EVALUATION OF ARIZONA'S FATALITY RATE

ANALYSIS OF PROCEDURAL ISSUES

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TABLE OF CONTENTS

1. INTRODUCTION

The purpose of this technical memorandum is to describe the results of activities to resolve the five procedural issues contained in Chapter 5 of the Interim Report dated October 30, 1986. The resolution of the issues is a prerequisite to the finalization of the preferred VMT algorithm and its validation. A brief summary of the issues is provided below and a description of the analysis activities and major conclusions are presented in the following chapters of the memorandum.

VEHICLE CLASSIFICATION STUDY PROCEDURES

This issue required the review of current ADOT data collection procedures for obtaining vehicle classification data. In particular, the procedure for sampling vehicle classification data on various road classes and the length of the data collection period was reviewed. The review of current ADOT procedures considered the research reported in the "Vehicle Classification Procedure Study" and the vehicle classification data currently being collected by ADOT.

VEHICLE CLASS DESIGNATIONS

This issue required the review and definition of vehicle type designations for use in the manual collection of vehicle classification data. The criteria used to designate vehicle types was to minimize the variance in mpg within each roadway class.

VEHICLE MIX FACTORS BY ROAD CLASS

This issue required the development of vehicle mix characteristics for each roadway class to be used in the VMT procedure. A review was conducted of existing classification data and the need for collection of supplemental data. The information obtained from an analysis of these data is used to verify or adjust the vehicle mix characteristics within a given roadway class.

GASOLINE VERSUS DIESEL FUEL VEHICLES IN THE ARIZONA TRAFFIC POPULATION

This issue involved the differentiation of diesel vehicles from gasoline vehicles. When collecting vehicle classification data, differentiation between gasoline and diesel powered vehicles is difficult and sometimes impossible. The percentages of diesel and gasoline powered vehicles within the traffic population were reviewed using Arizona vehicle registration data.

ADOPTION OF MPG FACTORS

This issue required the adoption of an information source for mpg data selection of mpg estimates by vehicle class. A review of the various mpg sources was conducted to determine the source most appropriate for use in the VMT algorithm.

2. VEHICLE CLASSIFICATION STUDY PROCEDURES

REVIEW OF ADOT VEHICLE CLASSIFICATION STUDIES

The Arizona Department of Transportation (ADOT) has an ongoing program for collecting data on statewide vehicle classifications. Vehicle classification data are periodically collected at 125 locations distributed throughout the state. Vehicles are classified by ADOT into the following categories:

- o Automobiles, station wagons, vans with rear windows and motorcycles.
- o Camper recreational vehicles and motor homes.
- o School and Transit buses.
- o Pickup trucks, pickups with shells or campers, panel trucks and vans without rear windows.
- o Single unit trucks with two axle dual tires or three axles.
- o Tractor-Semi Trailer with three, four, or five axles.
- o Truck and Trailer with four, five, or six axles.
- o Truck trains with five or six axles.

The number of data collection sites by roadway functional class in rural and urban areas is shown in Table 1 along with the number of miles of each functional class within the state. For the years 1979 through 1984, 110 of the 125 sites were sampled at least once each year. These 110 sites were used in an analysis of vehicle class distributions by road class. The study sample included 103 sites (93.6 percent) on rural roads and seven sites on urban roadways. For the rural roadways, 101 (98 percent) of the sites are located on the four most highly sampled functional classifications (principle arterial-interstate, principle arterial-other, minor arterial, and major collector) and are estimated to account for 81 percent of the rural VMT. The distribution of sites and the number of samples taken on each of these four rural classifications was sufficient for statistical analysis. The number of sites and samples on the remaining three rural roads and on all of the urban roads was considered inadequate to represent these functional classes for statistical analysis (in the next issue).

Each site was sampled between 10 and 14 times during the study period. The sample periods were three consecutive hours beginning between 7:00 AM and 2:00 PM. A cursory review of the sample indicated that all the samples were

obtained on weekdays. This could bias an analysis of vehicle classification if Saturdays and Sundays exhibited a significantly different vehicle mix. The existence of such a difference can not be determined with available information.

Table 1

NUMBER OF ADOT VEHICLE CLASSIFICATION SITES, AND MILES OF ROADWAY BY ROADWAY FUNCTIONAL CLASSIFICATION

	Rural Highways		Urban Highways	
Functional Class	# Sites	Miles*	# Sites	Miles*
Principle Arterial--Interstate	28	1,021	3	129
Principle Arterial--Other	27	1,078	3	371
Minor Arterial	39	2,253	1	963
Major Collector	20	4,071	NA	NA
Minor Collector	2	3,825	NA	NA
Collector	NA	NA	2	924
Local	0	55,065	0	6,437
Total	116	67,313	9	8,824

* Source: Highway Statistics 1984, USDOT, FHWA, Washington, D.C., 1985.
NA = Not Applicable

A previous study for ADOT (1) indicated that the hourly variation of vehicle class is minor and concluded that the percent of vehicles by class could be considered constant throughout the day on rural highways. Therefore, the sampling period and the rate of sampling for this study are considered more than adequate to base conclusions regarding vehicle class characteristics. The previous study did not evaluate the potential shift in vehicle mix by day of week.

CONCLUSION

The current ADOT program to sample statewide vehicle classification data is adequate as a source of vehicle classification information for the following rural roadway classifications.

- o Principle arterial--interstate
- o Principle arterial--other
- o Minor arterial
- o Major collector

Since these classifications are estimated to contain over 80 percent of the rural VMT, current ADOT data provide an adequate database for analyzing and aggregating vehicle classes by rural roadway class.

ADOT vehicle classification data are insufficient for performing similar analyses on urban road classes and limited supplemental data should be collected and analyzed as a part of this study.

The current ADOT vehicle classification program should be expanded to include a representative sample of vehicle classification data on urban road classes.

3. VEHICLE CLASS DESIGNATIONS

METHODOLOGY

Statistical analyses were performed on the ADOT vehicle classification database described in the previous chapter. Analyses were performed only on the vehicle classification distributions for the following rural classes of roadway.

- o Principle arterials--interstate
- o Principle arterials--other
- o Minor arterials
- o Major collectors

ADOT data were not available in sufficient numbers to allow the analysis for other rural classes or urban highways.

The vehicle classifications that were analyzed included the eight classes currently used in ADOT vehicle classification studies (refer to the list of vehicle types in Chapter 2).

The objective of the analysis was to determine if selected classes of vehicles can be combined to reduce the number of vehicle classes in the VMT algorithm.

The criteria used to establish the vehicle types to be used in the VMT algorithm were:

- o Physical characteristics must allow for the visual discrimination of vehicle types.
- o Vehicle type designations should conform to the existing classification scheme to allow the use of existing data and existing data collection procedures, if feasible.
- o Vehicle classes should represent significant portions of the vehicle population.
- o There should be significantly different fuel consumption characteristics between vehicle classes.
- o Vehicle classes should attempt to minimize the variance of fuel consumption chaacteristics within a particular road class.

CONCLUSION

The analysis resulted in the aggregation of the following four classes of vehicles.

- Automobiles including: passenger cars, station wagons, vans with rear windows and motorcycles.
- Light trucks including: pickup trucks, pickups with shells or campers, panel trucks, and vans without rear windows.
- Medium trucks including: camper recreational vehicles, mobile homes, school and transit buses, and single unit trucks with two axle dual tires or three axles.
- Heavy trucks including: tractor-semi trailer with three, four or five axles, truck and trailer with four, five, or six axles, and trains with five or six axles.

The following comments are provided as justification for aggregation of the above vehicle classes.

- The automobile classification exhibits the largest within group variation in vehicle mpg. This is due to the large variation in vehicle mpg for passenger cars of different types, and due to the combining of vans with rear windows and motorcycles into the "single vehicle" classification. Vans with rear windows exhibit vehicle and mpg characteristics that are similar to those of light trucks and therefore should logically be grouped into the light truck classification. However, the existing ADOT vehicle classification scheme is based on the travel function (or purpose of vehicle utilization) and physical characteristics of the vehicle. Hence, vans with rear windows, which are typically used for carrying passengers, are grouped with other passenger vehicles. The proportion of vans within the automobile group is unknown, and could not be disaggregated from the ADOT data. The proportion of motorcycles within the ADOT data is also unknown. However, a previous ADOT study (1) collected vehicle classification data with motorcycles as a separate group. This study indicated that motorcycles accounted for a maximum of 1.5 percent and a minimum of 0.6 percent of the vehicles on rural roads, with a mean value of 1.1 percent. Thus, the influence of motorcycle mpg characteristics is not significant within the automobile classification on rural roads. Furthermore, the bias produced by motorcycles may be offset somewhat by the inclusion of the vans with rear windows in this group (the proportion of vans in this class is also very small).
- Pickup trucks with campers are grouped with camper recreational vehicles in the ADOT classification schedule. ADOT procedures require data collectors to count pickups with campers in the classification with other pickups and vans without rear windows. Hence, the designation of this vehicle type in the light truck category. The light trucks satisfy all of the criteria for designation as a separate vehicle classification.
- Camper recreational vehicles and motor homes are, in general, single unit trucks with modified bodies. These vehicles generally have the weight and operating characteristics of single unit trucks as well. Therefore, it was logical to aggregate this vehicle type into the medium truck classification. This same reasoning was applied to the grouping of transit and school buses into the medium truck classification.

- A review of the available fuel consumption characteristics (see discussion of mpg values) indicated that above a weight of approximately 19,000 pounds, large trucks exhibit very similar mph characteristics regardless of the other physical differences in the vehicles. Therefore, tractor-semi trailers, truck and trailers, and truck trains may be aggregated into a "heavy truck" classification.

4. VEHICLE DISTRIBUTION FACTORS BY ROAD CLASS

METHODOLOGY

The analysis of vehicle distributions concentrated on the four rural functional classifications for which there were sufficient data. These are:

- o Principle Arterial--Interstate
- o Principle Arterial--Other
- o Minor Arterial
- o Major Collector

Statistical analyses were conducted to test for differences in vehicle mix between roadway functional classifications.

CONCLUSIONS

The analysis produced the following conclusions:

- o Vehicle distributions for rural interstates and rural non-interstates (aggregated) were significantly different.
- o Vehicle distributions for the rural non-interstates were significantly different, due primarily to the large vehicle classification sample size available for analysis. Practically, however, the distributions do not differ substantially when the percentage of vehicle types are compared across road class. Table 2 shows the percentages of the vehicle types identified in the preceeding chapter for the three classes of rural non-interstates.

Table 2

VEHICLE CLASS DISTRIBUTIONS FOR RURAL NON-INTERSTATES

	Vehicle Class			
Rural Road Class	Auto	Light Truck	Medium Truck	Heavy Truck
Principle-Other	56.8	30.5	8.0	4.7
Major Arterial	56.2	33.2	8.3	2.3
Major Collector	59.3	31.9	5.9	2.9
Average	57.2	31.8	7.6	3.5

A sensitivity analysis for the rural non-interstate group was performed to estimate weighted mpg using an average (combined--over the rural non-interstates) percentage versus the individual percentages for each road class. The weighted mpg's produced in this analysis differed by 0.3 mpg or by 1.6 percent. This relatively small difference justifies the aggregation of rural non-interstates despite the observed statistical difference.

- The vehicle distribution on rural interstates was very stable over the six year study period with very small fluctuations about the mean in the percent vehicles by vehicle type. Vehicle distributions on rural non-interstates showed a similar time stability. Adjustments in vehicle distribution trends over time is not warranted.

- The vehicle distribution by month of year by roadway functional classification is significantly different. All vehicle classes were shown to fluctuate significantly with the exception of medium-duty trucks. Aggregation of the data into the "rural interstate" and "rural non-interstate" classes verifies this finding. The distribution of vehicle mix displayed in these figures suggest seasonal variations in these characteristics.

- Vehicle mix differences on rural roadways by region within the State was shown to be statistically significant. However, due to the large database used in the analysis, practical significance (particularly, where the use of fuel efficiency data is concerned) was not achieved.

  The evaluation of the regional variation in vehicle mix ws performed to determine if the application of a statewide "mpg" value for a defined roadway class was appropriate or if significant regional differences in vehicle class existed to result in specific "mpg" values by region of state. Regional boundaries used were identical to those used in the previous ADOT study "Vehicle Classification Procedure Study" (FHWA/AZ-84/195,II). The vehicle mix characteristics by region are displayed in Tables 3 and 4 for rural interstates and rural non-interstates, respectively.

- Statistically significant differences in vehicle mix were observed by region and season of year for the aggregation of "rural interstates" and "rural non-interstate" classifications. These differences, however, were not significant for fuel efficiency calculations. The characteristics are displayed in Tables 5 and 6. Seasonal designations were as follows:

  Winter: December, January, February
  Spring: March, April, May
  Summer: June, July, August
  Fall: September, October, November

  Based on these findings, vehicle mix sampling should take into account the seasonal and regional variation within the state. However, the effect of these differences on fuel efficiency (mpg) is not considered significant.

Similar type analyses will be conducted on the urban roadway classifications following completion of the data collection effort on urban roadways.

Table 3
VEHICLE MIX (%) BY REGION FOR INTERSTATE HIGHWAYS

Region	Auto	Light Truck	Medium Truck	Heavy Truck	Weighted MPG
1	56.5	14.9	9.4	19.2	16.7
2	56.4	18.8	9.5	15.4	17.1
3	58.8	17.3	8.1	15.7	17.3
TOTAL	57.7	17.1	8.8	16.4	17.1

Table 4
VEHICLE MIX (%) BY REGION FOR INTERSTATE HIGHWAYS

Region	Functional Class	Auto	Light Truck	Medium Truck	Heavy Truck	Weighted MPG
1	Principal Arterial-Other	54.9	31.6	8.5	4.9	--
	Minor Arterial	53.7	35.1	8.5	2.6	--
	Major Collector	62.9	29.1	5.8	2.2	--
						18.6
2	Principal Arterial-Other	58.6	24.0	8.7	8.7	--
	Minor Arterial	59.1	30.3	8.4	2.2	--
	Major Collector	56.8	34.6	5.8	2.7	--
						18.8
3	Principal Arterial-Other	58.0	31.0	7.3	3.6	--
	Minor Arterial	51.9	38.8	7.1	2.2	--
	Major Collector	58.8	31.5	6.0	3.6	--
TOTAL		57.4	31.8	7.6	3.5	18.8

Table 5

VEHICLE MIX BY REGION AND SEASON FOR INTERSTATE ROADWAYS

Region	Season	Auto	Light Truck	Medium Truck	Heavy Truck	Total
1	Winter	54.3	15.1	7.8	22.8	100.0
	Spring	54.2	15.1	9.9	20.7	100.0
	Summer	60.0	14.4	9.4	16.2	100.0
	Fall	53.8	15.8	9.5	21.0	100.0
	TOTAL	56.5	14.9	9.4	19.2	100.0
2	Winter	54.3	19.5	10.2	16.0	100.0
	Spring	56.1	19.7	10.1	14.1	100.0
	Summer	62.1	16.1	8.2	13.6	100.0
	Fall	53.5	19.9	9.3	17.2	100.0
	TOTAL	56.4	18.8	9.5	15.4	100.0
3	Winter	57.2	17.3	8.3	17.2	100.0
	Spring	61.3	16.3	8.3	14.2	100.0
	Summer	60.8	17.7	7.5	13.9	100.0
	Fall	56.1	18.2	8.3	17.4	100.0
	TOTAL	58.8	17.3	8.1	15.7	100.0

Table 6

VEHICLE MIX BY REGION AND SEASON FOR NON-INTERSTATE ROADWAYS

Region	Season	Auto	Light Truck	Medium Truck	Heavy Truck
1	Winter	58.9	31.0	6.8	3.3
	Spring	54.6	33.1	8.4	4.0
	Summer	59.9	29.0	8.0	3.1
	Fall	50.0	37.8	8.2	4.0
	TOTAL	56.0	32.4	8.0	3.6
2	Winter	57.7	30.6	8.4	3.3
	Spring	58.0	30.5	7.9	3.5
	Summer	60.6	29.7	6.8	2.9
	Fall	57.3	31.1	7.9	3.8
	TOTAL	58.4	30.5	7.8	3.4
3	Winter	60.7	29.3	6.7	3.2
	Spring	55.7	33.3	7.4	3.6
	Summer	58.0	32.1	6.9	3.0
	Fall	52.4	36.3	7.0	4.2
	TOTAL	57.4	32.3	7.0	3.4

5. GASOLINE VERSUS DIESEL FUEL VEHICLES IN THE ARIZONA TRAFFIC POPULATION

METHODOLOGY

The analysis of fuel type usage by vehicle distributions concentrated on three major vehicle types. They were:

- o Light duty vehicles (typically passenger cars).
- o Light duty trucks (truck-type vehicles having gross vehicle weights of 8,500 pounds or less).
- o Heavy duty vehicles (truck-type vehicles having gross vehicle weights greater than 8,500 pounds).

It should be noted that these classes are comparable to the ADOT vehicle classification schemes defined earlier, i.e., light duty vehicles consist of all auto-type vehicles, light duty trucks relate to the light truck class, and heavy duty vehicles comprise the medium and heavy duty truck classes.

Comparisons of recent (7/13/86) Arizona vehicle registration data were conducted to determine the percentage of gasoline fuel versus diesel fuel type usage between vehicle classes. A similar comparison for validation purposes was conducted on 1985 (6/30/85) Arizona registration statistics. Table 7 summarizes the comparisons.

CONCLUSIONS

The findings indicate that low percentages of diesel fuel use exist among light duty vehicles and light duty trucks. Approximately 1.50 to 2.00 percent of vehicles registered in Arizona in these classes are diesel fuel users. The impact of this small percentage of diesel fuel users on the fuel efficiency (mpg) characteristics of these vehicle classes would be expected to be statistically insignificant and, therefore, may be exempted from use in the VMT model calculations.

However, for the heavy duty vehicles (comprising the medium and heavy duty truck types), diesel fuel use is significant. Statewide 1986 registration data indicates that over one-third of the vehicles in this class are diesel fuel users. While the vehicle registration data does not readily separate diesel use by medium-duty or heavy-duty truck, a similar percentage mix (diesel vs. gasoline) is proposed for both

types. For model purposes, a two-thirds "gasoline" and one-third "diesel" fuel use percentage split is proposed. As annual figures are available from the Motor Vehicles Division, this split should be checked and revised as necessary.

Table 7

DIESEL VERSUS GASOLINE FUEL TYPE USAGE AMONG ARIZONA-REGISTERED VEHICLES

		1985			1986		
Vehicle Type	Place of Registration	Total Vehicles	Diesel-Use Vehicles	% Diesel	Total Vehicles	Diesel-Use Vehicles	% Diesel
Light Duty Vehicles	Maricopa County	914,576	13,699	1.50	935,657	14,117	1.51
	Pima County	285,696	4,331	1.52	287,442	4,366	1.52
	Yuma County	39,374	887	2.25	40,458	875	2.16
	Statewide	1,568,525	22,798	1.45	1,591,772	23,238	1.46
Light Duty Trucks	Maricopa County	280,493	5,349	1.91	294,334	5,776	1.96
	Pima County	90,958	1,595	1.75	93,054	1,770	1.90
	Yuma County	19,493	865	4.44	20,174	864	4.28
	Statewide	572,731	10,681	1.86	593,825	11,494	1.94
Heavy Duty Vehicles	Maricopa County	27,139	8,626	31.78	29,060	10,081	34.69
	Pima County	6,676	1,679	25.15	6,812	1,755	25.76
	Yuma County	1,754	340	19.38	1,737	348	20.00
	Statewide	51,618	16,293	31.56	57,594	19,316	33.54

6. ADOPTION OF MPG FACTORS

METHODOLOGY

The analysis of this issue included a literature review of various sources of fuel efficiency (mpg) data for the vehicle classes described in the earlier portions of this report. In addition, adjustment factors to reflect environmental impacts, vehicle type and age, driving habits (urban vs. rural), and other areas were researched to fully identify reliable base "mpg" estimates.

CONCLUSIONS

The analysis of this issue resulted in the following key conclusions:

- The key source of base "mpg" data for passenger vehicles (autos) is data published annually by the EPA. These data are based primarily on new vehicle testing. Adjustment factors for vehicle population age, on-road use (urban vs. rural driving percentage), and regional/seasonal type impacts have been developed in key research efforts conducted over the years.
- The key source of base "mpg" data for the truck classifications (i.e., light, medium, and heavy) is data published by United States Department of Commerce in its annual Census of Transportation: Truck Inventory and Use Survey. Data are available on a national and individual state basis and is supplied by the trucking industry as a requisite for highway user tax purposes. The data is essentially pro-rated based on fuel efficiency ranges. The use of individual state-registered data limits the regional/seasonal adjustment needs. Furthermore, the data accounts for on-road usage and vehicle age considerations. For use in the VMT model, "mpg" characteristics are similar for Arizona-registered trucks and non-Arizona registered trucks travelling within the State.

7. REFERENCES

1. Matthias, J.S. and A.G. Dean, "Vehicle Classification Procedure Study," Arizona Department of Transportation Report No. FHWA/AZ-84/195, I, Final Report, June, 1984

2. Highway Statistics 1984, USDOT, FHWA, Washington, D.C., 1985.