vehicle and 0% (+30%) and +3.5% (-30%) for the Lead-Acid battery vehicle.