New Mexico on the Road: Impact of Fuel Consumption and CO_2 from NM Cars

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Introduction

The automobile is an essential part of daily life in New Mexican people. The transportation system in our state is not the most adequate, and *encourages* individuals to use personal, inefficient vehicles instead. Consider the greenhouse gas emissions and oil cost. The automobile's main contribution comes from the carbon dioxide (CO_2) emitted as the engine burns fuel. While the contribution of a single car emission is minimal, the collective contribution may become a problem of vast scale. Moreover, the fact that the amount of CO_2 associated with cars is the product of factors such as travel distances and type of cars, the problem may be aggravated by the low-efficient cars used by most New Mexicans and the large amount of driving distances. Furthermore, as a state that imports oil from other countries or states, the overall cost may be very high. In this preliminary report, we present a snapshot of the New Mexican's daily driving by analyzing a specific but important spot of New Mexico, namely, the I25 Interstate route between mile 230 (Albuquerque) to mile 283 (Santa Fe).

The report presents our initial research and data collection of automobile traffics in a representative place of the state, and illustrates a partial, simplified version of our proposed project. By automobiles we mean personal motor vehicles, including light trucks, such as pickups, SUVs, and VANs as well as sedans and wagons. We plan to expand this preliminary study and, as the time permits, applied to more areas of the state.

The remainder of this report is organized as follows. Section 2 presents the data collection, i.e., traffic and vehicle counts methodology. Section 3 defines different metrics used along the paper, and Section 4 concludes the report and gives an overview of our future work.

Data Collection

Traffic Count

This section describes the information of the traffic of the I25 Interstate between miles 233 (Albuquerque) and 283 (Santa Fe). The report contains the *Annual Average Daily Traffic* (AADT), which is currently listed in the New Mexico State Highway and Transportation Department's Consolidated Highway Data Base [1]. Table II in Appendix A presents the raw data quantifying the traffic. The Table II includes the following information:

- Posted Route: The Consolidated Highway Data Base identifies routes as Interstate, United States, New Mexico, County Road, Ramps, Frontage, Loops, etc.
- Beginning milepoint: identifies point where roadway section begins.
- Direction: where listing refers to a "P" and "M" at the same milepoint, this signifies a divided highway "Positive" and "Minus" directions. AADT for these two directions should be added together to get one AADT for the Traffic Section. Usually P = North and East bound direction of travel and M = South and West

bound direction of travel (according to the direction of the route). If only a “P” is listed this is not a divided highway and the AADT for both lanes has been totaled and listed.

- Functional Class: functional classification of roads used in traffic monitoring. For our studies, the functional class is always Interstate.
- County: reflects county name.
- Type: roadway Segment Type; example: 11 = Major Intersection, 12 = Major Intersection on Interstate, 19 = Minor, 23 = County Line, etc.
- Year: lists three years of AADT.
- Method: used to calculate AADT. The methods are: COV - count derived from recent coverage counts; AGF – Annual Growth Factor, generalized from coverage counts within the traffic segment and updated with loop and growth factors; GEN – count generalized from a coverage or ATR count; ATR – count collected from Automatic Traffic Recorder data; WIM – count collected from Weigh-In-Motion stations data. If a traffic section/segment has not had a coverage count within the three year count cycle, the AADT is factored, and considered non-standard data which lowers the confidence level.
- Year: year of actual coverage count.
- Terminus: Description of route section.
- Heavy Commercial: Percentage of Heavy Commercial Vehicles larger than a car, passenger truck, or motorcycle.

Part of the information in Table II in Appendix A is summarized in Figure 1, where the linear network topology refers to the main intersections in the I25 Interstate, between miles 233 and 283. The arrows and the numbers represent the traffic flow direction and number of vehicles, in thousands, in the flow direction. The nodes represent the main intersections or exits along the Interstate. Note that flow conservation constraints are violated, since the traffic entering or leaving the Interstate are not shown.

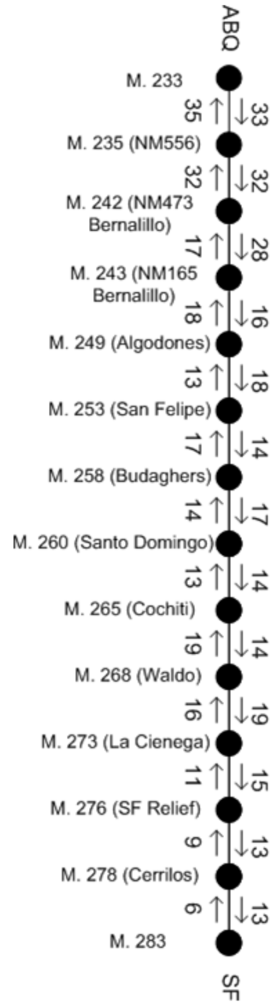

Figure 1. AADT between Santa Fe and Albuquerque. The arrows and the numbers represent the traffic flow direction and number of vehicles, in thousands, in the flow direction.

National Vehicle Count

Table I lists the rolling stock results by automaker, including estimates of the number of vehicles in service and their average on-road fuel economy. The data was obtained from the report by DeCicco and Fung [2]. These data were used to estimate not only the overall fuel consumption in the Interstate 25, between miles 233 and 283, but also the fuel consumption distribution by brand. The information in Table I permits us to know the vehicle population share, or ratio of a given automaker to the overall automobile population. For example, the vehicle population share of an automaker *B* is:

$$p_B = \frac{B \text{ vehicle population}}{\text{Overall vehicle population}}. \tag{1}$$

For example, for GM automaker, the share vehicle population is:

$$p_{GM} = \frac{\text{GM vehicle population}}{\text{Overall vehicle population}} = \frac{64.4}{203.7} = 0.31,$$

i.e., 31 % of the automobiles in the country are from GM.

Manufacturer	Vehicle population (millions)	On-road fuel economy (mpg)
GM	64.4	19.2
Ford	49.8	18.6
DaimlerChrysler	30.4	18.0
Toyota	18.6	21.6
Honda	13.3	24.2
Nissan	10.0	20.8
Volkswagen	3.7	22.7
Hyundai	2.8	23.8
Mitsubishi	3.0	21.8
BMW	2.0	19.7
Kia	1.3	21.0
Subaru	2.0	22.4
Others	2.5	19.1
Big Three	144.6	18.7
Overall	**203.7**	**19.6**

Table I. National vehicle stock and fuel consumption by automaker, 2004.

Metrics

In order to compute the oil consumption of an automobile, we focus on two main factors: Travel Demand (TD) and Fuel Use Rate (FUR).

Travel Demand

The travel demand accounts for the amount of driving or vehicle miles of travel (VMT). For our preliminary studies, we used the data shown in Section 2.1. We applied the travel demand computation procedure to all the I25 Interstate sections shown in Figure 1. For computation purposes, the following metrics are defined.

Aggregate Vehicle Travel Distance

This metric quantifies the aggregate vehicle travel distance (AVTD) per roadway section. For a given section, the AVTD is given by Equation (2):

$$\text{AVTD} = \text{AADT} \cdot \text{roadway section length.} \tag{2}$$

Aggregate Vehicle Travel Distance Per Automaker

We decompose the AVTD metric to study also the individual contribution of automobiles from different automakers. The aggregate vehicle travel distance of an automaker *B* (AVDT_B) per roadway section is given by:

$$\mathrm{AVTD}_B = \mathrm{AADT} \cdot p_B, \tag{3}$$

where p_B represents the vehicle population share of automaker *B* and is given by Equation (1).

Fuel Consumption Rate

The other main factor that contributes to fuel consumption is the fuel consumption rate, which can be defined as the inverse of the fuel economy. Thus, for an automobile of an automaker *B*, its fuel consumption rate ($\mathrm{FCR_B}$) is:

$$\mathrm{FCR}_B = \frac{1}{\text{on-road fuel economy of } B}, \tag{4}$$

where the on-road fuel economy of automaker *B* is given in Table I (in mpg).

Aggregate Fuel Consumption Per Automaker

This metric quantifies the aggregate fuel consumption of an automaker *B* ($\mathrm{AFC_B}$) per roadway section. For a given section, the $\mathrm{AFC_B}$ is given by Equation (5):

$$\mathrm{AFC}_B = \mathrm{AVTD}_B \cdot \mathrm{FCR}_B, \tag{5}$$

where $\mathrm{AVDT_B}$ and $\mathrm{FCR_B}$ are given by Equations (3) and (4) respectively.

Overall Aggregate Fuel Consumption Per Automaker

To compute the overall fuel consumption of an automaker, we define the overall aggregate fuel consumption of an automaker *B* ($\mathrm{OAFC_B}$) as:

$$\mathrm{OAFC}_B = \sum_{\forall \text{ roadway section } x} \mathrm{AVTD}_B \text{ (in section x)}. \tag{6}$$

where $\mathrm{AVDT_B}$ and $\mathrm{FCR_B}$ are given by Equations (3) and (4) respectively.

Overall Aggregate Fuel Consumption

Finally, we compute the overall aggregate fuel consumption (OAFC) that includes all automakers. This metric can be computed as:

$$\mathrm{OAFC} = \sum_{\forall B} \mathrm{OAFC}_B = \sum_{\forall B} \left(\sum_{\forall \text{ roadway section } x} \mathrm{AVTD}_B \text{ (in section x)} \right). \tag{7}$$

Preliminary Results

Figures 1 and 2 show the Annual Average Daily Traffic in both directions, south and north bounds. The portions of the I25 Interstate between miles 233 and 235 are heavily loaded compared to other portions because they represent entry (exit) points to (from) Albuquerque, as seeing in Figure 1 (Figure 2). Figure 1 also shows an approximated traffic flow of 15 thousands automobiles, except for some milestones such as 278, 276, 273 and 265. The first three milestones represent entry points to I25 Interstate south bound from Santa Fe (i.e., St. Francis Dr., Cerrillos Rd, and Santa Fe Relief), while the former represents a short portion of I25 Interstate, between Waldo Canyon and Cochiti Lake, that has higher AADT than those of other portions of the I25. Figure 3 shows the fuel consumption of each automaker given by Equation (6). Both north and south bound directions are taken into account. The estimations show that the fuel consumption of Americans GM, Ford, and DaimlerChrysler represent most of the total fuel consumption; the combined fuel consumption of these three automakers accounts for approximately 75 % of the total fuel consumption. Clearly, they have a disproportionate impact, burning more fuel per mile than the international average. Figure 4 shows the Overall Aggregate Fuel Consumption given by Equation (7). The bar at the left-hand side shows the OAFC for current conditions; the bar at the center illustrates the hypothetical case where all the automobiles are fuel-efficient. By fuel-efficient we mean a car such as Honda Fit 2009 [3], which has an on-route fuel economy of 33 mpg. Finally, the bar at the right-hand side shows the OAFC, assuming that: (i) fuel-efficient cars are used (Honda Fit); and (ii) automobiles are fully utilized (four persons per car, instead of the estimated 1.2 persons per can under current conditions). The purpose of comparing these three bars is to highlight the reasons of the non-efficient use of fuel in New Mexico: (i) the fuel use per mile or fuel economy of the cars; and (ii) aggregate vehicle travel distance. The latter is a determining factor in New Mexico, where the transportation heavily depends on automobiles.

Future Work

This paper has shown a preliminary report of fuel consumption in a strategic part of New Mexico, namely, along the I25 Interstate between Albuquerque and Santa Fe. It represents our initial research and data collection of automobile traffics along this representative route place of the state. We have defined the metrics AVTD, AVTDB, FCRB, AFCB, OAFCB, and OAFC, which (i) allow us to quantify fuel consumptions; and (ii) are fundamental to determine CO_2 emissions. The computation of CO_2 emissions is part of our future work, which will be completed at the end of this project. We plan also to validate the data of Table I, by researching if whether it accurately represents the automobile stock of New Mexico or not. Formulating the fuel consumption and CO_2 emission problems are also part of our future plans. If the time permits, we plan to devise a software to extract data from the Consolidated Highway Data Base [1] and automatically apply our model to all the roads of New Mexico.

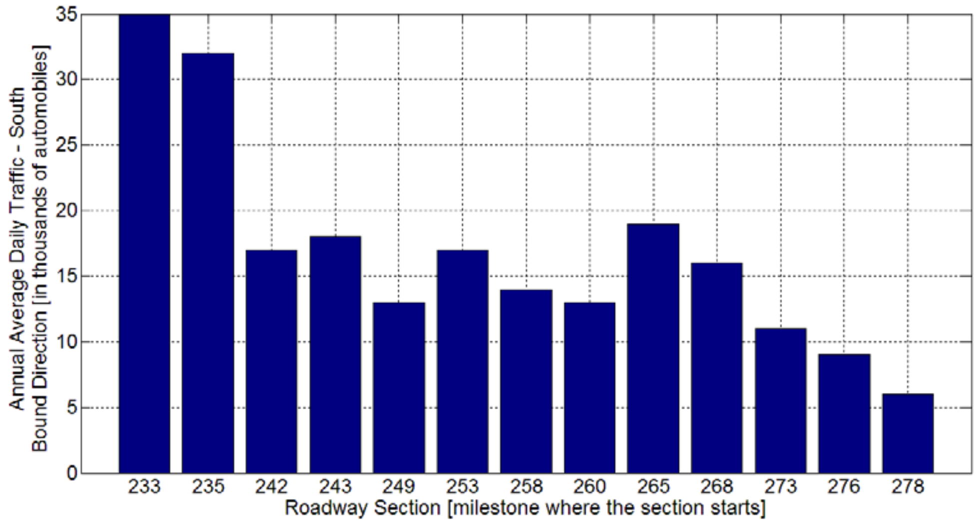

Figure 1: Annual Average Daily Traffic, south bound, in thousands of automobiles.

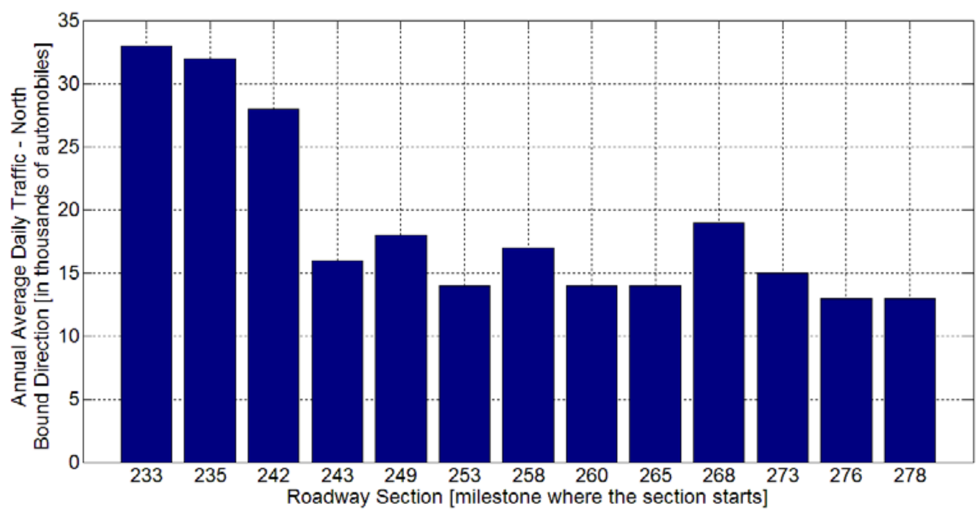

Figure 2: Annual Average Daily Traffic, north bound, in thousands of automobiles.

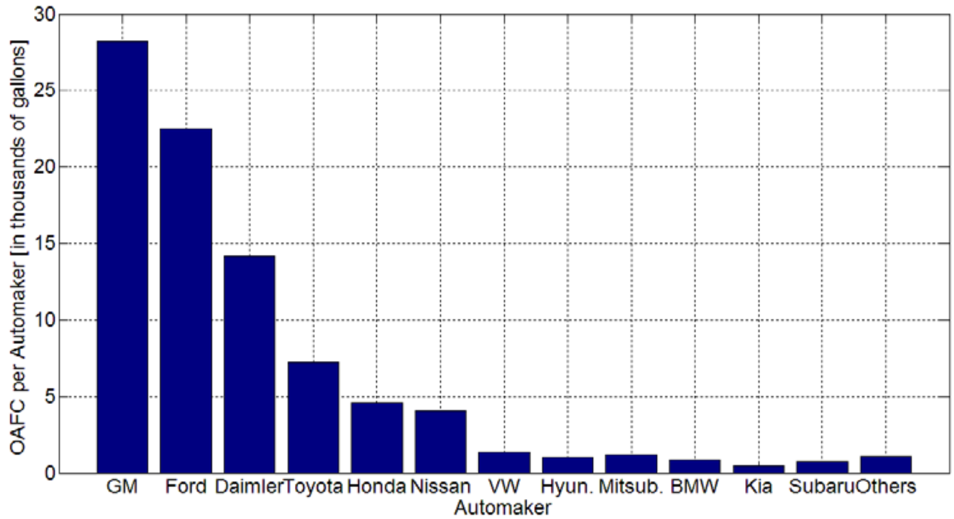

Figure 3. Overall Aggregate Fuel Consumption per Automaker, computed according to Equation (6).

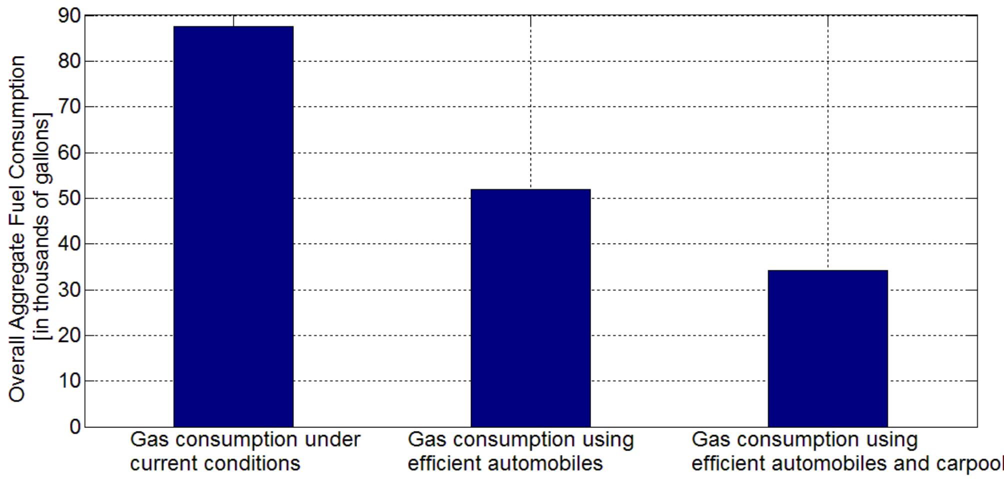

Figure 4. Overall Aggregate Fuel Consumption given by Equation (7).

Conclusion

Our report shows the preliminary data our research and data collection of the automobile traffic in representative places in the state of New Mexico (between Santa Fe and Albuquerque). Our report also illustrates a partial and simplified version of our proposed project. Since we proposed our project we have expanded our research and went more in depth with the research we showed previously. We've also completed our MatLab model. We also completed our project.

References

[1] New Mexico State Highway and Transportation Department's Consolidated Highway Data Base, available online: http://www.nmshtd.state.nm.us.

[2] J. DeCicco and F. Fung, Global Warming On the Road, Technical Report, 2006. Available online: http://www.edf.org/documents/5301_Globalwarmingontheroad.pdf.
[3] Honda Fit specifications. Available online: http://automobiles.honda.com/fit/

Appendix A – AADT Data Collection

Table II. Annual Average Daily Traffic in Interstate 25, between miles 233 and 283.

POSTED ROUTE	BEGIN MPNT	DIR	FUNC CLS	COUNTY	TYP	2008	2007	2006	METH	YEAR	TERMINUS	HEAVY COMM
I00025	229.911	M	INTS	BERNALILLO	1	76,085	78,386	76,253	ATR	2008		3
	229.911	P			1	78,953	81,320	78,965	ATR	2008		3
	230.600	M			12	77,219	75,901	74,139	AGF	1999	JEFFERSON INTERCHANGE	13
	230.600	P			12	78,459	77,120	75,330	AGF	1999	JEFFERSON INTERCHANGE	13
	231.126	M			1	77,219	75,901	74,139	AGF	1999		13
	231.126	P			1	78,459	77,120	75,330	AGF	1999		13
	231.770	M			12	70,835	69,626	68,010	AGF	1999	SAN MATEO BOULEVARD INTERCHANGE	13
	231.770	P			12	64,300	63,203	61,736	AGF	1999	SAN MATEO BOULEVARD INTERCHANGE	13
	231.800	M			1	70,835	69,626	68,010	AGF	1999		13
	231.800	P			1	64,300	63,203	61,736	AGF	1999		13
	231.831	M			1	70,835	69,626	68,010	AGF	1999		13
	231.831	P			1	64,300	63,203	61,736	AGF	1999		13
	232.000	M			1	70,835	69,626	68,010	AGF	1999		13
	232.000	P			1	64,300	63,203	61,736	AGF	1999		13
	232.205	M			12	65,682	64,561	63,063	AGF	1999	SAN ANTONIO AVENUE INTERCHANGE	13
	232.205	P			12	66,584	65,448	63,929	AGF	1999	SAN ANTONIO AVENUE INTERCHANGE.	13
	232.451	M			1	65,682	64,561	63,063	AGF	1999		13
	232.451	P			1	66,584	65,448	63,929	AGF	1999		13
	233.000	M			1	65,682	64,561	63,063	AGF	1999		13
	233.000	P			1	66,584	65,448	63,929	AGF	1999		13
	233.100	M			12	37,469	36,830	35,975	AGF	2005	PASEO DEL NORTE INTERCHANGE	13
	233.100	P			12	37,776	37,131	36,269	AGF	2005	PASEO DEL NORTE INTERCHANGE	13
	233.300	M			12	53,256	52,347	51,132	AGF	1999	PASEO DEL NORTE INTERCHANGE	13
	233.300	P			12	45,941	45,157	44,109	AGF	1999	PASEO DEL NORTE INTERCHANGE.	13
	233.471	M			1	53,256	52,347	51,132	AGF	1999		13
	233.471	P			1	45,941	45,157	44,109	AGF	1999		13
	233.600	M			1	53,256	52,347	51,132	AGF	1999		13
	233.600	P			1	45,941	45,157	44,109	AGF	1999		13
	233.800	M			12	37,748	37,104	36,243	AGF	1999	NM 528/ALAMEDA INTERCHANGE.	13
	233.800	P			12	33,282	32,714	31,955	AGF	1999	NM 528/ALAMEDA INTERCHANGE.	13
	233.841	M			12	37,748	37,104	36,243	AGF	1999		13
	233.841	P			12	33,282	32,714	31,955	AGF	1999		13
	233.891	M			12	37,748	37,104	36,243	AGF	1999		13
	233.891	P			12	33,282	32,714	31,955	AGF	1999		13
	234.191	M			1	37,748	37,104	36,243	AGF	1999		13
	234.191	P			1	33,282	32,714	31,955	AGF	1999		13
	234.321	M			12	37,748	37,104	36,243	AGF	1999		13
	234.321	P			12	33,282	32,714	31,955	AGF	1999		13
	234.400	M			1	37,748	37,104	36,243	AGF	1999		13
	234.400	P			1	33,282	32,714	31,955	AGF	1999		13
	234.600	M			1	37,748	37,104	36,243	AGF	1999		13
	234.600	P			1	33,282	32,714	31,955	AGF	1999		13
	234.946	M			1	37,748	37,104	36,243	AGF	1999		13
	234.946	P			1	33,282	32,714	31,955	AGF	1999		13
	235.000	M			1	37,748	37,104	36,243	AGF	1999		13

POSTED ROUTE	BEGIN MPNT	DIR	FUNC CLS	COUNTY	TYP	2008	2007	2006	METH	YEAR	TERMINUS	HEAVY COMM
I00025	235.000	P	INTS	BERNALILLO	1	33,282	32,714	31,955	AGF	1999		13
	235.186	M			12	31,659	31,119	30,397	AGF	1999	NM 556/TRAMWAY RD. INTERCHANGE.	13
	235.186	P			12	27,917	27,441	26,804	AGF	1999	NM 556/TRAMWAY RD. INTERCHANGE.	13
	235.200	M			12	31,659	31,119	30,397	AGF	1999	NM 556/TRAMWAY ROAD INTERCHANGE.	13
	235.200	P			12	27,917	27,441	26,804	AGF	1999	NM 556/TRAMWAY ROAD INTERCHANGE.	13
	235.321	M			12	30,018	29,506	31,056	AGF	2007		11
	235.321	P			12	24,913	24,488	27,379	AGF	2007		11
	235.334	M			12	35,487	36,365	36,421	AGF	1999	NM 556/TRAMWAY ROAD INTERCHANGE.	10
	235.334	P			12	31,962	32,753	32,804	AGF	1999	NM 556/TRAMWAY ROAD INTERCHANGE.	10
	235.371	M			1	35,487	36,365	36,421	AGF	1999		10
	235.371	P			1	31,962	32,753	32,804	AGF	1999		10
	235.400	M			1	35,487	36,365	36,421	AGF	1999	X	10
	235.400	P			1	31,962	32,753	32,804	AGF	1999	X	10
	235.561	M			12	35,487	36,365	36,421	AGF	1999	X	10
	235.561	P			12	31,962	32,753	32,804	AGF	1999	X	10
	235.691	M			12	28,463	29,167	29,212	AGF	2004	X	10
	235.691	P			12	26,361	27,013	27,055	AGF	2004	X	10
	235.841	M			12	35,487	36,365	36,421	AGF	1999	X	10
	235.841	P			12	31,962	32,753	32,804	AGF	1999	X	10
	236.210	M			1	35,487	36,365	36,421	AGF	1999		10
	236.210	P			1	31,962	32,753	32,804	AGF	1999		10
	236.299	M		SANDOVAL	23	35,487	36,365	36,421	AGF	1999	BERNALILLO/SANDOVAL COUNTY LINE.	10
	236.299	P			23	31,962	32,753	32,804	AGF	1999	BERNALILLO/SANDOVAL COUNTY LINE.	10
	236.300	M			1	35,487	36,365	36,421	AGF	1999		10
	236.300	P			1	31,962	32,753	32,804	AGF	1999		10
	239.794	M			1	35,487	36,365	36,421	AGF	1999		10
	239.794	P			1	31,962	32,753	32,804	AGF	1999		10
	239.900	M			1	35,487	36,365	36,421	AGF	1999		10
	239.900	P			1	31,962	32,753	32,804	AGF	1999		10
	241.347	M			1	35,487	36,365	36,421	AGF	1999		10
	241.347	P			1	31,962	32,753	32,804	AGF	1999		10
	241.858	M			1	35,487	36,365	36,421	AGF	1999		10
	241.858	P			1	31,962	32,753	32,804	AGF	1999		10
	242.000	M			1	35,487	36,365	36,421	AGF	1999		10
	242.000	P			1	31,962	32,753	32,804	AGF	1999		10
	242.100	M			12	31,503	30,965	31,428	AGF	1999	NM 473--BERNALILLO INTERCHANGE.	12
	242.100	P			12	28,385	27,901	28,318	AGF	1999	NM 473--BERNALILLO INTERCHANGE.	12
	242.123	M			1	31,503	30,965	31,428	AGF	1999		12
	242.123	P			1	28,385	27,901	28,318	AGF	1999		12
	242.300	M			1	31,503	30,965	31,428	AGF	1999		12
	242.300	P			1	28,385	27,901	28,318	AGF	1999		12
	242.398	M			1	31,503	30,965	31,428	AGF	1999		12
	242.398	P			1	28,385	27,901	28,318	AGF	1999		12
	242.657	M			1	31,503	30,965	31,428	AGF	1999		12
	242.657	P			1	28,385	27,901	28,318	AGF	1999		12

POSTED ROUTE	BEGIN MPNT	DIR	FUNC CLS	COUNTY	TYP	2008	2007	2006	METH	YEAR	TERMINUS	HEAVY COMM
I00025	243.392	M	INTS	SANDOVAL	1	31,503	30,965	31,428	AGF	1999		12
	243.392	P			1	28,385	27,901	28,318	AGF	1999		12
	243.500	M			12	17,027	16,736	16,986	AGF	1999	I-25 EXIT 242 -- US 550 AND NM 165 (BERNALILL	10
	243.500	P			12	14,939	14,684	14,904	AGF	1999	I-25 EXIT 242 -- US 550 AND NM 165 (BERNALILL	10
	243.533	M			12	14,429	14,183	14,395	AGF	2005	I-25 EXIT 242 -- US 550 AND NM 165 (BERNALILL	10
	243.533	P			12	13,851	13,615	13,819	AGF	2005	I-25 EXIT 242 -- US 550 AND NM 165 (BERNALILL	10
	243.921	M			12	17,027	16,736	16,986	AGF	1999		10
	243.921	P			12	14,939	14,684	14,904	AGF	1999		10
	244.434	M			12	16,953	16,664	16,913	AGF	2004	I-25 EXIT 242 -- US 550 AND NM 165 (BERNALILL	10
	244.434	P			12	15,806	15,536	15,768	AGF	2004	I-25 EXIT 242 -- US 550 AND NM 165 (BERNALILL	10
	244.440	M			1	16,953	16,664	16,913	AGF	2004		10
	244.440	P			1	15,806	15,536	15,768	AGF	2004		10
	244.640	M			1	16,953	16,664	16,913	AGF	2004		10
	244.640	P			1	15,806	15,536	15,768	AGF	2004		10
	246.500	M			1	16,953	16,664	16,913	AGF	2004		10
	246.500	P			1	15,806	15,536	15,768	AGF	2004		10
	246.606	M			1	16,953	16,664	16,913	AGF	2004	3.073 MILES NORTH OF I-25 EXIT 242 (US 550/NM	10
	246.606	P			1	15,806	15,536	15,768	AGF	2004	3.073 MILES NORTH OF I-25 EXIT 242 (US 550/NM	10
	246.838	M			1	16,953	16,664	16,913	AGF	2004		10
	246.838	P			1	15,806	15,536	15,768	AGF	2004		10
	247.861	M			1	16,953	16,664	16,913	AGF	2004		10
	247.861	P			1	15,806	15,536	15,768	AGF	2004		10
	249.258	M			12	17,864	17,559	17,822	AGF	2004	JCT NM 474 -- ALGODONES (EXIT 249).	10
	249.258	P			12	18,203	17,892	18,159	AGF	2004	JCT NM 474 -- ALGODONES (EXIT 249).	10
	249.921	M			1	17,864	17,559	17,822	AGF	2004		10
	249.921	P			1	18,203	17,892	18,159	AGF	2004		10
	251.000	M			1	17,864	17,559	17,822	AGF	2004		10
	251.000	P			1	18,203	17,892	18,159	AGF	2004		10
	251.056	M			1	17,864	17,559	17,822	AGF	2004		10
	251.056	P			1	18,203	17,892	18,159	AGF	2004		10
	251.374	M			1	17,864	17,559	17,822	AGF	2004		10
	251.374	P			1	18,203	17,892	18,159	AGF	2004		10
	251.460	M			1	17,864	17,559	17,822	AGF	2004		10
	251.460	P			1	18,203	17,892	18,159	AGF	2004		10
	251.480	M			1	17,864	17,559	17,822	AGF	2004		10
	251.480	P			1	18,203	17,892	18,159	AGF	2004		10
	251.518	M			1	17,864	17,559	17,822	AGF	2004		10
	251.518	P			1	18,203	17,892	18,159	AGF	2004		10
	252.628	M			1	17,864	17,559	17,822	AGF	2004		10
	252.628	P			1	18,203	17,892	18,159	AGF	2004		10
	252.710	M			1	17,864	17,559	17,822	AGF	2004		10
	252.710	P			1	18,203	17,892	18,159	AGF	2004		10
	252.850	M			1	17,864	17,559	17,822	AGF	2004		10
	252.850	P			1	18,203	17,892	18,159	AGF	2004		10
	253.736	M			12	16,385	16,790	16,816	AGF	1999	NM 315-SAN FELIPE PUEBLO INTERCHANGE.	10

POSTED ROUTE	BEGIN MPNT	DIR	FUNC CLS	COUNTY	TYP	2008	2007	2006	METH	YEAR	TERMINUS	HEAVY COMM
I00025	253.736	P	INTS	SANDOVAL	12	15,923	16,317	16,342	AGF	1999	NM 315-SAN FELIPE PUEBLO INTERCHANGE.	10
	253.800	M			12	16,385	16,790	16,816	AGF	1999	NM 315-SAN FELIPE PUEBLO INTERCHANGE.	9
	253.800	P			12	15,923	16,317	16,342	AGF	1999	NM 315-SAN FELIPE PUEBLO INTERCHANGE.	9
	253.994	M			12	12,761	13,077	13,097	AGF	2005	NM315 SAN FELIPE PUEBLO INTERCHANGE	10
	253.994	P			12	13,507	13,841	13,862	AGF	2005	NM315 SAN FELIPE PUEBLO INTERCHANGE	10
	254.080	M			1	12,761	13,077	13,097	AGF	2005		10
	254.080	P			1	13,507	13,841	13,862	AGF	2005		10
	254.100	M			1	12,761	13,077	13,097	AGF	2005		10
	254.100	P			1	13,507	13,841	13,862	AGF	2005		10
	256.985	M			1	12,761	13,077	13,097	AGF	2005		10
	256.985	P			1	13,507	13,841	13,862	AGF	2005		10
	257.080	M			1	12,761	13,077	13,097	AGF	2005		10
	257.080	P			1	13,507	13,841	13,862	AGF	2005		10
	257.100	M			1	12,761	13,077	13,097	AGF	2005		10
	257.100	P			1	13,507	13,841	13,862	AGF	2005		10
	257.372	M			1	12,761	13,077	13,097	AGF	2005		10
	257.372	P			1	13,507	13,841	13,862	AGF	2005		10
	257.404	M			1	12,761	13,077	13,097	AGF	2005		10
	257.404	P			1	13,507	13,841	13,862	AGF	2005		10
	258.650	M			1	12,761	13,077	13,097	AGF	2005		10
	258.650	P			1	13,507	13,841	13,862	AGF	2005		10
	258.916	M			12	15,553	15,938	15,963	AGF	2002	BUDAGHERS INTERCHANGE	10
	258.916	P			12	14,962	15,332	15,356	AGF	2002	BUDAGHERS INTERCHANGE.	10
	259.000	M			12	17,559	17,993	18,021	AGF	2002	BUDAGHERS INTERCHANGE	9
	259.000	P			12	17,354	17,783	17,810	AGF	2002	BUDAGHERS INTERCHANGE	9
	259.342	M			1	17,559	17,993	18,021	AGF	2002		9
	259.342	P			1	17,354	17,783	17,810	AGF	2002		9
	259.906	M			1	17,559	17,993	18,021	AGF	2002		9
	259.906	P			1	17,354	17,783	17,810	AGF	2002		9
	259.924	M			1	17,559	17,993	18,021	AGF	2002		9
	259.924	P			1	17,354	17,783	17,810	AGF	2002		9
	260.400	M			12	13,237	13,564	13,585	AGF	2003	NM22 SANTO DOMINGO PUEBLO INTERCHANGE	10
	260.400	P			12	14,088	14,436	14,458	AGF	2003	NM22 SANTO DOMINGO PUEBLO INTERCHANGE	10
	260.606	M			12	15,494	15,877	15,901	AGF	1999	NM22 SANTO DOMINGO PUEBLO INTERCHANGE.	10
	260.606	P			12	15,038	15,410	15,434	AGF	1999	NM22 SANTO DOMINGO PUEBLO INTERCHANGE.	10
	260.890	M			12	14,103	14,452	14,474	AGF	2005	NM22 SANTO DOMINGO PUEBLO INTERCHANGE	5
	260.890	P			12	14,208	14,559	14,581	AGF	2005	NM22 SANTO DOMINGO PUEBLO INTERCHANGE	5
	260.910	M			1	14,103	14,452	14,474	AGF	2005		5
	260.910	P			1	14,208	14,559	14,581	AGF	2005		5
	263.400	M			1	14,103	14,452	14,474	AGF	2005		5
	263.400	P			1	14,208	14,559	14,581	AGF	2005		5
	263.414	M			1	14,103	14,452	14,474	AGF	2005		5
	263.414	P			1	14,208	14,559	14,581	AGF	2005		5
	264.490	M			1	14,103	14,452	14,474	AGF	2005		5
	264.490	P			1	14,208	14,559	14,581	AGF	2005		5

POSTED ROUTE	BEGIN MPNT	DIR	FUNC CLS	COUNTY	TYP	2008	2007	2006	METH	YEAR	TERMINUS	HEAVY COMM
I00025	264.504	M	INTS	SANTA FE	23	14,103	14,452	14,474	AGF	2005	SANDOVAL/SANTA FE COUNTY LINE	5
	264.504	P			23	14,208	14,559	14,581	AGF	2005	SANDOVAL/SANTA FE COUNTY LINE	5
	264.524	M			1	14,103	14,452	14,474	AGF	2005		5
	264.524	P			1	14,208	14,559	14,581	AGF	2005		5
	264.952	M			1	14,103	14,452	14,474	AGF	2005		5
	264.952	P			1	14,208	14,559	14,581	AGF	2005		5
	265.171	M			1	14,103	14,452	14,474	AGF	2005		5
	265.171	P			1	14,208	14,559	14,581	AGF	2005		5
	265.181	M			1	14,103	14,452	14,474	AGF	2005		5
	265.181	P			1	14,208	14,559	14,581	AGF	2005		5
	265.786	M			12	16,347	16,751	16,777	AGF	2004	NM16 COCHITI LAKE INTERCHANGE	13
	265.786	P			12	17,022	17,443	17,470	AGF	2004	NM16 COCHITI LAKE INTERCHANGE	13
	266.146	M			12	18,636	19,097	19,126	AGF	2002	NM16 COCHITI LAKE INTERCHANGE	28
	266.146	P			12	15,557	15,942	15,967	AGF	2002	NM16 COCHITI LAKE INTERCHANGE.	28
	266.210	M			12	12,510	12,819	12,839	AGF	2006	NM16 COCHITI LAKE INTERCHANGE	10
	266.210	P			12	14,172	14,523	14,545	AGF	2006	NM16 COCHITI LAKE INTERCHANGE	10
	266.230	M			1	12,510	12,819	12,839	AGF	2006		10
	266.230	P			1	14,172	14,523	14,545	AGF	2006		10
	267.652	M			1	12,510	12,819	12,839	AGF	2006		10
	267.652	P			1	14,172	14,523	14,545	AGF	2006		10
	267.700	M			1	12,510	12,819	12,839	AGF	2006		10
	267.700	P			1	14,172	14,523	14,545	AGF	2006		10
	268.100	M			1	12,510	12,819	12,839	AGF	2006		10
	268.100	P			1	14,172	14,523	14,545	AGF	2006		10
	268.348	M			1	12,510	12,819	12,839	AGF	2006		10
	268.348	P			1	14,172	14,523	14,545	AGF	2006		10
	268.358	M			1	12,510	12,819	12,839	AGF	2006		10
	268.358	P			1	14,172	14,523	14,545	AGF	2006		10
	268.730	M			12	19,032	18,483	17,945	ATR	2008	WALDO INTERCHANGE	19
	268.730	P			12	18,580	18,167	17,748	ATR	2008	WALDO INTERCHANGE	19
	268.930	M			1	19,032	18,483	17,945	ATR	2008		19
	268.930	P			1	18,580	18,167	17,748	ATR	2008		19
	269.204	M			1	19,032	18,483	17,945	ATR	2008		19
	269.204	P			1	18,580	18,167	17,748	ATR	2008		19
	271.332	M			1	19,032	18,483	17,945	ATR	2008		19
	271.332	P			1	18,580	18,167	17,748	ATR	2008		19
	271.931	M			1	19,032	18,483	17,945	ATR	2008		19
	271.931	P			1	18,580	18,167	17,748	ATR	2008		19
	272.930	M			12	12,027	17,412	17,008	COV	2008	EXIT 271 -- LA CIENEGA INTERCHANGE (C.R. 50F/	20
	272.930	P			12	14,589	17,488	17,082	COV	2008	EXIT 271 -- LA CIENEGA INTERCHANGE (C.R. 50F/	20
	273.130	M			12	16,012	15,739	17,173	AGF	2007	EXIT 271 -- LA CIENEGA INTERCHANGE (C.R. 50F/	22
	273.130	P			12	15,489	15,225	13,956	AGF	2007	EXIT 271 -- LA CIENEGA INTERCHANGE (C.R. 50F/	22
	276.700	M			1	16,012	15,739	17,173	AGF	2007		22
	276.700	P			1	15,489	15,225	13,956	AGF	2007		22
	276.796	M			1	16,012	15,739	17,173	AGF	2007		22

POSTED ROUTE	BEGIN MPNT	DIR	FUNC CLS	COUNTY	TYP	2008	2007	2006	METH	YEAR	TERMINUS	HEAVY COMM
I00025	276.796	P	INTS	SANTA FE	1	15,489	15,225	13,956	AGF	2007		22
	277.070	M			12	11,044	14,968	14,621	COV	2008	EXIT 276 -- NM 599 INTERCHANGE (SANTA FE BYPA	15
	277.070	P			12	12,623	13,730	13,411	COV	2008	EXIT 276 -- NM 599 INTERCHANGE (SANTA FE BYPA	15
	277.307	M			1	11,044	14,968	14,621	COV	2008		15
	277.307	P			1	12,623	13,730	13,411	COV	2008		15
	277.703	M			1	11,044	14,968	14,621	COV	2008		15
	277.703	P			1	12,623	13,730	13,411	COV	2008		15
	278.910	M			12	14,078	13,838	13,517	AGF	2002	NM14, CERRILLOS ROAD INTERCHANGE	17
	278.910	P			12	14,390	14,144	13,816	AGF	2002	NM14, CERRILLOS ROAD INTERCHANGE	17
	278.926	M			12	8,890	16,121	15,747	COV	2008	NM14, CERRILLOS ROAD INTERCHANGE.	15
	278.926	P			12	12,875	16,719	16,331	COV	2008	NM14, CERRILLOS ROAD INTERCHANGE.	15
	279.110	M			1	8,890	16,121	15,747	COV	2008		15
	279.110	P			1	12,875	16,719	16,331	COV	2008		15
	281.978	M			1	8,890	16,121	15,747	COV	2008		15
	281.978	P			1	12,875	16,719	16,331	COV	2008		15
	283.000	M			1	8,890	16,121	15,747	COV	2008		15
	283.000	P			1	12,875	16,719	16,331	COV	2008		15
	283.800	M			12	6,594	6,481	6,331	AGF	2005	US84 SAINT FRANCIS DRIVE INTERCHANGE	10
	283.800	P			12	10,178	10,004	9,772	AGF	2005	US84 SAINT FRANCIS DRIVE INTERCHANGE	10
	283.810	M			12	7,851	7,717	7,538	AGF	2004	US84 SAINT FRANCIS DRIVE INTERCHANGE	10
	283.810	P			12	13,012	12,790	12,493	AGF	2004	US84 SAINT FRANCIS DRIVE INTERCHANGE	10
	283.831	M			12	11,573	11,376	11,112	AGF		US84 SAINT FRANCIS DRIVE INTERCHANGE	10
	283.831	P			12	11,573	11,376	11,112	AGF		US84 SAINT FRANCIS DRIVE INTERCHANGE	10
	283.833	M			12	11,539	11,342	11,079	AGF	2000	US84 SAINT FRANCIS DRIVE INTERCHANGE.	10
	283.833	P			12	13,204	12,979	12,678	AGF	2000	US84 SAINT FRANCIS DRIVE INTERCHANGE.	10
	283.931	M			12	6,282	11,097	10,839	COV	2008	US84 SAINT FRANCIS DRIVE INTERCHANGE	16
	283.931	P			12	9,081	13,095	12,791	COV	2008	US84 SAINT FRANCIS DRIVE INTERCHANGE	16
	284.010	M			1	6,282	11,097	10,839	COV	2008		16
	284.010	P			1	9,081	13,095	12,791	COV	2008		16
	284.313	M			1	6,282	11,097	10,839	COV	2008		16
	284.313	P			1	9,081	13,095	12,791	COV	2008		16
	284.504	M			1	6,282	11,097	10,839	COV	2008		16
	284.504	P			1	9,081	13,095	12,791	COV	2008		16
	285.230	M			12	12,649	12,433	12,144	AGF	1997	NM466, US285, OLD PECOS TRAIL INTERCHANGE	10
	285.230	P			12	11,873	11,670	11,399	AGF	1997	NM466, US285, OLD PECOS TRAIL INTERCHANGE	10
	285.332	M			12	11,763	12,687	13,036	ATR	2008	NM466, US285, OLD PECOS TRAIL INTERCHANGE	13
	285.332	P			12	11,302	12,097	12,352	ATR	2008	NM466, US285, OLD PECOS TRAIL INTERCHANGE	13
	285.430	M			1	11,763	12,687	13,036	ATR	2008		13
	285.430	P			1	11,302	12,097	12,352	ATR	2008		13
	285.915	M			1	11,763	12,687	13,036	ATR	2008		13
	285.915	P			1	11,302	12,097	12,352	ATR	2008		13
	290.490	M			1	11,763	12,687	13,036	ATR	2008		13
	290.490	P			1	11,302	12,097	12,352	ATR	2008		13
	290.980	M			1	11,763	12,687	13,036	ATR	2008		13
	290.980	P			1	11,302	12,097	12,352	ATR	2008		13

Appendix B – MatLab Code

```
clear all;
close all;
%----------------------------------------------------------
%
%                    INPUT PARAMETERS
%
%----------------------------------------------------------

% D REFERS TO THE DISTANCE IN MILES BETWEEN MILESTONES
D = [5 7 1 6 4 5 2 5 3 5 1 2 5];

% CARS BETWEEN MILESTONES;
%F_ABQ_SF: VEHICLES TRAVELING FROM ABQ TO SF
F_ABQ_SF = [33 32 28 16 18 14 17 14 14 19 15 13 13]*1E3;

%F_SF_ABQ: VEHICLES TRAVELING FROM SF TO ABQ
F_SF_ABQ = [35 32 17 18 13 17 14 13 19 16 11 9 6]*1E3;

% RATIO OF PERSONAL MOTOR VEHICLES TO TOTAL VEHICLES
PMV = [0.9 0.88 0.9 0.9 0.9 0.91 0.95 0.9 0.81 0.78 0.85 0.85 0.86];

% ATD REFERS TO THE AGGREGATE TRAVEL DISTANCE
ATD_ABQ_SF = F_ABQ_SF.*D.*PMV;
ATD_SF_ABQ = F_SF_ABQ.*D.*PMV;

% VEHICLE POPULATION, IN THIS ORDER:
```

```
% 1- GM 2- FORD 3- DAIMLER-CHRYSLER 4- TOYOTA 5- HONDA 6- NISSAN 7-
% VOLKSWAGEN 8- HYUNDAI 9- MITSUBISHI 10- BMW 11- KIA 12- SUBARU 13- OTHERS
VP = [0.316 0.244 0.149 0.091 0.065 0.049 0.018 0.014 0.015 0.01 0.006 0.01
0.012];

% RATE CONSUMPTION, IN GALLONS PER MILE, PER BRAND IN THE ABOVE ORDER
RC = [1/19.2 1/18.6 1/18 1/21.6 1/24.2 1/20.8 1/22.7 1/23.8 1/21.8 1/19.7
1/21.0 1/22.4 1/19.1];


% AVERAGE NUMBER OF PASSENGERS PER VEHICLE
APPV = 1.2;

% AVERAGE CAPACITY PER VEHICLE
PCPV = 5;

%-------------------------------------------------------
%
%                    COMPUTATION
%
%-------------------------------------------------------

% CONSUMPTION PER BRAND
CPB_ABQ_SF = zeros(length(RC), length(ATD_ABQ_SF));
CPB_SF_ABQ = zeros(length(RC), length(ATD_SF_ABQ));

for i = 1:length(RC),
    CPB_ABQ_SF(i,:) = ATD_ABQ_SF*RC(i)*VP(i);
    CPB_SF_ABQ(i,:) = ATD_SF_ABQ*RC(i)*VP(i);
end

%TOTAL CONSUMPTION, ADDING ALL THE MILESTONES
TTC = zeros(length(RC),1);
for i = 1:length(RC),
    for j = 1:length(CPB_ABQ_SF),
        TTC(i) = TTC(i) + CPB_ABQ_SF(i,j) + CPB_SF_ABQ(i,j);
    end
end

% TRANSPORT CAPACITY = (VEHICLES)*(AVERAGE CAPACITY PER VEHICLE)
TC_ABQ_SF = ATD_ABQ_SF*PCPV;
TC_SF_ABQ = ATD_SF_ABQ*PCPV;
TTTC = sum(TC_ABQ_SF) + sum(TC_SF_ABQ);


% TOTAL GAS CONSUMPTION, INCLUDING OR AUTOMAKERS
TGC = sum(TTC);

% WHAT WOULD BE THE TOTAL GAS CONSUMPTION IF PEOPLE START USING
% A GAS EFFICIENT CAR, SAY A HONDA FIT (33 MPG)
RC_FIT = 1/33;
GC_EFFICIENT_ABQ_SF = ATD_ABQ_SF*RC_FIT;
GC_EFFICIENT_SF_ABQ = ATD_SF_ABQ*RC_FIT;
TGC_EFFICIENT = sum(GC_EFFICIENT_ABQ_SF) + sum(GC_EFFICIENT_SF_ABQ);

% WHAT WOULD BE THE TOTAL GAS CONSUMPTION IF PEOPLE CAR-POOL USING
% A GAS EFFICIENT CAR AS BEFORE, HONDA FIT.

%NC: NUMBER OF CARS THAT WOULD BE NEEDED; FIT_CAP: FIT CAPACITY
FIT_CAP = 4;
NC_ABQ_SF = (F_ABQ_SF.*PMV)*APPV/FIT_CAP;
NC_SF_ABQ = (F_SF_ABQ.*PMV)*APPV/FIT_CAP;
```

```
% ATD_EFFICIENT_CAR_POOL REFERS TO THE AGGREGATE TRAVEL DISTANCE APPLYING
% CAR-POOL W/ AN EFFICIENT AUTOMOBILE
ATD_EFFICIENT_CAR_POOL_ABQ_SF = NC_ABQ_SF.*D;
ATD_EFFICIENT_CAR_POOL_SF_ABQ = NC_SF_ABQ.*D;

%TC_EFFICIENT_CAR_POOL
TGC_EFFICIENT_CAR_POOL = sum(ATD_ABQ_SF*RC_FIT) +
sum(ATD_EFFICIENT_CAR_POOL_SF_ABQ*RC_FIT);

%USED TRANSPORT CAPACITY;
UTC_ABQ_SF = ATD_ABQ_SF*APPV;
UTC_SF_ABQ = ATD_SF_ABQ*APPV;
TTUC = sum(UTC_ABQ_SF) + sum(UTC_SF_ABQ);

%-----------------------------------------------------------------------
% PLOT OVERALL AGGREGATE FUEL CONSUMPTION PER AUTOMAKER
%-----------------------------------------------------------------------
figure(1);
bar(TTC/1000);
ylabel('OAFC per Automaker [in thousands of gallons]');
xlabel('Automaker');
grid on;
%set(gca,'XTick',-pi:pi/2:pi);
set(gca,'XTickLabel',{'GM','Ford','Daimler','Toyota','Honda', 'Nissan', 'VW',
'Hyun.', 'Mitsub.', 'BMW', 'Kia', 'Subaru', 'Others'});


%-----------------------------------------------------------------------
% PLOT AUTOMOBILES PER SECTION
%-----------------------------------------------------------------------
figure(2);
bar(F_ABQ_SF/1000);
ylabel('Annual Average Daily Traffic - North Bound Direction [in thousands of
automobiles]');
xlabel('Roadway Section [milestone where the section starts]');
grid on;
set(gca,'XTickLabel',{'233','235','242','243','249', '253', '258', '260',
'265', '268', '273', '276', '278', '283'});



%-----------------------------------------------------------------------
% PLOT AUTOMOBILES PER SECTION
%-----------------------------------------------------------------------
figure(3);
bar(F_SF_ABQ/1000);
ylabel('Annual Average Daily Traffic - South Bound Direction [in thousands of
automobiles]');
xlabel('Roadway Section [milestone where the section starts]');
grid on;
set(gca,'XTickLabel',{'233','235','242','243','249', '253', '258', '260',
'265', '268', '273', '276', '278', '283'});

%-----------------------------------------------------------------------
% PLOT AGGREGATE VEHICLE TRAVEL DISTANCE (PER SECTION)
%-----------------------------------------------------------------------
%figure(4);
%bar(ATD_ABQ_SF/1000);
%ylabel('AVTD - North Bound Direction [in thousands of miles]');
%xlabel('Automaker');
%grid on;
%set(gca,'XTick',-pi:pi/2:pi);
```

```
%set(gca,'XTickLabel',{'GM','Ford','Daimler','Toyota','Honda', 'Nissan', 'VW',
'Hyun.', 'Mitsub.', 'BMW', 'Kia', 'Subaru', 'Others'});


%-------------------------------------------------------------------------
% PLOT CAPACITY
%-------------------------------------------------------------------------
figure(5);
%PLOT CAPACITY
bar([0.3 0.6], [TTTC TTUC]/1e6);
ylabel('Transport Capacity [in millions of miles-persons per day]');
%set(gca,'XTickLabel',{'Total Capacity', 'Used Capacity'});
grid on;


%-------------------------------------------------------------------------
% PLOT TOTAL GAS CONSUMPTION
%-------------------------------------------------------------------------
figure(6);
bar([0.2 0.3 0.4], [TGC TGC_EFFICIENT TGC_EFFICIENT_CAR_POOL]/1000);
ylabel('Overall Aggregate Fuel Consumption [in thousands of gallons]');
%set(gca,'XTickLabel',{'Total Capacity', 'Used Capacity'});
grid on;
```