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PHOENIX METROPOLITAN AREA EXTERNAL TRIP STUDY

Volume I
Final Report

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16. ABSTRACT

The Maricopa Association of Governments Transportation Planning Office is updating the computer models used to prepare forecasts of traffic volume in the Phoenix area. One element of the modeling effort involves external travel or trips having both origin and destination outside the area but passing through the area.

Roadside interviews were conducted togather data on such trips to aid in model calibration. Specifically, data was gathered on the following items:

1) Trip Origin
2) Trip Destination
3) Trip Purpose
4) Vehicle Garaging Location
5) Vehicle Occupancy
6) Vehicle Classification
7) Vehicle Registration

This document describes the procedures utilized in the gathering of the described data.

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EXTERNAL TRIP STUDY

Volume I
Statistical Procedures and Model Development

Prepared for

ARIZONA DEPARTMENT OF TRANSPORTATION
ARIZONA TRANSPORTATION RESEARCH CENTER

Prepared by

BARTON-ASCHMAN ASSOCIATES, INC.

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1.

INTRODUCTION

All major metropolitan areas in the United States currently have ongoing transportation planning programs. In the Phoenix, Arizona metropolitan area, the Maricopa Association of Governments Transportation and Planning Office (MAGTPO) has the responsibility for this program. Information from this program is used to derive design year traffic forecasts which are the basis for all roadway improvement projects in the metropolitan area. Needless to say, it is essential to periodically update methods and procedures to produce reliable results.

STUDY PURPOSE

MAGTPO is currently involved in a major effort to update all aspects of the transportation model for the Phoenix metropolitan area. One component of this model estimates external travel, which is travel through the region and into the region. The purpose of the study described here was to update the external travel portion of this model to reflect current conditions and advancements in the state-of-the-art.

STUDY OBJECTIVES

This study had four broad objectives:

1. To collect, in a cost-effective way, current data on travel which passes through the Phoenix region, or which originates, or is destined to the Phoenix region and passes through the cordon line;

2. To organize these data into trip tables that can be used with the existing model and data to evaluate the impact of 1985 travel on purposes, policies, or transportation improvements;

3. To devise a method(s) of estimating external travel in the Phoenix region in the years 1990, 1995, 2000, and 2015; and

4. To determine the applicability of the methodology to Tucson and other metropolitan areas.

STUDY PROCEDURE

Roadside interview surveys were conducted at the seventeen external stations on the Phoenix highway network defined by MAGTPO. The survey obtained seven categories of information, as follows:

1. Trip origin;

2. Trip destination;

3. Trip purpose;

4. Vehicle garaging location;

5. Vehicle occupancy;

6. Vehicle classification; and

7. State of vehicle registration.

As part of this effort, a separate vehicle classification count was also performed. Specific details relating to the conduct of the survey are described in Volume II of this report, "Procedures Manual."

Volume I contains six chapters. Chapter 2 summarizes the results of a literature search performed to ascertain any recent research results concerning external trip studies. In Chapter 3, the sampling procedures used in the study are described. This is followed by a discussion in Chapter 4 of the coding and factoring of the survey results. Chapter 5 discusses the suggested modeling approach, as well as certain preliminary survey results. Finally, Chapter 6 describes development of the external trip model and the transferability of that model to other areas.

2.

LITERATURE SEARCH

This chapter will describe briefly the literature review undertaken in developing the methodology utilized for the External Trip Study for Phoenix. The major considerations in reviewing prior experience in conducting external surveys involve coming to grips with the following issues:

— How to contact travelers entering or exiting the study area,

— How to obtain data from these travelers,

— The role of sampling technique and sample size requirements for sampling travelers, and

— The hours of observation.

The publication Urban Origin-Destination Studies published by the United States Department of Transportation is a major source of information on the external survey. That document devotes an entire section, Chapter 6, "The External Survey," to the subject.

This reference lists three basic types of external survey techniques -- the roadside interview, the postcard survey, and the license plate (registration) survey. The following statements are reproduced from that report:

"The roadside interview -- In this technique, a sample of vehicles is stopped at each roadside interview station. An interviewer obtains the desired information by questioning the driver, and then the vehicle proceeds. A good interviewer should be able to complete an interview within one or two minutes. This is the technique that has been used in hundreds of studies over the past thirty years.

Advantages:

1. The most complete and accurate information is usually obtained when a personal contact is made between respondent and interviewer.

2. The response rate is greater (relative to the voluntary return technique), thereby minimizing the survey bias.

3. Samples can be chosen from a traffic stream to satisfy planned statistical standards.

Disadvantages:

1. This technique is more expensive than the other techniques described here, because a larger number of personnel are required.

2. On high volume facilities there may be some traffic delays during the survey, especially during peak travel periods.

3. This technique is often dangerous, especially on high volume facilities, because survey personnel must operate on the highway and interfere with the regular flow of traffic.

The voluntary return postcard -- In this type of external survey postcards are handed to the drivers of all or a sample of vehicles passing through roadside stations. The drivers are asked to read the instructions, complete the form, and return it by mail, postage free. This technique has been used many times at toll facilities and on high volume highways where travel data are needed.

Advantages:

1. It is less expensive than the traditional approach, because fewer people are needed in the field.

2. The field work can be accomplished faster than by the roadside interview approach, because postcards are handed to the driver with minimum delay.

3. It is much less likely to delay traffic.

Disadvantages:

1. Personal contact is not made with respondent.

2. Fewer questions can be included on the questionnaire.

3. The response rate is usually quite low, averaging about 25 to 35 percent in many cases. Therefore, a significant bias may be found in the data; this limits the amount of analysis that can be performed.

4. This technique still requires stopping traffic.

License plate technique -- Some research has been done which indicates travel data can be collected successfully by using the technique of recording license plate numbers. The technique requires that an observation and recording of the license plate be made for each vehicle crossing an interview station. A mail-back questionnaire is then sent to the owner of the vehicle who then voluntarily sends it back with the necessary information filled in.

This technique has been done manually, and some research has also been completed using cameras to record license plate numbers. The success of the survey depends upon quick access to registration records to match a license number to a vehicle owner so that questionnaires can be sent out quickly. It is desirable to have registration records on computer tape to make this procedure more efficient.

In a traffic study conducted in Boston, the owners of vehicles were located by using automated registration files and then contacted and asked to return a questionnaire. The following summarizes the major results:

Total questionnaires sent out	4805
Overall return rate:	
In-state respondents	64.8%
Out-of-state respondents	59.8%

Another study was undertaken to test a postal survey technique in Kansas using automated registration files. The following summarizes the major results:

Total vehicles sampled	17,300
Sample rate	25%
Overall return rate	52.8%

Advantages:

1. This has the same advantages as the voluntary return postcard technique; it is in effect, a variation of that technique.

2. In addition, this technique is safer, because traffic is not stopped.

3. If a camera is used to record license plate numbers there will be a smaller number of field personnel needed.

4. The research cited above indicates the response rate may be higher, as compared to the voluntary return postcard technique.

Disadvantages:

1. Personal contact is not made with respondents.

2. Fewer questions can be asked, because of the voluntary response.

3. Night operation is difficult.

4. There is still a response bias that must be carefully controlled.

5. It is difficult to use economically and efficiently unless all motor vehicle registrations are on computer tape, because quick access is needed to obtain vehicle addresses and send out the questionnaires. (The questionnaire should be mailed out within 24 hours to be most effective.)

   This requirement is further complicated by out-of-state vehicles. If there is a substantial volume of such vehicles registered in states that do not have computerized registration records, it will be extremely difficult to mail out the questionnaires."

Barton-Aschman Associates, Inc. recommends the roadside interview for the Phoenix area over the postcard survey because it is believed that the sampling technique recommended reduces significantly the crew size. No more than three roadside interviewers are needed at any time and when a fewer number are needed, the other interviewer(s) and relief person can edit and code. The other personnel, police, manual classifiers, crew chief, and flagmen are common to both techniques. The safety factor can be maximized by hiring police protection and being certain that a police car with flashing lights is conspicuous at the station during all hours of operation.

Finally, the use of sampling combined with a station set up to bypass non-sampled vehicles avoids any delay except to sampled vehicles, which is held to a maximum of two minutes. The disadvantages of the postcard technique, on the other hand, seem to be fatal flaws in the opinion of the consultant. This is especially true of the lack of personal contact and the low response rate, which requires a higher initial sample. These comments apply to the license plate technique, as well.

A major reason the roadside interview approach was selected was that a sample technique can be used to overcome the disadvantages as discussed in the U.S. DOT report. The sample technique was reported on in the Final Report of the Chicago Area Transportation Study, (July 1971, page III-45).

This formula draws on sampling theory which states that the precision of a sample estimate basically is inversely proportional to the square root of the sample size:

$$\sigma_p = \sqrt{\frac{pq}{n} \times \frac{m-n}{m-1}}$$

where: σ_p = standard error of proportion p

p = proportion of sample possessing a given attribute such as trip purpose to work

$q = 1-p$

n = number in sample

m = universe size

This formula can be solved for different precision levels and values of p. If we assume p=q=0.5 and if we set p to be equal to plus or minus 0.05, we can solve for a sample rate guaranteed to give a standard error $\pm$ 0.05, which is $\pm$ 10% at the 68% confidence level for values of p approaching 0.5. If one accepts this precision for a single hour, one can solve to find the sample size as follows:

$$0.05 = \sqrt{\frac{0.25}{n} \times \frac{(m-n)}{(m-1)}}$$

and

$$n = \frac{100\ m}{m+99}$$

This means that the largest absolute sample size for a given time period (one hour) is 100 for this level of precision. Of course, for the combined two-hour peak-period, the precision would be much greater ($\pm$0.07%) and for the entire period of interviewing the precision of estimates based on the sample would be very high (assuming 12 hours @100, $\pm$2.8%). However, if 100 is the maximum sample size for any hour, it suggests that an interview crew of three would be adequate. For low volumes such as 25 vehicles per hour, 20 samples would be taken.

The last major concern was with the hours of operation. Twenty-four hour operation means expensive operation because of the costs of lighting the station and providing three shifts of police protection. In addition, the risk of an accident at a station is greatly increased by nighttime operations. Lastly, the volume of traffic during the hours of darkness is a small proportion of the twenty-four hour total.

According to the U.S. DOT report on the external survey, ". . . the experience of several States has indicated that a station operated during daylight hours only provides data that adequately represents travel."

The Highway Research Information Service (HRIS) was contacted and a computer search located a variety of publications that relate to the external roadside interview. The abstracts of these reports are listed in Appendix A.

3.

SAMPLING PROCEDURES

This section discusses the sample size requirements for the External Trip Study.

PRECISION REQUIREMENTS

Sampling permits the estimation of the value of attributes of a population at a specified level of accuracy. For example, if one wished to know the proportion of compact cars in the traffic stream on a given day, one could count the total vehicles passing and also the number of compacts. The ratio of the latter to the former is the desired statistic. However, one would not have to count all of the vehicles and all of the compacts. One could count a sample of the vehicles, and classify them according to whether or not they were compact. Because all of the vehicles were not counted and classified, the estimated proportion of vehicles that are compacts is subject to sampling error.

What this means is that if one were to estimate the proportion of compact cars based on a sample count of 100 and found the proportion to be 0.4 or 40 percent, the estimate of 40 percent could be high or low in comparison to the proportion that might be obtained if 100 percent of the vehicles were classified. This accuracy is usually expressed as the standard error of the proportion and the formula for the standard error is:

$$\sigma_p = \sqrt{\frac{pq}{n}}$$

where: σ_p = standard error of the proportion p

a = number in sample with attribute a (e.g., compact cars)

n = number of samples

p = the proportion of the sample possessing attribute a

$$p = \frac{a}{n}$$

q = the proportion of sample elements not possessing attribute a = 1-p.

In the case of our hypothetical example:

$$p = \sqrt{\frac{(0.4)(0.6)}{100}} = 0.04899$$

Since the proportion of compacts in the sample comes to 0.4, the standard error of the proportion is 12.25 percent of the proportion [(100)(0.04899)/0.04].

One standard error represents the 68 percent confidence level. This means that if the experiment were repeated 100 times, 68 times the estimate of the proportion of compacts would fall within a range defined as the sample proportion plus or minus one standard error or 0.4 $\pm$ 0.04899 or between 0.35101 and 0.44899. If greater accuracy is desired, the sample size must be increased. For example, if an accuracy level of $\pm$ 5 percent of the expected 0.4 proportion is desired, the standard error would be 0.02. The sample size required would be

$$0.02 = \sqrt{\frac{(0.4)(0.6)}{n}} \qquad n = 600$$

Also, if greater confidence in a specified level of accuracy is desired, the sample size must be increased. The confidence level of one standard error is 68 percent. If 90 percent confidence is desired, 1.645 standard errors are required and, for the 95 percent confidence level, 1.96 standard errors are needed. For example, if we desired $\pm$ 10 percent at the 95 percent confidence level, we need a standard error of 0.0204082 (0.04/1.96). The sample size needed would be

$$0.0204082 = \sqrt{\frac{0.24}{n}} \qquad n = 576$$

Sample size requirements are thus a function of confidence level and precision desired. There is one additional factor to consider and that is adjusting for finite populations. If the precision requirements call for a sample of 576 samples, and there are only 200 elements in the population, the sample size cannot be 576. This adjustment is given in the following equation, where m is the population size.

$$\sigma_p = \sqrt{\frac{pq\ (m-n)}{nm}}$$

If we assume $p = 0.5 = q$,

and an accuracy of $\pm$ 0.05 (10 percent), the equation reduces to

$$0.05 = \sqrt{\frac{0.25\ (m-n)}{nm}}$$

$$0.0025 = \frac{0.25\ (m-n)}{nm}$$

$$nm = 100\ (m-n)$$

$$nm + 100n = 100m$$

$$n = \frac{100\ m}{m+100}$$

This equation gives the samples required for relative error at the 68 percent confidence level of plus or minus ten percent (0.05/0.5=0.1).

For our case of a population of 200, the sample size would be 67. If the population total were 2,000, the sample size would be 95. For a population total of 20,000, the sample size would be 100. For a population of 2,000,000, the sample size would also be 100.

This sample size approach is the one that was recommended for use in the external study. It gives a number of samples that is fixed at 100 or less for any approach volume per hour. The major survey stations operated approximately 14 hours a day, with no hour requiring more than 100 vehicles to be stopped. Were we to operate at 100 per hour for 14 hours, we would obtain 1,400 samples in one direction. The accuracy of such a sample for the entire day would be 0.01336 which, assuming a p of 0.5, gives a relative error of 2.67 percent at the 68 percent confidence level and an error of 4.40 percent at the 90 percent confidence level.

ILLUSTRATION OF THE SAMPLING APPROACH

This approach is illustrated in Exhibit 1 for Buckeye Road, westbound between El Mirage and 115th Avenue, using count data for Thursday, December 6, 1984.

This procedure would yield 1,049 samples and an accuracy of $\pm$ 0.015 or $\pm$ 3 percent at the 68 percent confidence level and $\pm$ 5 percent at the 90 percent confidence level. Yet for each of the daylight hours, the hourly accuracy would be $\pm$ 10 percent at the 68 percent confidence level. For a two-hour peak period, the accuracy would be $\pm$ 4 percent at the 68 percent confidence and $\pm$ 6.7 percent at the 90 percent confidence level. Operating during daylight hours only, we would be sampling some 83 percent of the 24-hour volume and our sample total of 1,049 would represent a 20 percent sample of that total volume.

EXHIBIT 1

EXAMPLE OF RECOMMENDED SAMPLING APPROACH

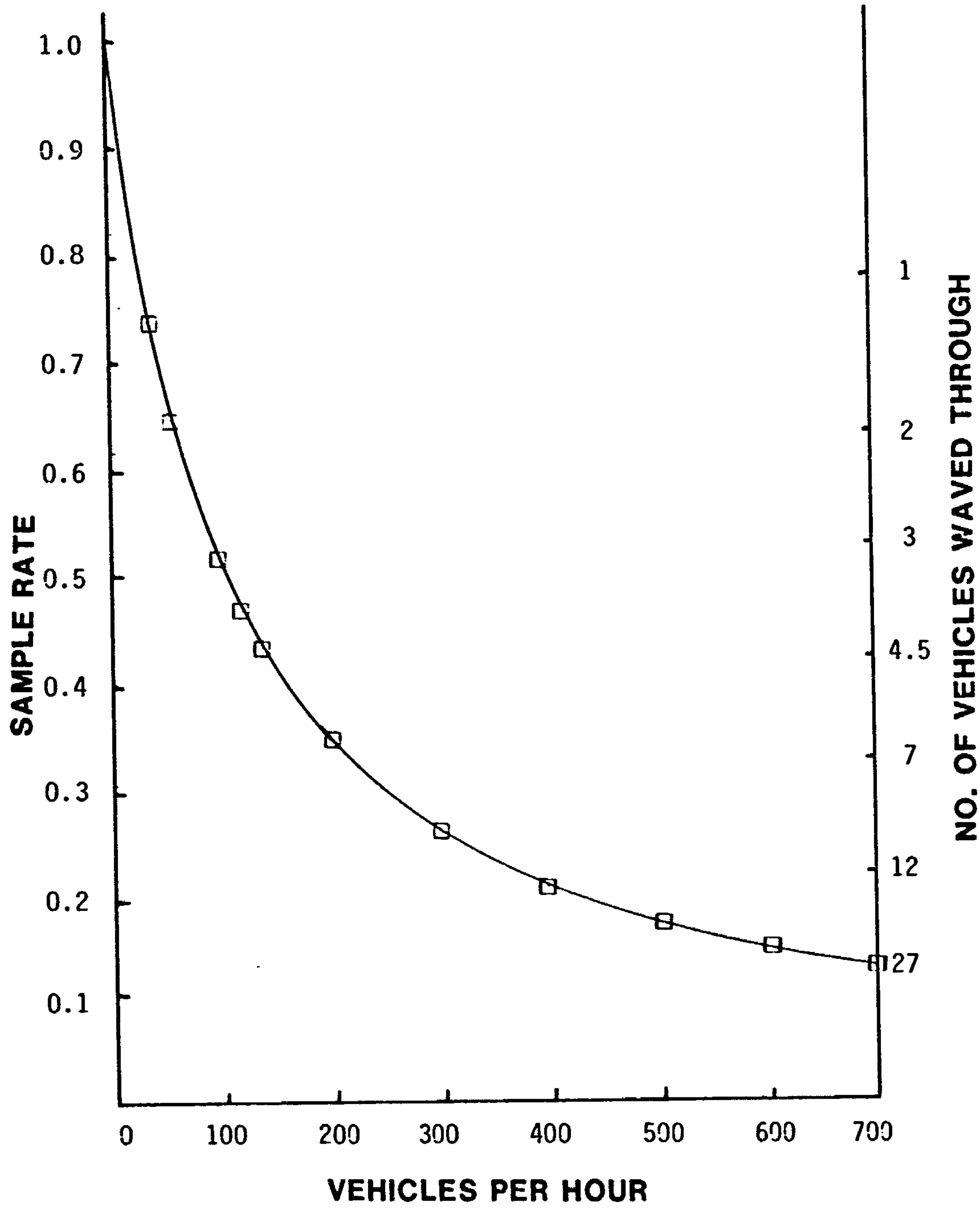
BUCKEYE ROAD

Start Hour	Volume	Number of Samples
0	58	Not Operated
1	44	" "
2	43	" "
3	30	" "
4	41	" "
5	153	" "
6	240	71
7	388	80
8	270	73
9	303	75
10	295	75
11	304	75
12	271	73
13	289	74
14	331	77
15	385	79
16	452	82
17	419	81
18	306	75
19	142	59
20	155	Not Operated
21	130	" "
22	127	" "
23	101	" "
Total	5,277	1,049

GRAPHIC ILLUSTRATIONS

Exhibit 2 illustrates the sample size as a percent of the approaching vehicles and also the cars that must be waved through assuming a three-person interviewing team.

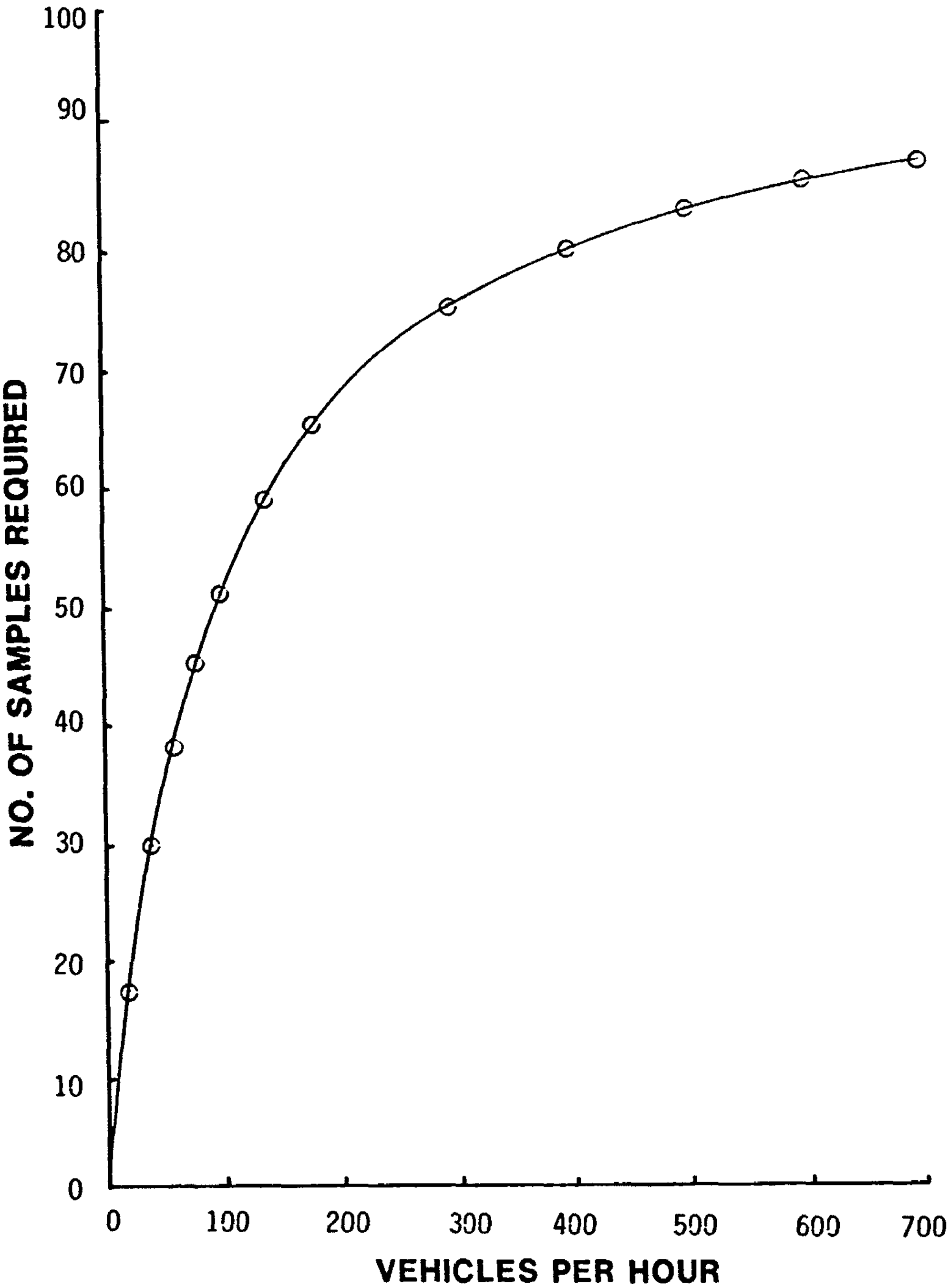
Exhibit 3 illustrates the number of samples required per hour given a specified approach volume.



SAMPLE RATE AS A FUNCTION OF
APPROACH VOLUME (ASSUMING 3 INTERVIEWERS)

BARTON ASCHMAN ASSOCIATES, INC.

EXHIBIT 2



REQUIRED SAMPLE
AS A FUNCTION OF HOURLY APPROACH VOLUME*

BARTON-ASCHMAN ASSOCIATES, INC.

EXHIBIT 3

* ±10 Percent Error at 68 Percent Confidence

4.

GEOCODING AND TRIP FACTORING

This section describes the conventions employed in coding origin/destination responses on the External Trip Survey.

Internal Zones

Internal zones were coded with their four-digit traffic analysis zone (TAZ) number, based on the MAG 1,193 zone system. Thus, the codes range from 0001 to 1193.

External Zones

Several versions of external zones were coded. Again, the codes were four-digit numbers, but the first digit in the sequence was a number other than 0 or 1. In this way the external zones (which begin with 2 - 9) can be readily differentiated from the internal zones (which begin with 0 or 1).

The external trips from unincorporated parts of Maricopa County were given external codes to represent the directional octant from which they came:

Directional Octant	External Station	Code
W	1194, 1195, 1196	2930
NW	1197	2931
N	1198, 1199	2932
NE	1200	2933
E	1201, 1202	2934
SE	1203 - 1207	2935
S	1208 - 1210	2936

Locations within Arizona, but outside the MAG study area, were assigned four-digit codes beginning with a 2 and followed by a place code previously adopted for use by MAG. Exhibit 4 contains a listing of these locations, including the code used here as well as the TAZ number.

Finally, codes were devised for trips beginning or ending outside Arizona. These codes begin with 3 - 9, as follows:

Origin/Destination	Code
Northern California	3100
Southern California (Los Angeles Area)	3200
Southern California (San Diego Area)	3300
Nevada	4000
Utah	5000
New Mexico	6000
Texas	7000
Colorado	8000
Other	9000

EXHIBIT 4

EXTERNAL CODES

Place Code	TAZ	Name	Place Code	TAZ	Name
2005	1268	Ajo (U)	2295	1219	St. Johns
2015	1213	Bagdad (U)	2297	1238	San Carlos (U)
2020	1275	Benson	2299	1267	San Luis
2025	1285	Bisbee	2300	1266	San Manuel (U)
2030	1234	Buckeye	2307	1205	Sedona (U) (Part)
2032	1241	Bylas (U)	2307	1205	Sedona (U) (Part)
2035	1254	Casa Grande	2310	1221	Show Low
2053	1207	Chino Valley	2315	1283	Sierra Vista
2055	1209	Clarkdale	2320	1217	Snowflake
2060	1235	Claypool (U)	2325	1265	Somerton
2065	1243	Clifton	2340	1273	South Tucson
2070	1248	Coolidge	2345	1223	Springerville
2073	1210	Cottonwood	2350	1242	Stargo (U)
2080	1286	Douglas	2355	1240	Superior
2085	1259	Duncan	2357	--	Surprise
2090	1224	Eagar	2358	1218	Taylor
2105	1255	Eloy	2365	1256	Thatcher
2115	1201	Flagstaff	2370	--	Tolleson
2120	1247	Florence	2375	1277	Tombstone
2123	1282	Fort Huachuca (U)	2380	1271	Tucson
2125	1194	Fredonia	2283	1263	Wellton
2129	1251	Gila Bend	2385	1260	West Yuma (U)
2145	1237	Globe	2390	1225	Wickenburg
2155	1196	Grand Canyon (U)	2395	1272	Willcox
2160	1246	Hayden	2400	1200	Williams
2165	1203	Holbrook	2401	1200	Williams (U)
2170	1280	Huachuca	2405	1249	Winkelman
2175	1208	Jerome	2410	1202	Winslow
2180	1245	Kearny	2415	1261	Yuma
2185	1199	Kingman	2425	1252	Yuma Proving Ground (U)
2187	1214	Lake Havasu City	2430	1252	Yuma Station (U)
2205	1264	Mammoth	2901	1206	Apache County (Unincorp. part)
2210	1269	Marana	2903	1276	Cochise County (Unincorp. part)
2220	1236	Miami	2905	1197	Coconino County (Unincorp. part)
2235	1284	Nogales	2907	1227	Gila County (Unincorp. part)
2238	1270	Oro Valley	2909	1258	Graham County (Unincorp. part)
2240	1195	Page (U)	2911	1239	Greenlee County (Unincorp. part)
2245	1222	Parker	2913	1229	Maricopa County (Unincorp. part)
2250	1281	Patagonia	2915	1198	Mohave County (Unincorp. part)
2252	1220	Payson (U)	2917	1211	Navajo County (Unincorp. part)
2265	1250	Pima	2919	1274	Pima County (Unincorp. part)
2275	1244	Plantside (U)	2921	1253	Pinal County (Unincorp. part)
2280	1215	Prescott	2923	1279	Santa Cruz County (Unincorp. part)
2282	1216	Prescott Valley	2925	1204	Yavapai County (Unincorp. part)
2290	1257	Safford	2927	1262	Yuma County (Unincorp. part)

EXTERNAL SURVEY TRIP FACTORS

This section addresses the problem of inserting factors into the External Survey records so that the sum of these factors across all records in one direction at one external station matches the total number of vehicles passing through that station in the same direction.

A. There are basically two factors to be calculated:

1. A factor to account for the fact that vehicles were sampled out of the traffic stream during the period of time for which the station was operated. Basically 6:00 a.m. to 7:00 p.m. for the high-volume stations and 10:00 a.m. to 7:00 p.m. for the low-volume stations. The sum of the factors for all sample records from a station operated in one direction should equal the manual count of vehicles passing through the station during its hours of operation. We will call this factor F_{13} or F_9 or F_n where n equals the hours of interviewing.

2. A factor to account for the fact that the station was operated for less than 24 hours -- designate this factor as F_{24}.

B. The 24-hour factor F_{24}. This factor is the product of the F_9 or F_{13} and an adjustment factor obtained from the 24-hour automatic counters. This adjustment is obtained for each station direction (inbound/outbound). In other words, we assume that the ratio of the vehicles manually counted during the station hours of operation to the 24-hour total vehicles is the same as the ratio of the machine count for the same time period to the 24-hour machine count period. For example, suppose we have the following:

	Manual Count		Automatic Machine Counter	
	13 Hour	24 Hour	13 Hour	24 Hour
Station X	7,534	?	7,315	8,200

The adjustment factor from the machine count is 8,200/7,315 = 1.121. The estimate of the 24-hour count which would have been achieved if the manual count had continued for all 24 hours is equal to 1.121 x 7, 534 = 8,446. The adjustment factor F_A is 1.121. This factor will be calculated for all stations in each direction.

C. The Stratum Factor F_k. This factor raises the sample vehicles to the manual count of those vehicles. This factor is the ratio of the actual count of vehicles in a stratum to the number of completed interviews in that stratum.

A stratum is defined by vehicle type and time of day. The vehicles types are:

- Auto
- Van/Pickup
- Trucks = 6 tires
- Trucks > 6 tires
- Recreation Vehicles
- Motorcycles
- Buses

The driver of all vehicle types except buses was interviewed. The time periods are hourly during the period of station operations. However, at first thought, the hours should be combined to form a peak period and a midday period. The table of factors for a station in one direction would look as shown on Exhibit 5.

One of the potential dangers in the factoring process is the potential of finding a stratum with no samples in it. The solution to this is aggregation, either across time and/or across vehicle type. Candidates for vehicle aggregation classes are:

- Autos, Vans, and Pickups
- Trucks
- Recreation vehicles and motorcycles

The third category could, if necessary, be combined with autos, vans, and pickups.

The best way to review the need for aggregation is to prepare a table of completed interviews for each station for each direction by hour of day by vehicle type.

EXHIBIT 5

HYPOTHETICAL FACTORS FOR STATION X

Vehicle Type	Peak Period			Midday Period		
	Sample	Count	Factor	Sample	Count	Factor
Auto	75	300	4.0	200	1000	5.0
Van/Pickup	10	50	5.0	25	100	4.0
Truck = 6 Tires	5	20	4.0	8	50	6.25
Truck > 6 Tires	2	15	7.5	5	25	5.0
Recreation Veh.	4	10	2.5	2	15	7.5
Motorcycle	2	5	2.5	2	10	5.0
Bus	-	7	-	-	15	-

These factors are stratum factors, and are specified as:

$$F_S = \frac{M_S}{N_S}$$

where:

F_S = Factor for stratum S.
M_S = Number of vehicles counted in stratum S.
N_S = Completed questionnaires in stratum S.

Stratum factors will be calculated for each station by direction.

5.

SUGGESTED MODELING APPROACH

This chapter reviews the results of the external survey and outlines the approach for modeling external trips as part of the regional travel forecasting process. Objectives appropriate to the external model and major decisions from a modeling standpoint are also outlined.

OBJECTIVES

The following objectives are suggested in relation to the external model:

- First, the model should make sensible use of the survey results and adequately reproduce observed external travel patterns;

- The model should form a logical and consistent element of the overall model set;

- The model should be capable of reflecting major changes in future external travel;

- The model must be realistic in its requirement for exogenous data;

- The model should be efficient and reasonable from an application standpoint.

Specification and development of the model should reflect its relative importance as part of the overall travel forecasting process. Since external travel forms a small part of total travel on the region's facilities, a relatively simple approach is suggested.

KEY DIMENSIONS

Decisions must be made with respect to three key dimensions of the model structure:

- What form of model should be employed -- a synthetic model such as the gravity model or a growth-factoring procedure, for example?

- What geographic basis should be used -- zones versus districts, external zones versus cordon stations?

- To what extent should external travel be disaggregated for modeling purposes by trip purpose, vehicle type, time of day, etc.?

A growth-factoring approach is simple yet retains the observed travel patterns to a greater extent than a synthetic model. A synthetic model, on the other hand, can *potentially* reflect the impact of major new facilities and major redistributions of travel, but only if properly structured and calibrated to do so.

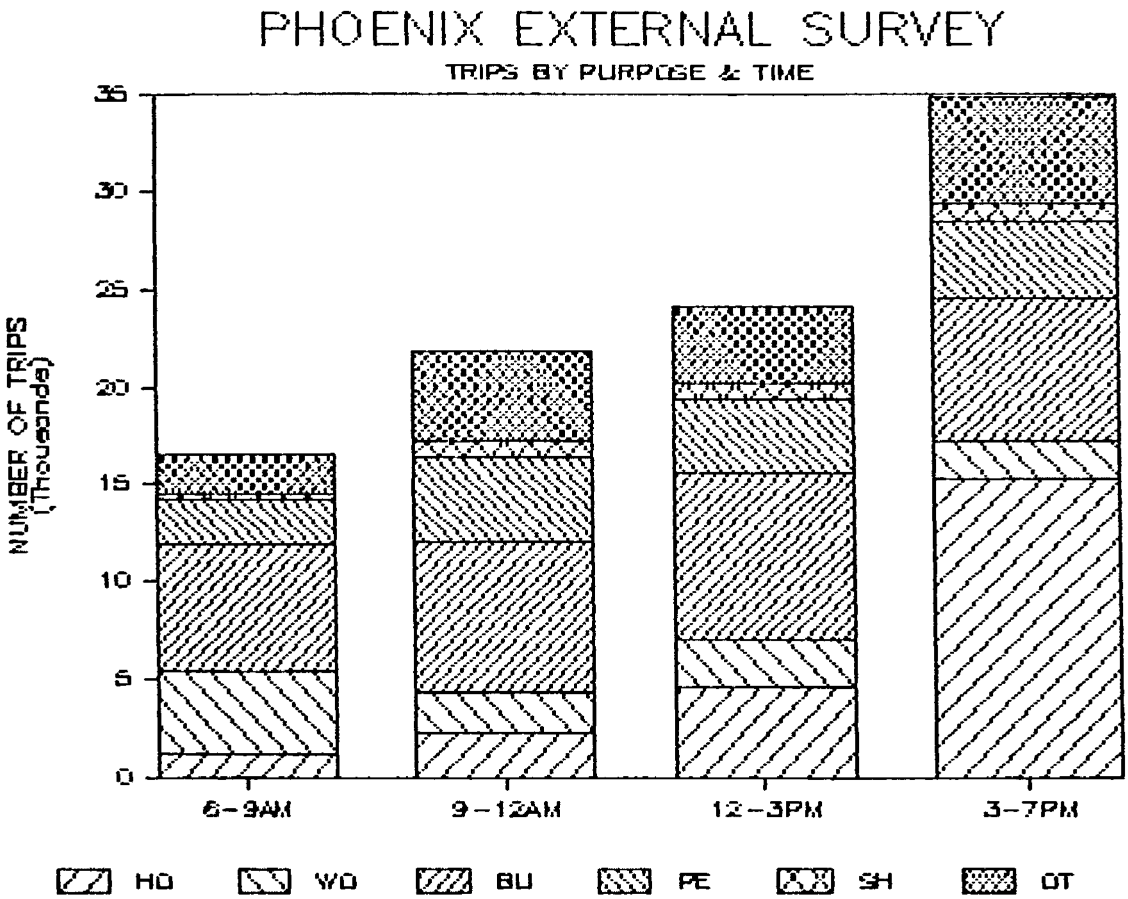
Ultimately, external travel must be combined with other regional trips to form total assignment matrices based on a geographic system of internal area traffic zones combined with external cordon station zones -- i.e., the external area is represented only by the external cordon stations, not by the system of external zones defined for the purposes of the survey. It is suggested that the external model be based on cordon stations rather than the external survey zones. This approach will be more efficient and will avoid the need to scale distances as in the special network developed for survey analysis.

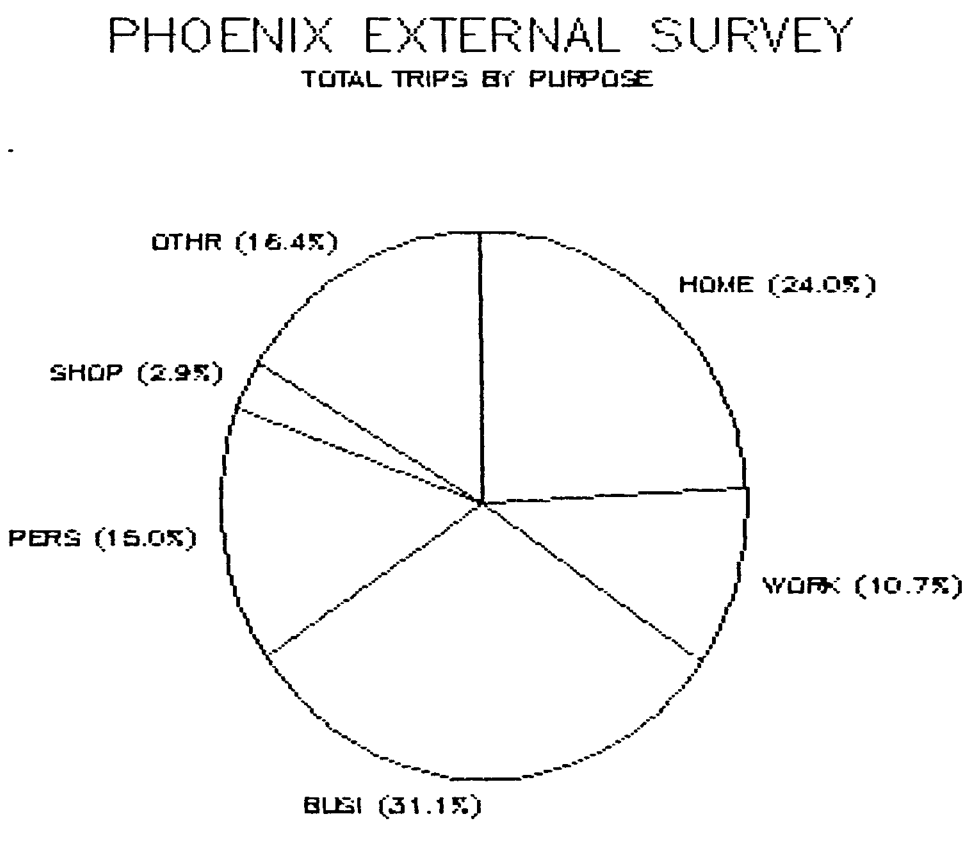
Ideally, the model should reflect important variations in the survey data; however, the model can become unwieldy if an overly disaggregated approach is adopted. The extent of disaggregation should be stringently curtailed to avoid this situation.

SURVEY RESULTS

The following exhibits illustrate external survey results. A tabulation of external survey data upon which the illustrations are based is also appended (See Appendices B and C). Exhibit 6 presents total expanded trips -- all stations combined -- by trip purpose and time of day. Total trips by period increase as the day progresses with the highest period being 3 - 7 PM (this is exaggerated by this being a four-hour period). The major cause for this temporal unevenness is trips for the purpose "HOME." Travel for the other purposes is much more nearly uniform over the day. The most common trip purpose is "BUSINESS." By contrast, WORK and SHOP are minor categories. In

EXHIBIT 6


PHOENIX EXTERNAL SURVEY
TRIPS BY PURPOSE & TIME
NUMBER OF TRIPS (Thousands)
0
5
10
15
20
25
30
35
6-9AM
9-12AM
12-3PM
3-7PM
HO
WO
BU
PE
SH
OT


PHOENIX EXTERNAL SURVEY
TOTAL TRIPS BY PURPOSE
OTHR (16.4%)
HOME (24.0%)
SHOP (2.9%)
PERS (15.0%)
WORK (10.7%)
BUSI (31.1%)

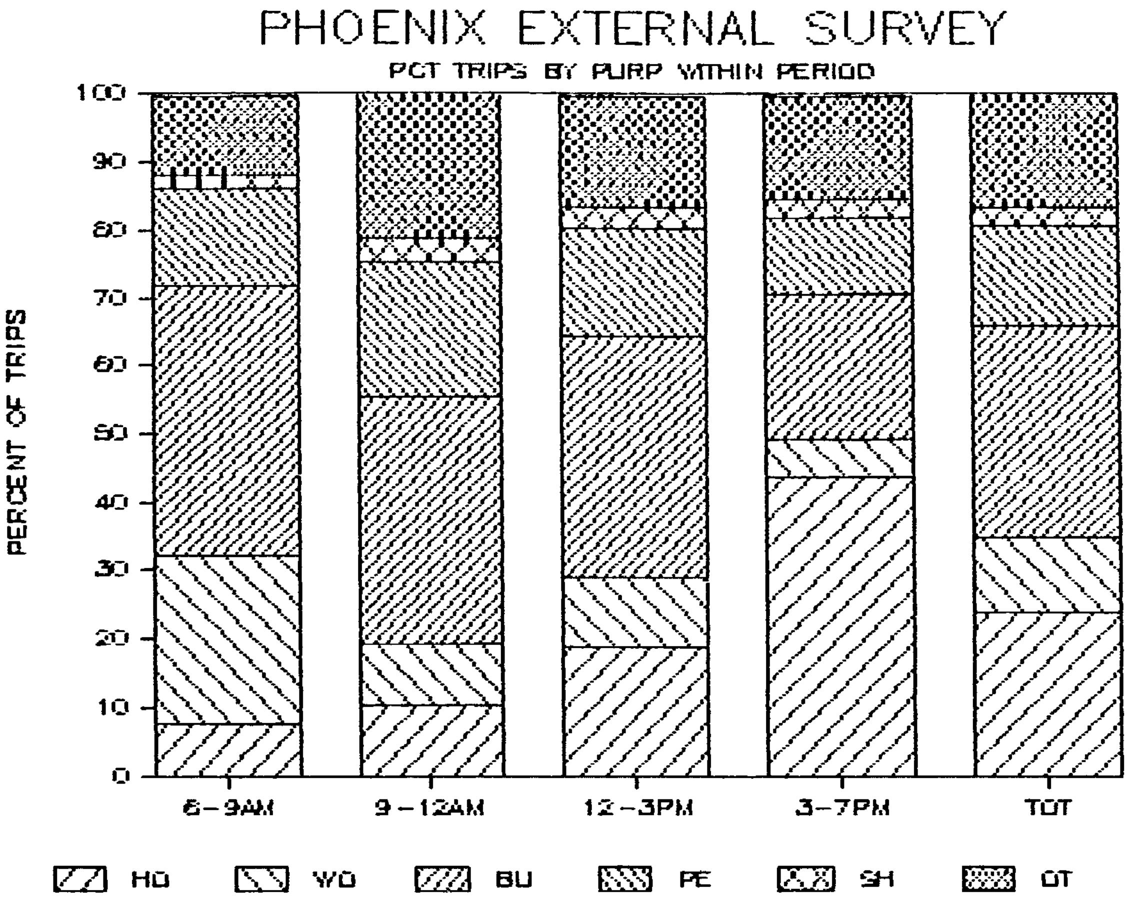
some of these exhibits, SOCIAL-RECREATION and OTHER trips have been combined since OTHER was a small category and only six subdivisions could be shown. The purpose breakdown is clearly very different than for internal trips, with a much smaller proportion related to HOME. The breakdown of external trips by purpose is further illustrated in Exhibit 7.

The breakdown of trips by vehicle type is shown in Exhibit 8. Trips by AUTO dominate, but there are a considerable number of trips by PICKUP/VAN (PUPV). Trucks account for a substantial portion of the WORK and BUSINESS trips, but not for other purposes, as would be expected. Very few trips were recorded by RECREATIONAL VEHICLES (RECV) or by MOTORCYCLE (MCYC).

Trip-length characteristics are illustrated in Exhibit 9. WORK and SHOP trips have relatively short average trip lengths, indicating they are more local in nature than other external trips. SOCIAL-RECREATION and OTHER trips have the longest trip length, as might be expected. Average trip length by vehicle type exhibits less deviation from the average but shows expected patterns in that RECV and 6+AXLE TRUCKS (6+TRK) have longer-than-average trip lengths and MCYC's have the shortest trip length. A detailed tabulation of trips and average trip distance for each station, cross classified by trip purpose and vehicle type, is presented in Appendix B.

Average trip length and total number of trips for each station are presented in Exhibit 10. As indicated, there is considerable variation in traffic volume and trip length among the stations. There is some tendency for average trip length to vary directly with the station volume, but this tendency is far from complete. The distribution of opportunities for each station also is a likely influence on trip length, but it is unlikely to fully explain the variation among stations — indeed, no single factor or variable is likely to do so. The distribution of external trips is

EXHIBIT 7


PHOENIX EXTERNAL SURVEY
PCT TRIPS BY PURP WITHIN PERIOD
PERCENT OF TRIPS
0
10
20
30
40
50
60
70
80
90
100
6-9AM
9-12AM
12-3PM
3-7PM
TOT
HO
WO
BU
PE
SH
OT

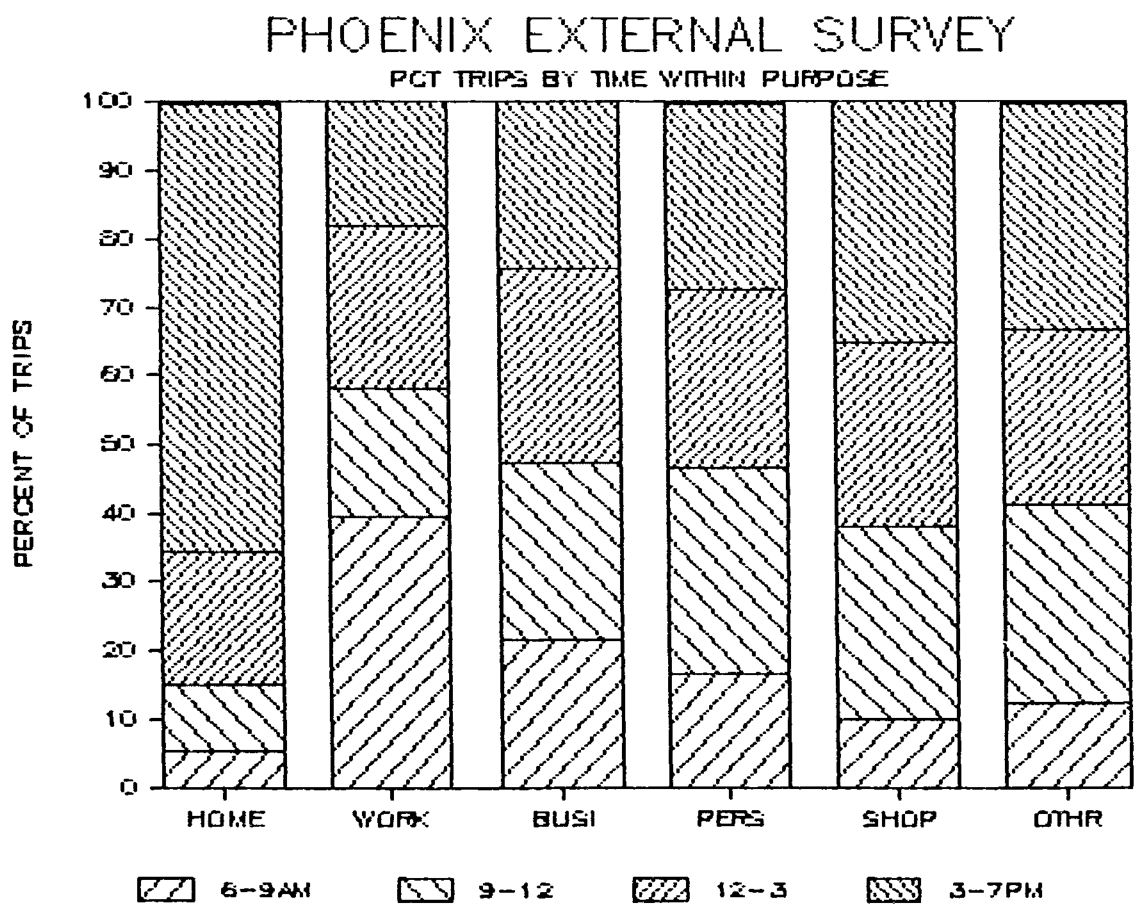
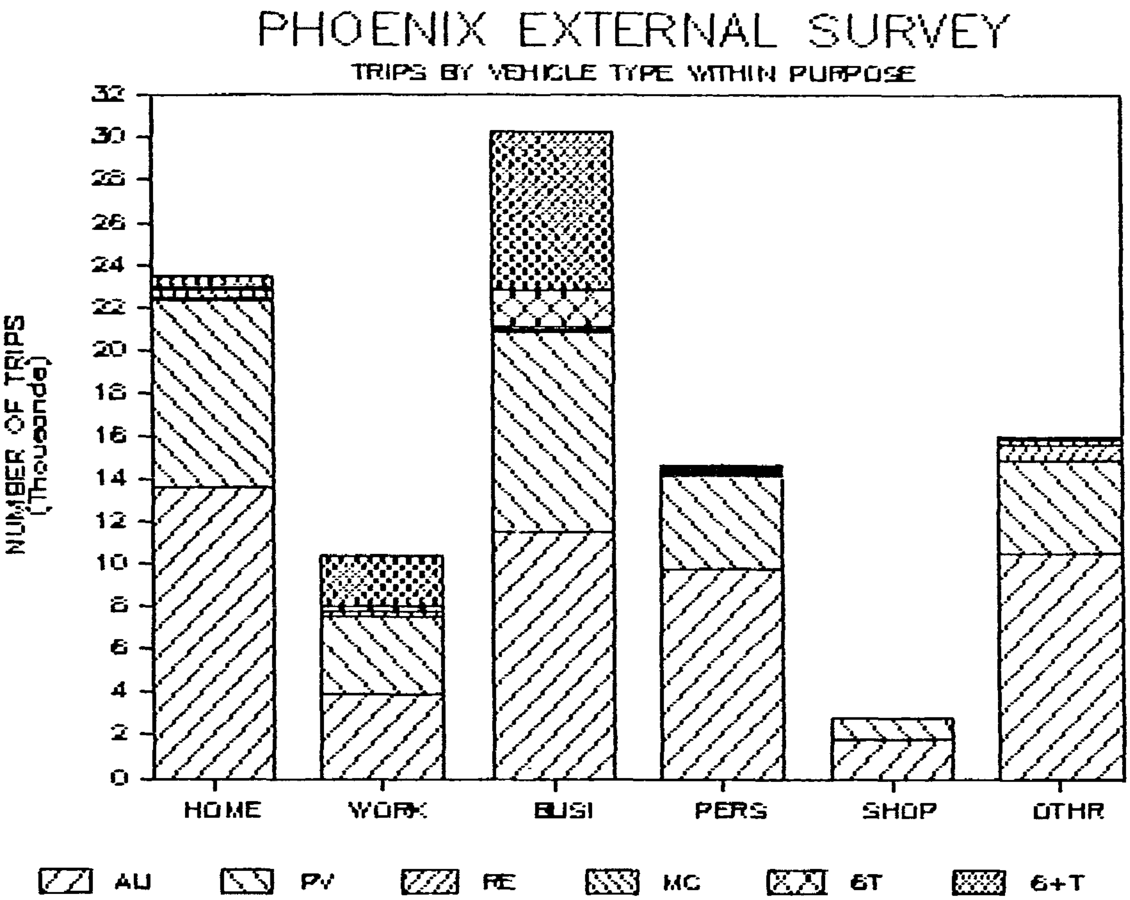
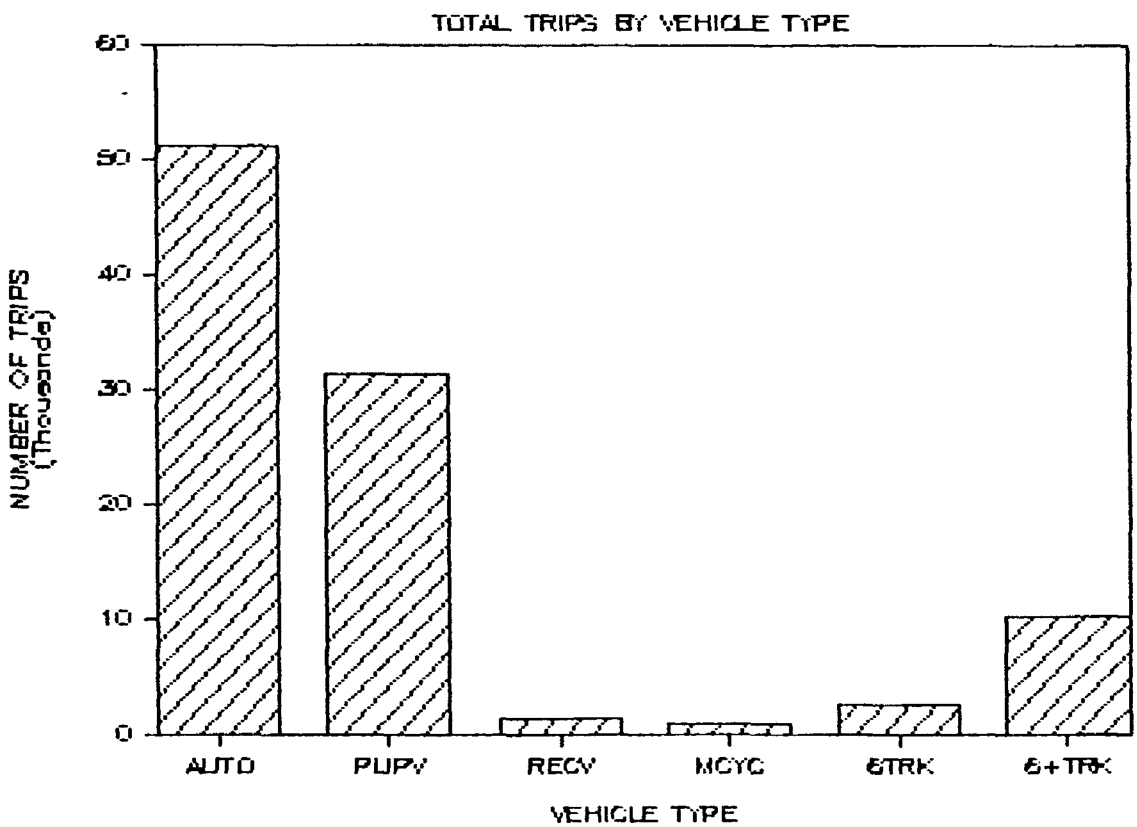

PHOENIX EXTERNAL SURVEY
PCT TRIPS BY TIME WITHIN PURPOSE
PERCENT OF TRIPS
0
10
20
30
40
50
60
70
80
90
100
HOME
WORK
BUSI
PERS
SHOP
OTHR
6-9AM
9-12
12-3
3-7PM

EXHIBIT 8

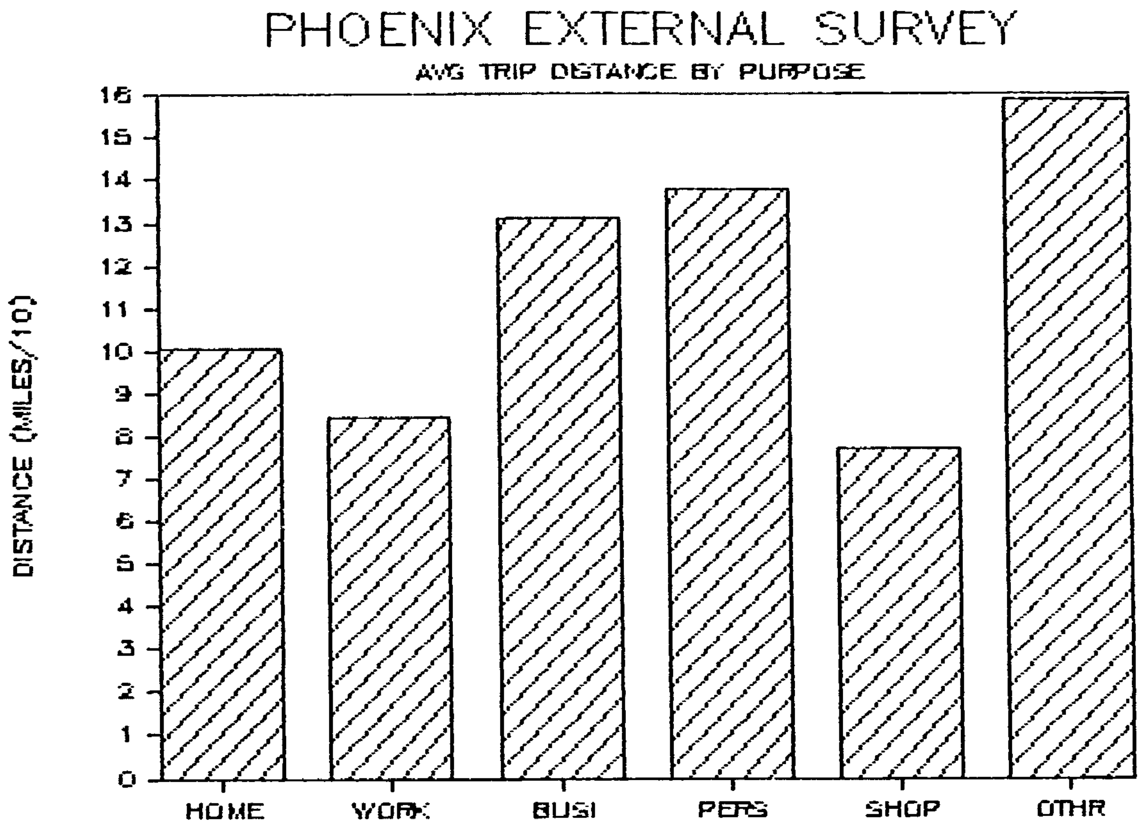


PHOENIX EXTERNAL SURVEY
TRIPS BY VEHICLE TYPE WITHIN PURPOSE
NUMBER OF TRIPS (Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
HOME
WORK
BUSI
PERS
SHOP
OTHR
AU
PV
RE
MC
6T
6+T



TOTAL TRIPS BY VEHICLE TYPE
NUMBER OF TRIPS (Thousands)
0
10
20
30
40
50
60
AUTO
PUPV
RECV
MCYC
6TRK
6+TRK
VEHICLE TYPE

EXHIBIT 9


PHOENIX EXTERNAL SURVEY
AVG TRIP DISTANCE BY PURPOSE
DISTANCE (MILES/10)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
HOME
WORK
BUSI
PERS
SHOP
OTHR

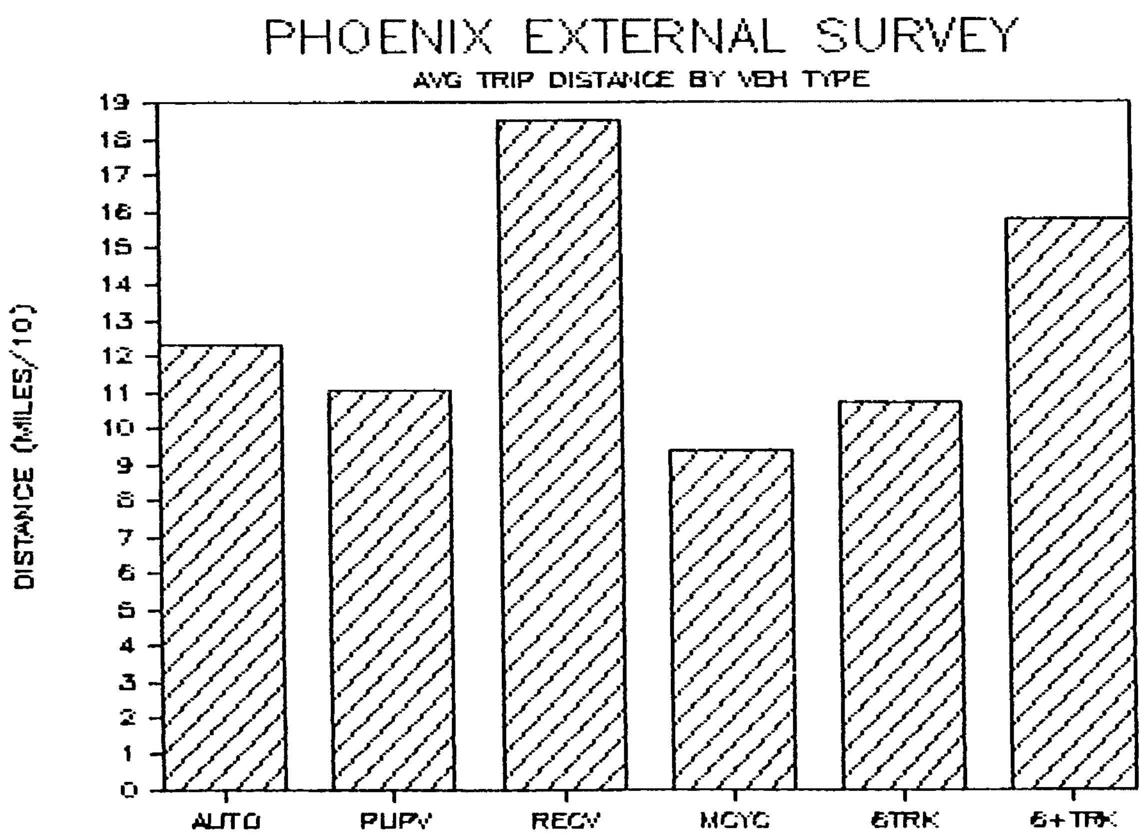
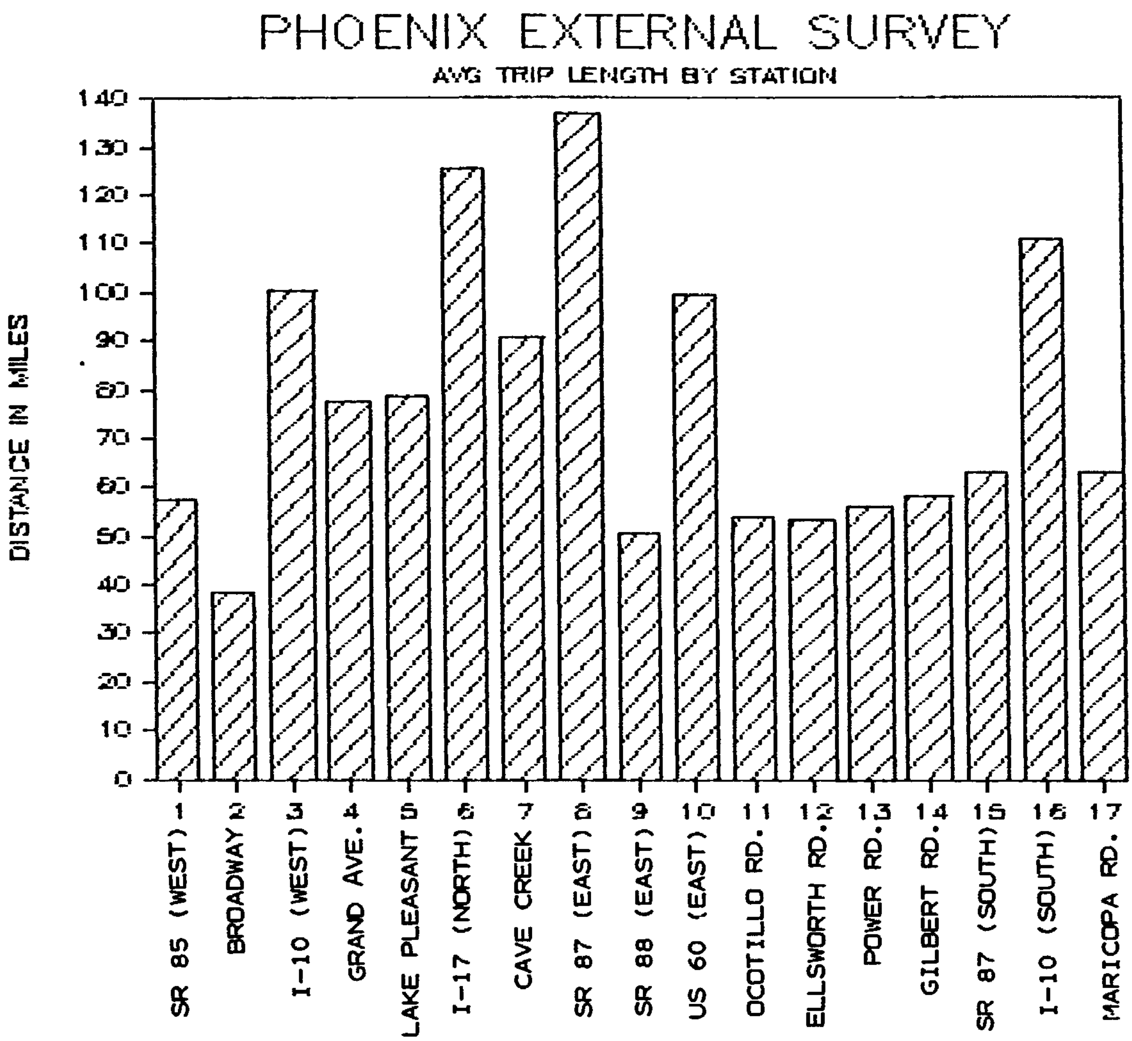
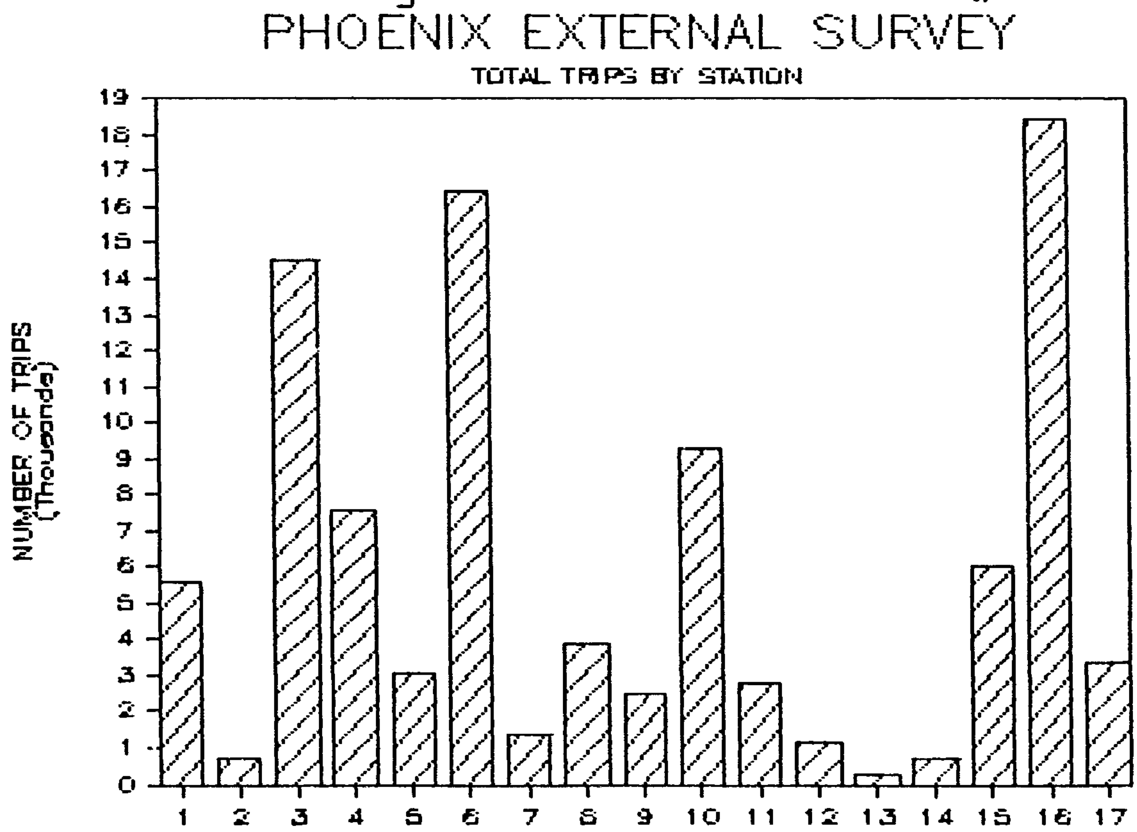

PHOENIX EXTERNAL SURVEY
AVG TRIP DISTANCE BY VEH TYPE
DISTANCE (MILES/10)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
AUTO
PUPV
RECV
MCYC
6TRK
6+TRK

EXHIBIT 10


PHOENIX EXTERNAL SURVEY
AVG TRIP LENGTH BY STATION
DISTANCE IN MILES
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
1 SR 85 (WEST)
2 BROADWAY
3 I-10 (WEST)
4 GRAND AVE.
5 LAKE PLEASANT
6 I-17 (NORTH)
7 CAVE CREEK
8 SR 87 (EAST)
9 SR 88 (EAST)
10 US 60 (EAST)
11 OCOTILLO RD.
12 ELLSWORTH RD.
13 POWER RD.
14 GILBERT RD.
15 SR 87 (SOUTH)
16 I-10 (SOUTH)
17 MARICOPA RD.


PHOENIX EXTERNAL SURVEY
TOTAL TRIPS BY STATION
NUMBER OF TRIPS
(Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

illustrated in Exhibits 11 and 12. Figure 11 shows the pattern of external - external trips; Exhibit 12, the pattern of external - internal trips to major subareas of the Phoenix region.

ALTERNATIVE MODEL STRUCTURES

The modeling of external trips involves two distinct steps -- the first related to trip generation and the second related to trip distribution. The trip-generation step almost certainly will involve some form of growth factoring. The growth factors may be global or specific to each station; they may be based on trends in traffic volumes or based on activity measures such as population or internal trip ends. The choice of growth-factor methodology is independent of the choice of trip-distribution methodology. Growth factors, either global or station-specific, will determine the magnitude of future external travel. These factors will be applied to observed external station volumes to yield future control totals to which the trip distribution will be balanced -- through either a fratar-type factoring procedure or a gravity model distribution procedure. Thus, the key decision relates to the most appropriate method of growth factoring.

An alternative and less typical approach is to combine both the trip generation and trip distribution steps into a single relationship. This approach would directly estimate trips at the interchange level in a single step -- often referred to as the direct demand model. This could be a particularly appropriate approach for the external trip model.

Based on the analysis of survey results, it seems unlikely that a *simple* synthetic model will be able to accurately reproduce the diverse external trip patterns observed. On the one hand, this fact could be overlooked on the basis that external trips represent only a small proportion of total

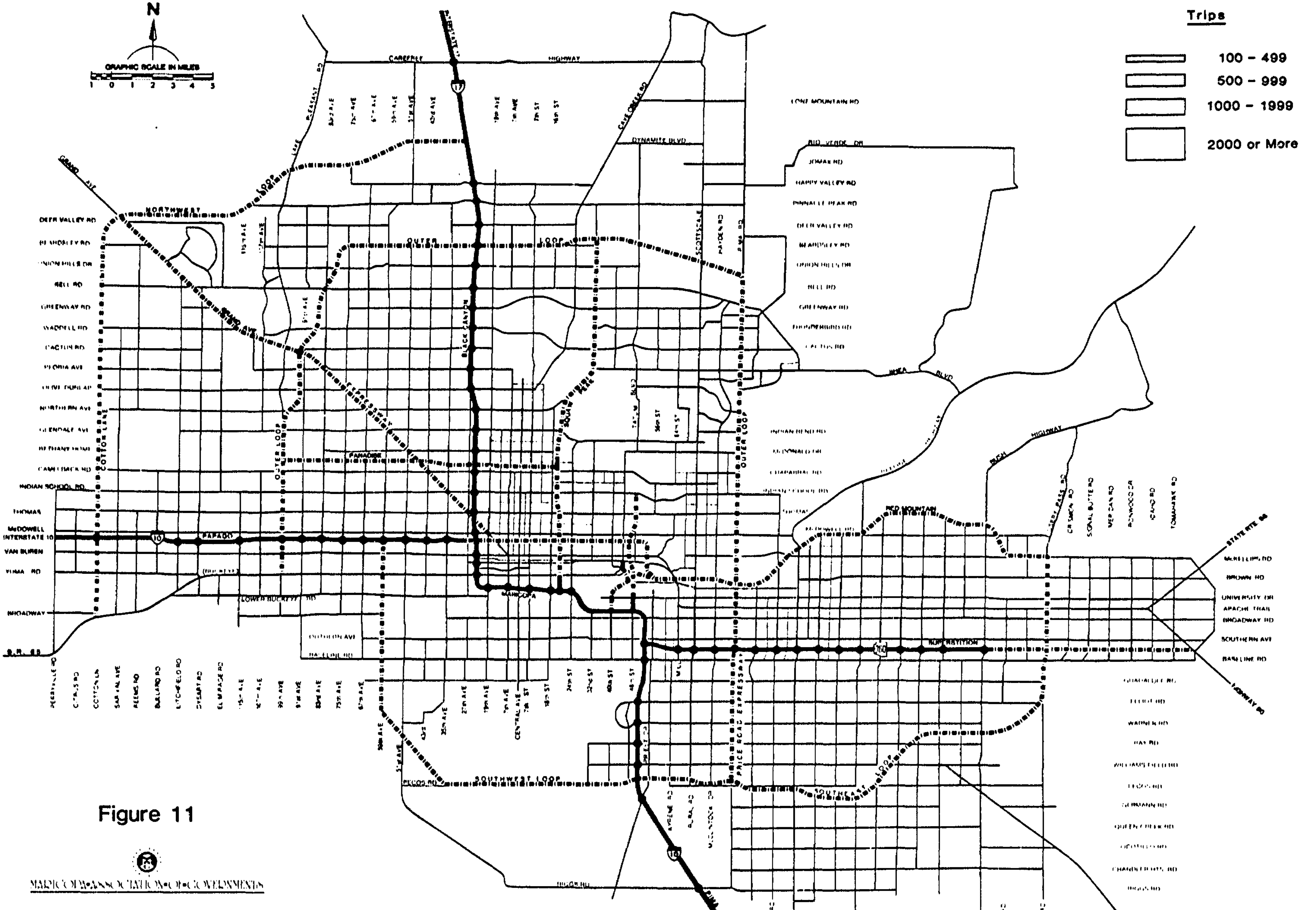


Figure 11

MARICOPA•ASSOCIATION•OF•GOVERNMENTS

1985 WEEKDAY VEHICLE TRIPS

EXTERNAL STATION to EXTERNAL STATION

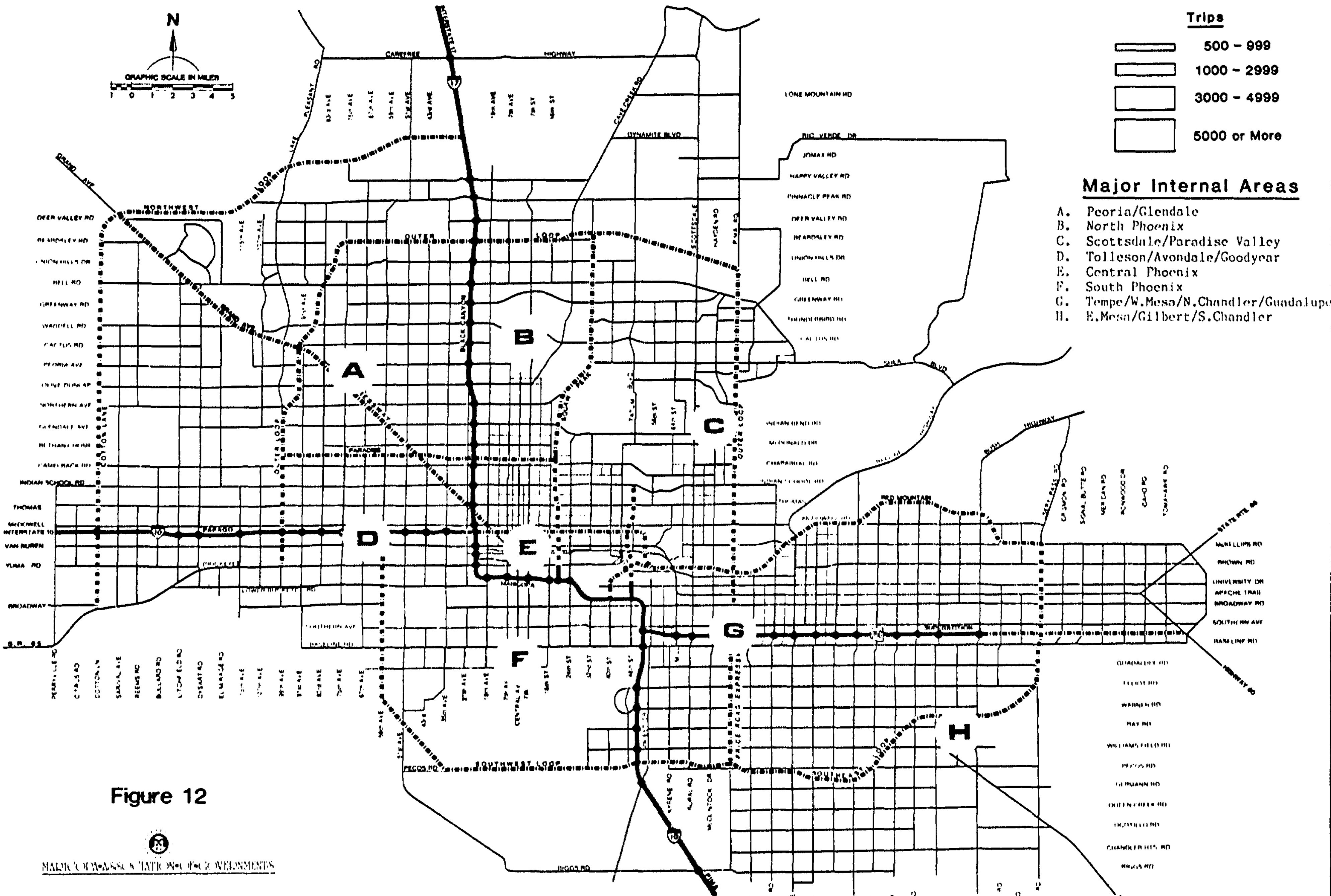


Figure 12

MARICOPA ASSOCIATION OF GOVERNMENTS

1985 WEEKDAY VEHICLE TRIPS

EXTERNAL STATION to MAJOR INTERNAL AREAS

travel. On the other hand, is it best to develop a synthetic model? A synthetic model would be more complicated to derive and to apply and could produce less accurate results compared to growth factoring the actual survey results. The growth-factoring approach retains the unique patterns observed at each station and does not involve the time, cost and uncertainty associated with a synthetic model. However, the growth-factoring approach will not reflect major reorientations of travel demand due to growth in new development areas or due to major new highway facilities. A synthetic model potentially could reflect such influences.

The simplest approach, and not an unreasonable one, would be to build a single trip table containing all external survey trips. For a given forecast year, two factors could be developed for application to this table -- one based on total internal trip growth to be applied to interchanges with an internal end; the other to be applied to X-X trips based on historic travel growth, population growth in the Southwest, and/or other general activity measures.

An extension of this approach would be to allow factors to vary by station or station group. This approach would necessitate separation of X-X and I-X/X-I trips and use of a matrix-balancing procedure rather than the simple factoring of a single matrix. This approach, which is still quite simple to apply, would provide much greater flexibility and would produce superior results with modest additional effort. There are also a variety of hybrid approaches. For example, station-specific growth factors might be developed for some or all stations for I-X/X-I trips with a single global factor applied to all X-X trips.

Based on discussions of alternative approaches at the Technical Advisory Committee meeting held on February 12, 1986, it was decided that a synthetic model would be the most desirable approach. An approach similar to that applied to Arizona State University (ASU) trips was agreed upon as a basis for the external model. This approach will be applied to trips between external stations and internal zones. Trips between external stations will be handled by growth factoring. Truck trips will be handled separately from other vehicles.

6.

MODEL DEVELOPMENT

MODEL FORMULATION

Although an approach similar to that used for ASU trips will be employed for external-internal trips, the approach is complicated by the fact that there are multiple external stations. This complication could be dealt with by developing a separate relationship for each external station. However, a more desirable approach is to develop a generalized relationship that can adequately reflect the differing characteristics across all external stations. This would be particularly desirable from a transferability standpoint.

A generalized relationship may be formulated as follows:

$$T_{ij} = P_i * A_j * D_{ij}$$

where: T_{ij} = trips between external station i and internal zone j

P_i = the "productions" for station i

A_j = the "attractions" for zone j

D_{ij} = a function of the separation between station i and zone j

The terms "productions" and "attractions" are used in a generalized manner.

Given the data available for model development, productions can be a function of the observed trip ends at each station and attractions can be a function of several internal zonal variables such as households and employment by type.

Zonal separation can be a function of time or distance derived from coded highway networks. Time is preferred to distance as it is a better indicator of available travel facilities. Off-peak highway time is proposed since external trips are not concentrated in peak periods.

CALIBRATION DATA

Since the desired external model is to be applied on a station-to-zone interchange basis, it is necessary to create a calibration dataset on an interchange basis. The dataset created for this model is described below.

Three types of data are included in the dataset:

1. Total trip productions for each station by vehicle type;
2. Household and employment data by internal zone;
3. Station-to-zone off-peak highway time.

In order to prepare the external survey trip data for model development, trip tables were built for three vehicle types:

1. All non-truck vehicles;
2. Medium trucks;
3. Heavy trucks.

These tables were built from the survey data file in an origin-destination directional sense. For model development purposes, it was necessary to convert these tables to a production-attraction directional sense. This was accomplished by transposing each trip matrix then adding each table to its transpose, retaining only those interchanges representing external station-to-internal zone movements -- that is, the rows of the matrices corresponding to external stations (rows 1194 to 1210) and columns corresponding to internal zones (columns 1 to 1193). The row totals for rows 1194 to 1210 represent the total external station productions.

Zonal data for model development was obtained from MAG. This data included the following variables for the year 1985:

1. Total households;
2. Industrial employment;
3. Retail employment; and
4. Other employment.

Total households were taken from the standard UTPS TAZ Demand Forecasting Dataset. Employment data was based on a recent employment survey. This data is presented in Appendix C.

The file for model development was created using a special application of the UTPS program UMODEL. The resulting file includes a record for each station-to-zone interchange containing the following variables:

Type	Variable
I	OBSERVED OTHER VEHICLE TRIPS
I	OBSERVED MEDIUM TRUCK TRIPS
I	OBSERVED HEAVY TRUCK TRIPS
I	OFF-PEAK HIGHWAY TIME
P	OBSERVED OTHER VEHICLE PRODUCTIONS
P	OBSERVED MEDIUM TRUCK PRODUCTIONS
P	OBSERVED HEAVY TRUCK PRODUCTIONS
A	TOTAL HOUSEHOLDS
A	INDUSTRIAL EMPLOYMENT
A	RETAIL EMPLOYMENT
A	OTHER EMPLOYMENT

I = Interchange variable

P = Station production variable

A = Internal zone attraction variable

UMODEL setups for creation of the calibration file are presented in Appendix E. The calibration file created is designed for input to the UTPS calibration program UFIT, which was used to derive the model relationships as described below.

CALIBRATION PROCESS

The basic calibration procedure used to derive estimating relationships for external trips was multiple linear regression as implemented in the UTPS program UFIT. At the outset it was assumed that the relationships involved would be other than simple linear relationships. Thus various transformation strategies were investigated to deal with complex, non-linear relationships as well as tests involving simple linear forms. As indicated above, the general model formulation assumes three components:

1. A production component based on the observed trips at each station;

2. An attraction component assumed to be a composite relationship involving total households and employment by type at each internal zone; and

3. A travel time component.

These components in various forms comprise the independent variables. The observed trips from external stations to internal zones comprise the dependent variables. For example, the simple linear form was as follows:

$$T_{ij} = a * P_i + b * HH_j + c * IE_j + d * RE_j + e * OE_j + f * TIME_{ij}$$

where:

T_{ij} = observed trips from i to j for a vehicle type
HH_j = households at j;
IE_j = industrial employment at j;
RE_j = retail employment at j;
OE_j = other employment at j; and
$TIME_{ij}$ = off-peak time from i to j.

As hypothesized, this simple form produced very poor results in the UFIT runs. In order to utilize linear regression for complex, non-linear relationships, it is necessary to assume a basic formulation, then transform this into linear components.

In general form, the hypothesized relationship is as follows:

$$f(T_{ij}) = f(P_i) * f(HH_j, IE_j, RE_j, OE_j) * f(TIME_{ij})$$

where the variables within each function are defined as above.

This formulation is very similar to the numerator of the gravity model frequently used for modeling trip distribution. In this case, the model combines both generation and distribution. The complexity of the formulation is due primarily to the attraction and time components. Initially, the attraction component was assumed to be a weighted combination of the available attraction-type variables, which was termed AJ. The time component was assumed to follow a gamma-type distribution, which is a left-skewed, bell-shaped distribution often used for gravity model deterrence functions. This distribution has the following form:

f(TIME) = (TIME**a) * EXP(b*TIME)

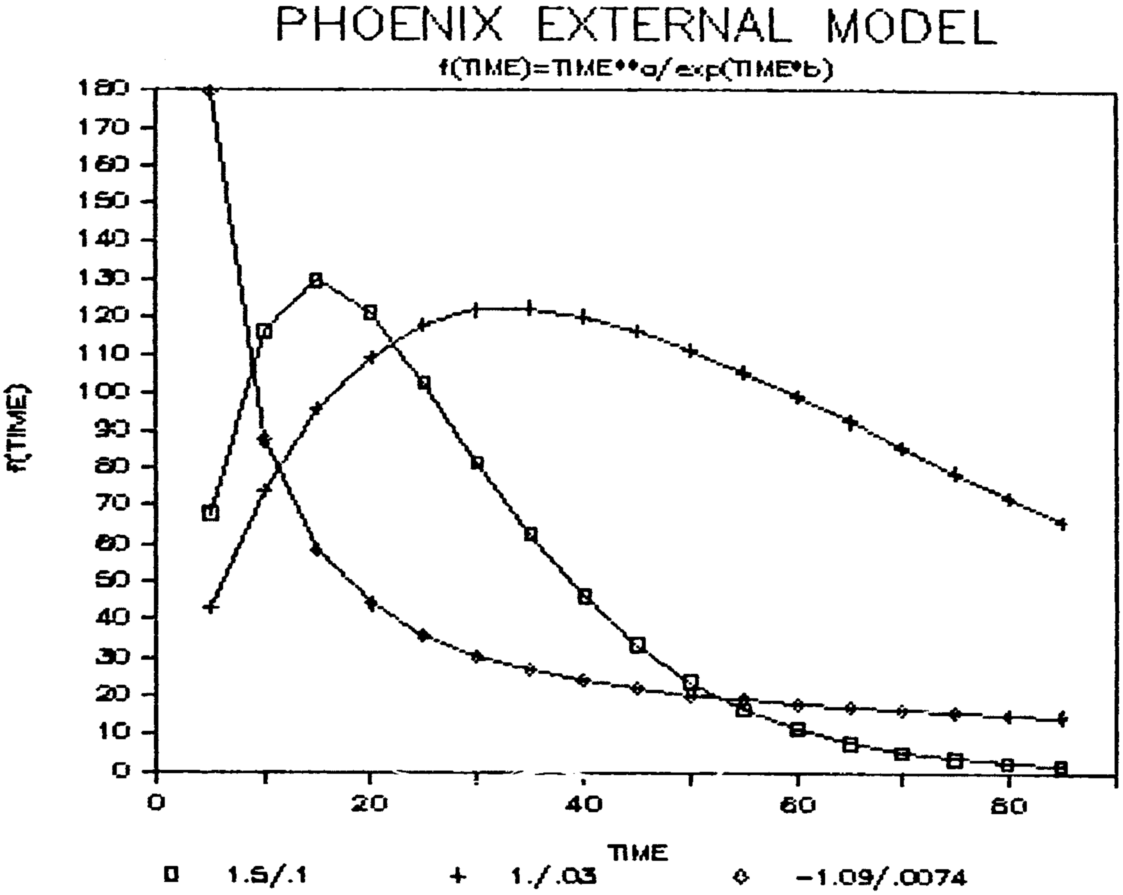
The shape of this distribution for various values of a and b is illustrated in Exhibit 13. Given these initial assumptions, the model can be expressed as:

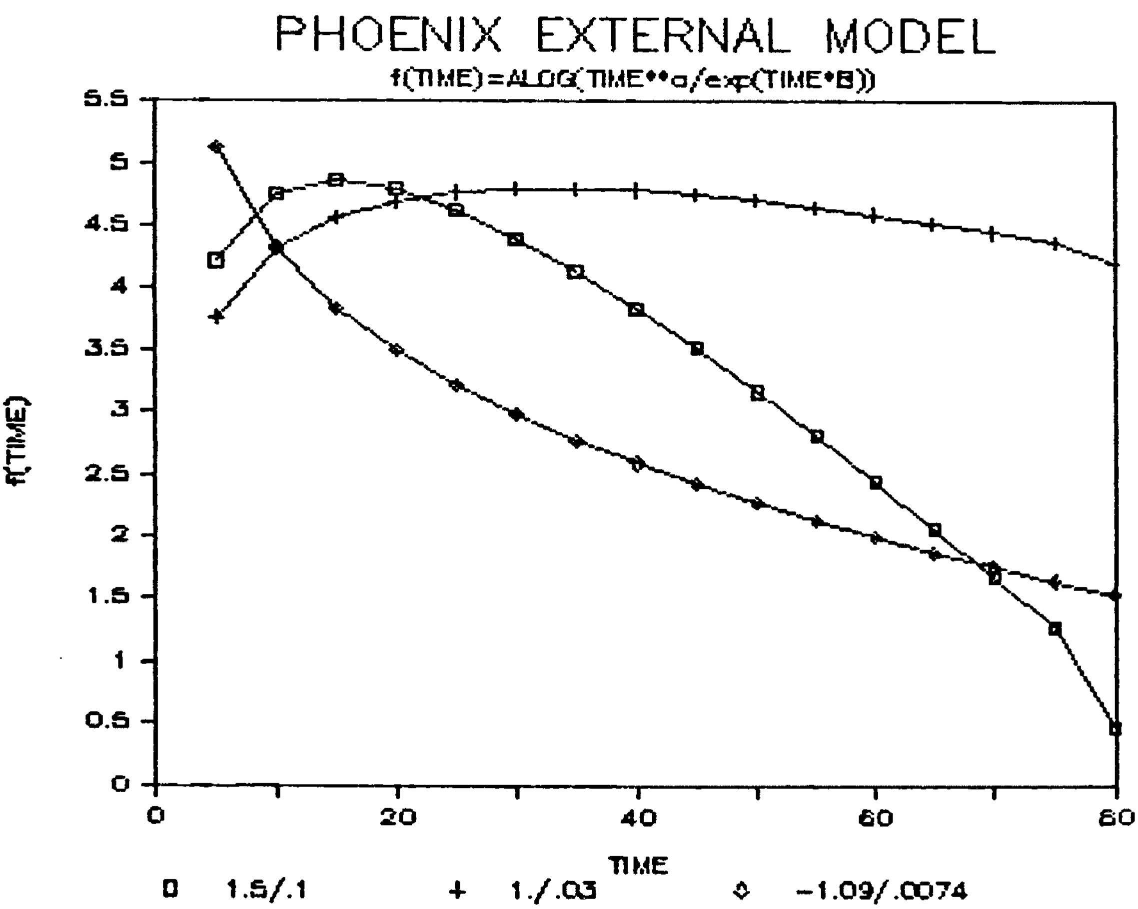
TIJ = PI * AJ * (TIME**a) * EXP(b*TIME)

This is clearly a non-linear relationship but can be transformed into additive, linear components by taking the LOG of both sides of the relationship yielding:

LOG (TIJ) = LOG (PI) + LOG (AJ) + a * LOG(TIME) + b * TIME

EXHIBIT 13


PHOENIX EXTERNAL MODEL
f(TIME)=TIME**a/exp(TIME*b)
f(TIME)
TIME
1.5/.1
1./.03
-1.09/.0074


PHOENIX EXTERNAL MODEL
f(TIME)=ALOG(TIME**a/exp(TIME*B))
f(TIME)
TIME
1.5/.1
1./.03
-1.09/.0074

Variations on this general form were evaluated using UFIT. The most promising results of these runs are summarized in Exhibit 14. A sample UFIT run is presented in Appendix F.

PRODUCTION MODEL

In order to apply the external trip model and evaluate its performance, the model was implemented within the UTPS program UMODEL. The user-coded subroutine for the model and the UMODEL application setup are presented in Appendix G. The model was applied using 1985 data and the results compared to observed survey data. Exhibit 15 presents the observed and estimated trip productions by vehicle type for each station. The model has been calibrated to accurately reproduce the productions at each station as indicated by Exhibit 15.

Exhibits 16-18 present observed versus estimated trip length frequency distributions. As indicated in these exhibits, the model also accurately reproduces the observed trip length distributions.

Exhibit 19 presents observed versus estimated trip attractions by vehicle type summarized by district (the zone-district equivalencies are included in Appendix D). While the comparisons in Exhibit 19 are not as satisfying as those in Exhibits 15-18, the model is doing as well as can be expected given the nature of the data involved. The trip matrices being estimated are very sparse, particularly for truck trips and especially for medium truck trips. Relatively few of the potential zone-to-zone interchanges have observed trips and the observed total trips from most of the stations is small in comparison to the number of potential destination zones. Given this situation, and recognizing that the survey data is also an estimate based on a sample survey, the model cannot be expected to reproduce survey

EXHIBIT 14

PHOENIX EXTERNAL MODEL - SUMMARY OF UFIT RUNS

COEFF.	OTHER VEH. TRIPS (OTHVEH) VALUE	STD.ERR.	t-RATIO	MED TRUCK TRIPS (MEDTRK) VALUE	STD.ERR.	t-RATIO	HVY TRUCK TRIPS (HVYTRK) VALUE	STD.ERR.	t-RATIO
A1	1.67600	0.08990	18.60	0.23960	0.04010	5.97	0.48080	0.06390	7.52
A2	0.31290	0.00580	54.20	0.00370	0.00110	3.46	0.02170	0.00123	17.70
A3	NA	NA	NA	0.00001	0.000003	4.11	0.000080	0.000004	1.90
A4	1.01520	0.01960	51.70	0.00061	0.00105	0.58	0.00245	0.00169	1.45
A5	NA	NA	NA	0.00400	0.00080	5.01	0.01630	0.00130	12.70
A6	0.00024	0.00001	21.80	0.00083	0.00032	2.56	0.00210	0.00050	4.02
A7	0.02645	0.00416	6.37	-0.07520	0.01450	-5.19	-0.17590	0.02330	-7.55
A8	0.01870	0.00320	5.91	0.00035	0.00083	0.42	-0.00046	0.00133	-0.34
A9	0.02230	0.00330	6.81	NA	NA	NA	NA	NA	NA

REGRESSION EQUATIONS:

LOG(OTHVEH) = A1 + A2*LOG(OTHVEHPR) + A4*LOG(exp(0.0074*TIME)/TIME**1.09) + A6*TOTHH
+ A7*LOG(RETEMP) + A8*LOG(INDEMP) + A9*LOG(OTHEMP)

LOG(MEDTRK) = A1 + A2*LOG(MEDTRKPR) + A3*TOTHH + A4*LOG(RETEMP) + A5*LOG(INDEMP)
+ A8*LOG(OTHEMP) + A6*TIME + A7*LOG(TIME)

LOG(HVYTRK) = A1 + A2*LOG(HVYTRKPR) + A3*TOTHH + A4*LOG(RETEMP) + A5*LOG(INDEMP)
+ A8*LOG(OTHEMP) + A6*TIME + A7*LOG(TIME)

NOTE: RETEMP WAS DROPPED FROM MEDTRK AND OTHEMP FROM BOTH MEDTRK AND HVYTRK DUE TO LOW SIGNIFICANCE

EXHIBIT 15

PHOENIX EXTERNAL MODEL - OBSERVED VS ESTIMATED PRODUCTIONS

STATION	OTHER VEHICLES OBS	OTHER VEHICLES EST	MEDIUM TRUCKS OBS	MEDIUM TRUCKS EST	HEAVY TRUCKS OBS	HEAVY TRUCKS EST
1194	4555	4591	178	224	348	476
1195	513	697	36	49	18	26
1196	9193	9201	255	292	2339	2349
1197	6459	6498	204	225	277	321
1198	2467	2559	41	42	91	101
1199	13016	13001	315	662	1199	1049
1200	1239	1141	28	8	5	34
1201	3367	3355	73	125	170	446
1202	2202	2149	45	13	96	125
1203	8010	8006	230	124	480	454
1204	2442	2465	106	144	111	111
1205	1105	1030	26	20	12	18
1206	276	411	5	0	12	23
1207	671	1028	30	41	17	39
1208	5082	5072	219	425	462	501
1209	12683	12673	484	607	2563	2582
1210	2989	2923	78	358	211	195
TOTAL	76269	76800	2353	3359	8411	8850

EXHIBIT 16

```
         EST AND OBS OTHER VEH TRIPS VS OFF-PEAK TIME
        OBSERVED (-) AND ESTIMATED (+)    TRIP LENGTH FREQUENCY DISTRIBUTIONS
        OBSERVED =   UMCON    (TABLE 2001)    ESTIMATED =   UMODEL   (TABLE 3001)
                             SKIM TREE =   OFPK TIM(TABLE 1001)
                                  (COUNTS SCALED BY  10)
     0    2    4    6    8   10   12   14   16   18   20      COUNTS       RATIO
     +----+----+----+----+----+----+----+----+----+----+    (+)    (-)   (+)/(-)
   0*                                                          0      0      0.0
   5*--                                                        2     51      0.0
  10**--                                                      42     90      0.5
  15********-------------                                    223    599      0.4
  20**************--------                                   404    639      0.6
  25***********************-                                 688    716      1.0
  30******************************++                         963    875      1.1
  35**********************************++++++++              1258    999      1.3
  40******************************+++++++++                 1172    899      1.3
  45***************************++++                          930    807      1.2
  50********************+++                                  688    585      1.2
  55***************++                                        498    425      1.2
  60************+                                            371    325      1.1
  65*********-                                               236    267      0.9
  70*****                                                    120    132      0.9
  75***-                                                      52     86      0.6
  80**-                                                       23     55      0.4
  85*-                                                         4     43      0.1
  90*-                                                         1     22      0.1
  95*                                                          0      6      0.0
 100*                                                          0      7      0.0
 105* (ALL REMAINING COUNTS ARE ZERO)                          0      0      0.0
          MEAN        VARIANCE       STD DEV    TOTAL COUNT                 AREA
          ----        --------       -------    -----------                 ----
  (+)   37.201   (+)   175.127   (+) 13.234   (+)      76762   COINCIDENT  87.837
  (-)   35.629   (-)   260.902   (-) 16.152   (-)      76290        TOTAL 112.163
```

EXHIBIT 17

```
    EST AND OBS MED TRK TRPS VS OFF-PEAK TIME
   OBSERVED (-) AND ESTIMATED (+)   TRIP LENGTH FREQUENCY DISTRIBUTIONS
   OBSERVED =  UMCON   (TABLE 2002)   ESTIMATED =  UMODEL  (TABLE 3002)
                  SKIM TREE =  OFPK TIM(TABLE 1001)
    0    4    8    12   16   20   24   28   32   36   40    COUNTS    RATIO
    +----+----+----+----+----+----+----+----+----+----+   (+)  (-)  (+)/(-)
  0*                                                         0    0     0.0
  5*                                                         0    2     0.0
 10*-                                                        0   19     0.0
 15*-----                                                    0   87     0.0
 20*-----                                                    4   93     0.0
 25******-----                                             130  195     0.7
 30**************++++++++++++++++                          787  241     3.3
 35************************++++++++++++++++++++++++       1270  441     2.9
 40****************+++++++++++++++++                       862  286     3.0
 45*********-------                                        202  273     0.7
 50*****-----                                              103  167     0.6
 55*---                                                      1   49     0.0
 60*----------                                               0  185     0.0
 65*-----------                                              0  208     0.0
 70*----                                                     0   84     0.0
 75*-                                                        0   13     0.0
 80*                                                         0    0     0.0
 85*                                                         0    0     0.0
 90*                                                         0    0     0.0
 95*                                                         0    0     0.0
100*-                                                        0   10     0.0
105* (ALL REMAINING COUNTS ARE ZERO)                         0    0     0.0
        MEAN       VARIANCE      STD DEV   TOTAL COUNT                 AREA
        ----       --------      -------   -----------                 ----
  (+)  33.274  (+)    28.844  (+)  5.371  (+)      3359  COINCIDENT  54.238
  (-)  39.213  (-)   233.445  (-) 15.279  (-)      2353       TOTAL 145.762
```

EXHIBIT 18

```
 EST AND OBS HVY TRK TRPS VS OFF-PEAK TIME
OBSERVED (-) AND ESTIMATED (+)   TRIP LENGTH FREQUENCY DISTRIBUTIONS
OBSERVED =  UMCON   (TABLE 2003)   ESTIMATED =  UMODEL  (TABLE 3003)
                SKIM TREE =  OFPK TIM(TABLE 1001)
  0    4    8   12   16   20   24   28   32   36   40    COUNTS     RATIO
  +----+----+----+----+----+----+----+----+----+----+   (+)  (-)  (+)/(-)
 0*                                                        0    0      0.0
 5*                                                        0   31      0.0
10*                                                       14   23      0.6
15****---                                                210  394      0.5
20********--                                             481  604      0.8
25**********++++++                                      1058  602      1.8
30********************+++                               1574 1252      1.3
35***********************++++                           1831 1495      1.2
40************++++++++++                                1470  760      1.9
45****************-----------                           1048 1737      0.6
50*******+++                                             652  384      1.7
55******--                                               328  467      0.7
60***-                                                   174  203      0.9
65*-----                                                  11  350      0.0
70*                                                        0   21      0.0
75*                                                        0   24      0.0
80*-                                                       0   64      0.0
85* (ALL REMAINING COUNTS ARE ZERO)                        0    0      0.0
        MEAN      VARIANCE      STD DEV   TOTAL COUNT                 AREA
        ----      --------      -------   -----------                 ----
 (+)  33.476  (+)   98.949  (+)  9.947  (+)      8851  COINCIDENT   79.020
 (-)  35.555  (-)  172.426  (-) 13.131  (-)      8411       TOTAL  120.980
```

EXHIBIT 19

PHOENIX EXTERNAL MODEL - OBSERVED VS ESTIMATED ATTRACTIONS

DISTRICT	OTHER VEHICLES OBS	OTHER VEHICLES EST	MEDIUM TRUCKS OBS	MEDIUM TRUCKS EST	HEAVY TRUCKS OBS	HEAVY TRUCKS EST
1	589	677	14	19	0	64
2	1217	1362	56	78	35	220
3	2618	3011	28	112	121	334
4	516	716	0	23	10	86
5	1085	1659	34	78	11	246
6	1905	1853	34	74	67	178
7	654	1163	14	47	20	149
8	2232	1593	34	52	47	140
9	553	830	20	21	19	74
10	1210	1323	51	32	0	118
11	623	429	11	16	63	48
12	901	1272	7	21	132	192
13	3062	2601	71	145	194	323
14	2841	1580	49	58	493	120
15	1322	2204	124	73	112	213
16	375	516	0	17	13	51
17	421	403	10	14	15	43
18	540	588	0	10	83	37
19	990	856	14	26	76	122
20	1499	1285	15	69	197	127
21	2265	1512	32	78	344	127
22	3158	3124	50	180	132	339
23	1953	2128	48	113	82	196
24	1566	1836	26	70	46	173
25	1627	1138	23	23	86	151
26	2025	1576	16	33	511	238
27	196	329	2	14	13	34
28	694	1304	59	87	584	230
29	2507	2004	322	145	950	237
30	745	1094	53	85	464	156
31	2378	2703	164	198	433	364
32	1797	1905	122	87	277	202
33	2588	1313	39	67	432	186
34	2205	1924	53	69	214	208
35	3302	3166	117	174	264	350
36	1414	1979	104	133	4	236
37	2240	4667	44	249	194	561
38	2035	3816	118	215	715	536
39	2255	1687	27	29	113	160
40	2050	1460	118	42	133	185
41	3611	798	34	11	160	56
42	449	204	0	2	37	23
43	867	1451	12	16	91	141
44	197	491	6	0	37	52
45	2515	1449	72	30	202	148
46	1218	2662	38	131	70	364
47	761	1588	25	23	59	109
48	2498	1502	43	67	56	204
TOTAL	76269	76731	2353	3356	8411	8851

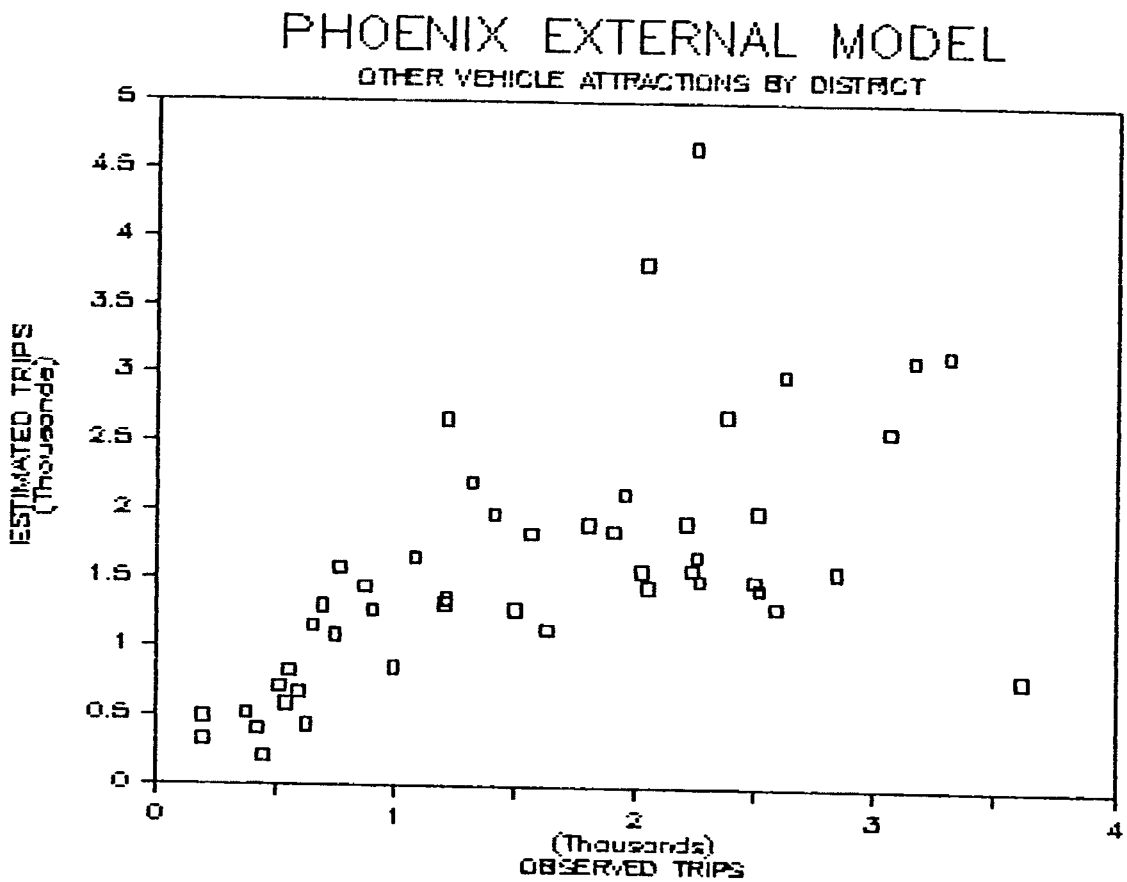
attractions with a high degree of accuracy. Where the number of trips involved is relatively large as for the other vehicle trips, there is general agreement between the observed and estimated attractions as indicated in Exhibit 19 and as further illustrated in Exhibit 20. If a few outliers are eliminated from Exhibit 20, the general result looks much improved.

The "outgoing" districts are as follows:

37 = Mesa vicinity
38 = South Central Area from Apache down to Reccor including South Moutain Park
41 = Eastern extremity of regions - Apache Junction
46 = Gilbert area -- far SE

Districts 37, 38 and 46 are comprised of a large number of zones; they do not represent the large generators as such. District 41 has a problem in the observed data as can be seen by reference to Appendix D. The district summary of data in Appendix D indicates there are some substantial discrepancies between the alternative sources of data. We have used the employment data from Source 2 (Recent Employment Survey). Data weaknesses in these outlying zones may be affecting other districts as well. Thus, the statistically "outlying zones" are in fact geographically outlying areas. The model appears to be overestimating trips in these outlying areas. However, this is where the internal models typically produce the least good results; hence, the potential error in the external model is not likely destroying what is otherwise a good estimate. Appendix H presents a statistical comparison of observed versus estimated values, with and without the four outlying districts indentified above.

EXHIBIT 20


PHOENIX EXTERNAL MODEL
OTHER VEHICLE ATTRACTIONS BY DISTRICT
ESTIMATED TRIPS
(Thousands)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
1
2
3
4
(Thousands)
OBSERVED TRIPS

In order to ensure that the model is utilizing the available attraction variables to best advantage, scatter plots of the EST-OBS error for other vehicle trips were prepared as shown in Exhibits 21-24. These exhibits plot EST-OBS other vehicle attractions by district versus total households (Exhibit 21), versus industrial employment (Exhibit 22), versus retail employment (Exhibit 23), and versus other employment (Exhibit 24). If any one of these plots indicated an unbalanced or biased distribution of the error term against an attraction variable, it would mean that attraction variable was poorly represented in the model. Exhibits 21-24 do not indicate the presence of any strong bias in the model estimates with respect to any one of the attraction variables. It is concluded, therefore, that the model is doing as well as can be expected and indeed is doing quite a good job of reproducing the general levels of travel demand produced by external stations both in number and in terms of vehicle miles of travel (VMT) as indicated by the trip length frequency distributions.

TRANSFERABILITY

Given the generalized structure of the external model development for Phoenix, the model could be readily adapted for use in another urban area. Recalibrations of the model would be essential, however. At a minimum, such recalibration would involve developing factors for each station to bring the total station productions into balance with counted volumes at each station. An O-D survey would not be necessary, just traffic counts by the three vehicle types used in the model. It would also be possible to combine medium trucks with other vehicle trips within the model for greater stability. In fact, this would be recommended.

In addition to traffic counts at each station, attraction variables as embodied in the Phoenix model would have to be available for the area in

EXHIBIT 21

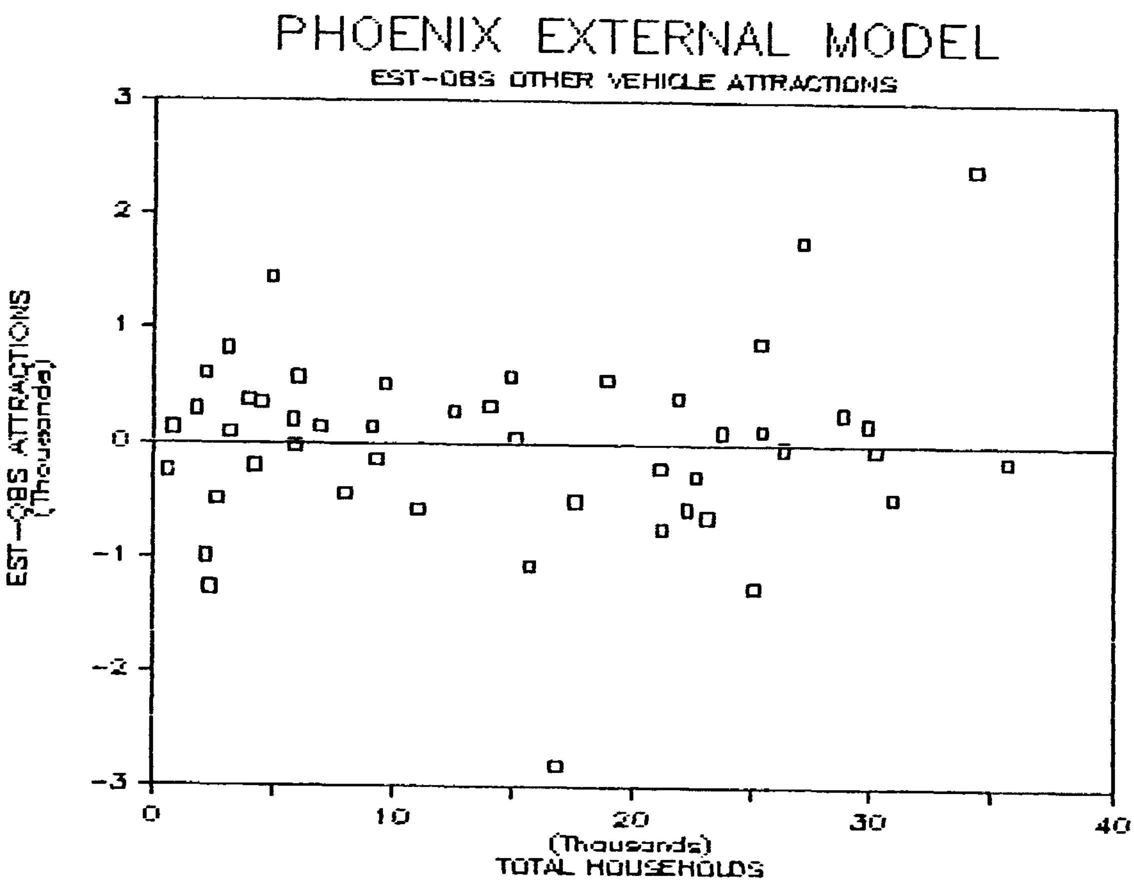

PHOENIX EXTERNAL MODEL
EST-OBS OTHER VEHICLE ATTRACTIONS
EST-OBS ATTRACTIONS
(Thousands)
3
2
1
0
-1
-2
-3
0
10
20
30
40
(Thousands)
TOTAL HOUSEHOLDS

EXHIBIT 22

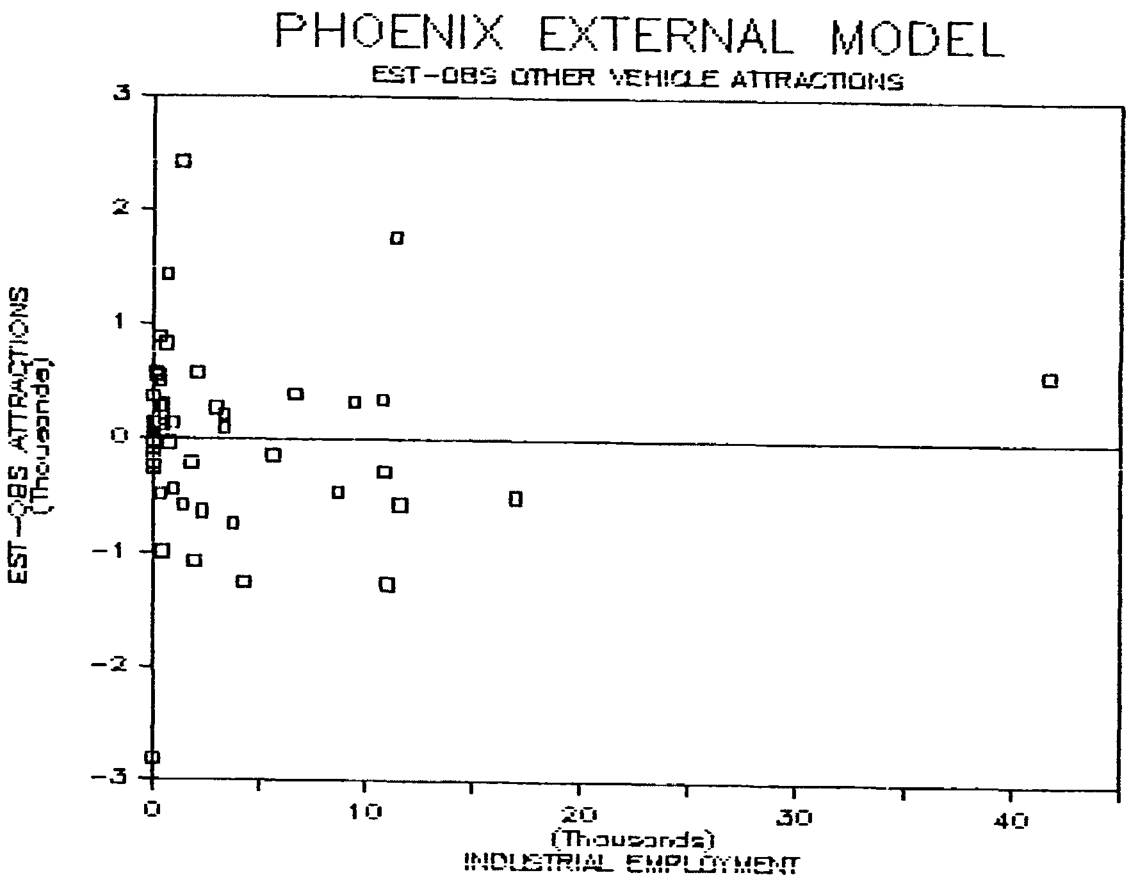
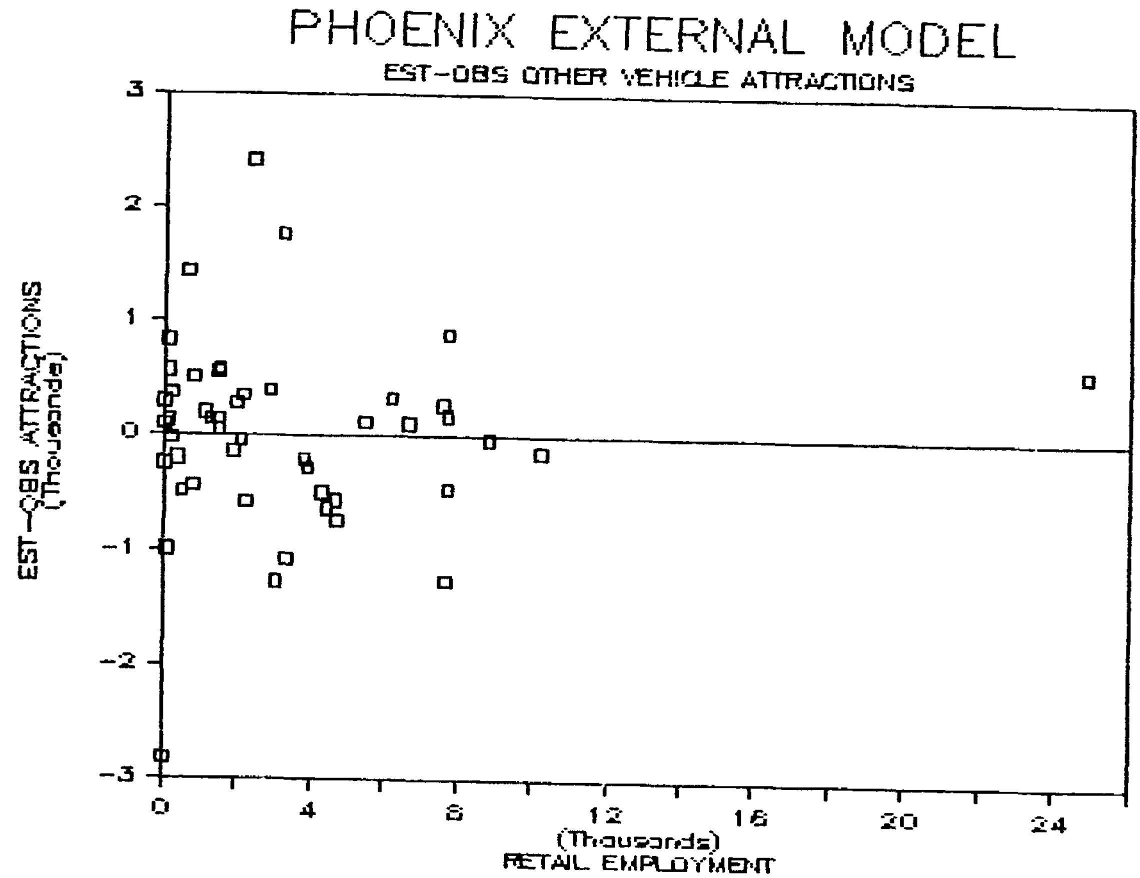
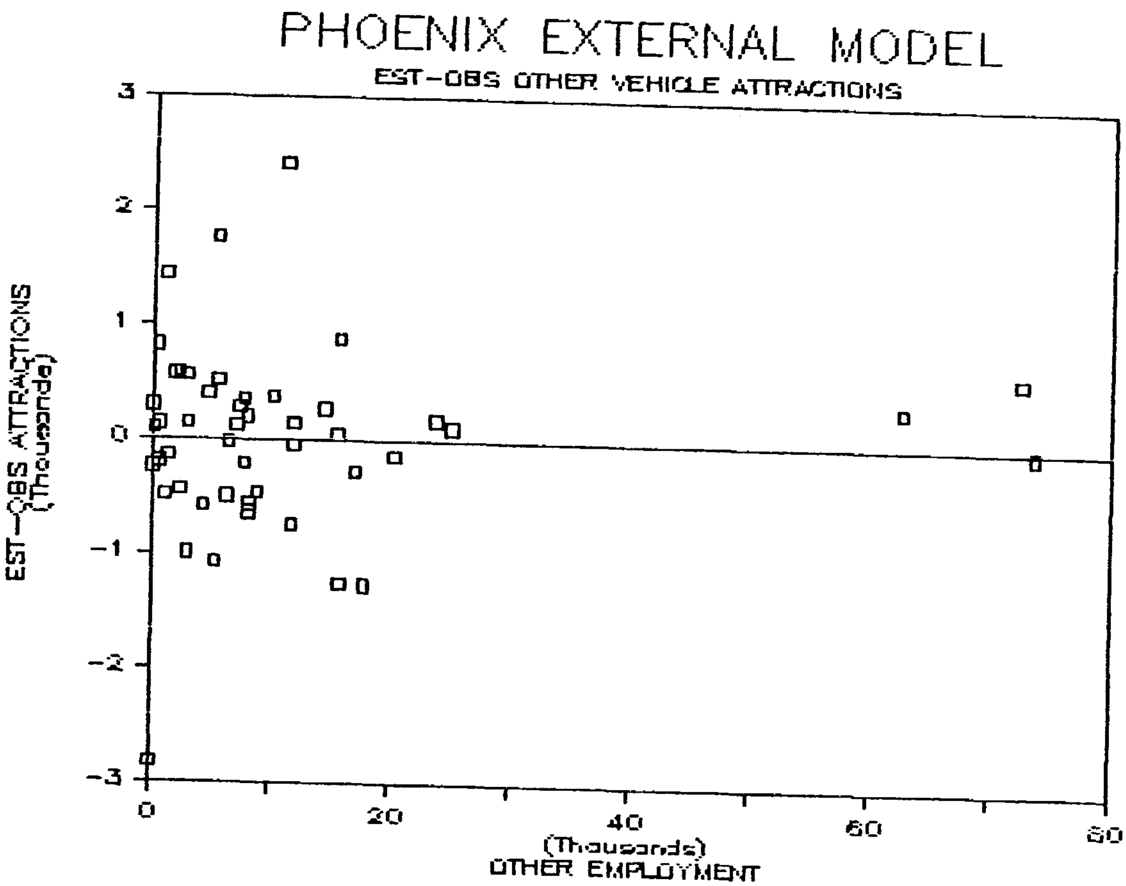

PHOENIX EXTERNAL MODEL
EST-OBS OTHER VEHICLE ATTRACTIONS
EST-OBS ATTRACTIONS (Thousands)
3
2
1
0
-1
-2
-3
0
10
20
30
40
(Thousands)
INDUSTRIAL EMPLOYMENT

EXHIBIT 23



PHOENIX EXTERNAL MODEL
EST-OBS OTHER VEHICLE ATTRACTIONS
EST-OBS ATTRACTIONS (Thousands)
3
2
1
0
-1
-2
-3
0
4
8
12
16
20
24
(Thousands)
RETAIL EMPLOYMENT

EXHIBIT 24



PHOENIX EXTERNAL MODEL
EST-OBS OTHER VEHICLE ATTRACTIONS
EST—OBS ATTRACTIONS
(Thousands)
3
2
1
0
-1
-2
-3
0
20
40
60
80
(Thousands)
OTHER EMPLOYMENT

question. The breakdown of employment as used for Phoenix may present a problem in other urban areas. If so, it would be possible to use the Phoenix calibration dataset to restructure the model in a manner consistent with the data available in the target urban area.

A further refinement in the adaptation of the model to another area is suggested -- the adjustment of average trip lengths based on comparative urban area size and/or comparative internal area average trip lengths. If a rational basis is available for estimating average trip lengths for the target area, then the model constants can be adjusted to reproduce these estimates.

APPENDIX A

Abstracts of Reports Related to External Roadside Interview Studies
(as reported by HRIS)

TRIP LENGTHS AND MODAL SPLIT OF RURAL TRAFFIC
Heijden, TG van der
Royal Dutch Touring Club ANWB
Verkeerskunde VOL. 35 No. 2 Feb 1984 pp 80-82 4 Fig. 2
Tab. 8 Ref. Dutch
Available From: Royal Dutch Touring Club ANWB Wassenaarseweg 220, P.O. Box 93200 The Hague Netherlands
SUBFILE: TRRL: IRRD: HRIS: UMTRIS
This article describes the results of roadside interviews on rural roads in the south of the Netherlands. These interviews were carried out to develop a simulation model for traffic movements on these roads. Additionally, six trip purposes (home-to-work, shopping, services, social, commercial, recreation) and four transport modes (cars, lorries, mopeds plus bicycles, and others) are distinguished. (TRRL)

BAGHDAD COMPREHENSIVE TRANSPORTATION STUDY DATABASE
French, GH: Munro-lafon, J
PTRC Education and Research Services Limited
Planning & Transport Res & Comp. Sum Ann Mtg. Proc 1983 pp 337-350 3 Fig.
Available From: Planning and Transport Res and Computation Co Ltd, 110 Strand, London WC2 England
SUBFILE: TRRL: IRRD: HRIS: UMTRIS
REPORT NO: Volume P237
The vast scale of potential development in Baghdad, with a possible investment of US $12,000 million between 1980 and 2000, demanded that the transportation planning had a large and reliable database. It was necessary for the database to cover land use and socio-economic data in addition to traffic information. Extensive surveys were carried out and the database was established on the computer system at the national computing centre. Twelve different surveys were carried out covering the complete range normally associated with studies of this sort. The surveys were very large: including 17,000 home interviews, 30,000 roadside interviews, 38,000 public transport interviews, 8,000 employment interviews, and 4,000 goods vehicle interviews. The scale of the surveys added to the many other problems associated with carrying out surveys in Baghdad and meant that the data collection and data processing phases occupied 18 months of the study in Iraq. Specific difficulties such as sample selection were associated with each of the surveys whilst others including quality control were general to all. The results from the various surveys showed that some had not produced returns consistent with the effort involved in conducting them. (Author/TRRL) Developing Countries. Proceedings of Seminar G held at the PTRC Annual Meeting, University of Warwick, England, 4-7 July 1983.

ROADSIDE INTERVIEWS IN URBAN TRAFFIC
Rosqvist, P; Rydhed, B
Chalmers University of Technology, Sweden Institute of Transportation, Fack S-402 20 Goeteborg 5 Sweden
1982 Monograph 26p 18 Fig. 4 Tab. 4 Phot. 6 Ref. Apps. Swedish
SUBFILE: TRRL: IRRD: HRIS
REPORT NO.: 1982:3
The aim of this report is to describe how to design roadside interviews in urban traffic. Short surveys should preferably be located near traffic signals where the natural stop at red light should be utilized in order to decrease traffic disturbances. The questions must be few and easy to understand. A field test has been performed. Results show that this method is useful when investigating origin destination traffic and the purpose of the journey. (TRRL)

O-D MATRIX PRODUCTION FROM CORDON SURVEY DATA
Echenique, ML; Williams, IN
Printerhall Limited
Traffic Engineering and Control VOL. 23 No. 12 Dec 1982 p 584 1 Fig. 6 Tab. 6 Ref.
SUBFILE: TRRL: IRRD: HRIS
This article describes the methodology utilized in a study commissioned by Merseyside County Council for Applied Research of Cambridge Ltd and Marcial Echenique & Partners jointly to develop, test and implement a suite of programs to process a freight flow survey for Merseyside. The purpose of the study was to take the file of information collected at the roadside interviews giving the origins and destinations of the sample of lorries interviewed, and then to produce from this an estimated expanded matrix of freight flows between all zone pairs in Merseyside. This involved a number of stages. Firstly, for zone pairs whose trips are adequately captured in the survey it is necessary to scale up the trips using an expansion factor to take account of the size of the sample. Next, it is necessary to average across cordons those trips which are captured by more than one cordon in order to avoid double-counting. Having now produced an expanded partial matrix a gravity-type model can be calibrated for this partial matrix and then used to produce estimates for the flows between the unobserved zone pairs in a consistent fashion. The final part of the paper describes a test of the methodology which was carried out. This demonstrates that in a situation where 27 per cent of the zone pairs are missing, the estimated trips suffer little in accuracy from those estimated using the full matrix. (Author/TRRL)

THE EFFECT OF THE NEW APPROACH ON DATA COLLECTION AND ANALYSIS
Haslam, JM
PTRC Education and Research Services Limited
Planning & Transport Res & Comp. Sum Ann Mtg. Proc NP214 July 1981 pp 13-21
3 Fig.
SUBFILE: TRRL: IRRD: HRIS
The author discusses the new approach to improve efficiency in traffic appraisal. No new data collection should be carried out if usable data already exists. Details are given of how surveys are controlled and carried out according to the procedures laid out in the traffic appraisal manual. Data can be converted to the correct appraisal year using the appropriate factors. Mention is made of statistical errors in automatic traffic counts and manual classified counts, and of the conduct of roadside and home interviews. (TRRL) Proceedings of the Seminar Q, Highway Construction and Maintenance, held at the PTRC Summer Annual Meeting, University of Warwick, England, July 13-16, 1981.

MANNING REQUIREMENTS FOR TRAFFIC SURVEYS
Gennaoui, FR; Tudge, RT
Australian Road Research Board, 500 Burwood Road, Vermont South Victoria, 3133 Australia 0572-1431
1982 pp 53-58 6 Tab. 2 Ref.
SUBFILE: TRRL: IRRD: HRIS
Traffic field surveys quite often account for a substantial proportion of the allocated budget for traffic studies. The validity and accuracy of the information collected largely depends on the level of preparation of field surveys. Such preparation would include the determination of suitable locations for the survey, adequate instruction to field staff and most important the determination of the required number of field personnel. In many instances, the use of more field staff than is required would add unnecessarily to the cost, whilst the usage of a smaller number of personnel, to reduce cost, invariably decreases the reliability of the data collected. This paper endeavours to provide detailed guidelines for the allocation of field staff required for the most labour intensive traffic surveys including traffic volume counts at intersection and mid-block, number plate surveys and roadside interview surveys. It is hoped that this paper would provide the basis for the better preparation of these traffic surveys (a). The number of the covering abstract of the conference is TRIS No. 368448. (TRRL) Proceedings of the Eleventh Australian Road Research Board Conference, held at the University of Melbourne, August 23-27, 1982.

DESIGN OF A COUNTY-WIDE TRAFFIC MONITORING SYSTEM
Harrison, I
Printerhall Limited
Traffic Engineering and Control VOL. 23 No. 1 Jan. 1982 pp 2-7 3 Fig. 5 Ref.
SUBFILE: TRRL: IRRD: HRIS
The author considers the contribution that different types of traffic data can make within a monitoring framework and describes the programme of data collection and modelling developed by Kent County Council. None of the data types: automatic traffic counts (atc), manual traffic counts (mtc) or roadside interviews (rsi) provides sufficient data on its own. A traffic count data base has been established to estimate flows and vehicle proportions on each link of the network and detect annual flow growth whilst monitoring seasonal factors. Collection of data for the dtp censuses provides a basis for the system, but it was decided that counts were needed on all "b" class roads and some specified "c" roads. A method of collecting mtc and atc data is described which after five years will provide observed data and conversion factors for every road link in Kent. The county traffic model has been built up from rsi data to assess the trip purposes and seasonal variations in flow. Applications of the monitoring system outlined include the production of county-wide flow maps which can be used for pavement design purposes and monitoring trends in traffic growth.

LICENSE PLATE PHOTO TECHNIQUE OF SURVEYING TRUCK TRAVEL FOR MODELLING PURPOSES
Perera, MH; Corupe, EG
Roads and Transportation Association of Canada
RTAC Annual Conference Preprints VOL. 1 Sep 1981 pp 889-1009 15 Fig. 2 Phot.
SUBFILE: TRRL: IRRD: HRIS: RTAC
The objective of this study was to originate a practical methodology for collecting travel data for commercial vehicles on multi-lane highway facilities. The most common type off traffic survey is the roadside interview origin-destination survey for auto and truck traffic. In these surveys, trip information is sought by directly interviewing the motorists on the highway. For safety reasons, this method of travel data collection is not suitable for application on multi-lane, high-volume, high-speed facilities. The license plate photo survey technique has been used by the province since 1977 to obtain trip information from automobile users. In November, 1980, the technique was applied for the first time to study the travel characteristics of truck movement. The location selected for the survey was on Highway 401 at Keele Street within metropolitan Toronto. This paper details the methodology adopted in this survey and the advantages and shortcomings of this technique and suggests improvements. Documentation

relating to the nature of the information sought in the questionnaire, data usage, and survey statistics will form part of the paper. A statement of the suitability of this methodology will be provided as a natural outcome of the evaluation. (a)

A SURVEY OF RECREATIONAL TRAFFIC IN THE YORKSHIRE DALES
Greening, PAK; Smith, PG
Transport and Road Research Laboratory, Old Wokingham Road, Crowthorne RG11, 6AU Berkshire, England
1980 Monograph 26p 15 Fig. 2 Tab. 11 Ref.
SUBFILE: TRL: IRRD: HRIS
REPORT NO.: TRRL Supl Rpt SR539
In 1975 TRRL conducted a roadside interview survey of recreational traffic in the Yorkshire Dales National Park. A route mapping technique was used to record details of the journey, and stops within the park. Data from the survey were used to develop diagrams showing the distribution of traffic flow in the dales on the survey days. The distribution and duration of stops and trip length between stops are also discussed. The trip origin data were used to derive equations relating trip rate per 1,000 car-owning households in the origin zone with distance, travel time and generalized cost. (a) (TRRL)

ANGLO-SCOTTISH CAR TRAVEL FROM SURVEYS ON THE A74 ROAD NEAR LOCKERBIE
Hardman, EJ: Walker, MJ
Transport and Road Research Lab., Crowthorne (England). 35 p
Available From: National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161
SUBFILE: NTIS
REPORT NO.: TRRL-LR-856
Surveys of car travel across the Anglo-Scottish border were carried out as part of a program of research on long distance travel. This report presents results of three roadside surveys, carried out for seven day periods in April 1974, October 1974, and April 1975 on the southbound carriage-way of the A74 Road near Lockerbie. A random selection of car drivers was interviewed and the traffic count and composition were monitored. Car drivers whose journeys were not terminating south of the English/Scottish border accounted for only seven percent of the sample and they were excluded from the results. Of the remainder, 86 percent were traveling more than 200km. In total, about 20,000 drivers were surveyed during the three weeks; this represented 33 percent of the total southbound movement by car. The

analysis revealed that an average of 40 percent of trans-border traffic originated within the Glasgow PTE area and that nearly half of the total car driver trips were made for holiday purposes; work and private travel took 37 and 15 percent of the market respectively. The main difference between April and October results was a doubling of the proportion of Scottish holiday makers, resulting in a 30 percent increase in the proportion of journeys to North West England in autumn. (Copyright (c) Crown Copyright 1979.)

REGIONAL HIGHWAY TRAFFIC MODEL: NON HOME-BASED TRIP END MODEL

Duncan, JB
Planning and Transport Res and Computation Co. Ltd., 109 Bedford Chambers, King Street, London WC2 England

1978 pp 158-167 2 Fig. 2 Tab.
SUBFILE: HRIS

The form and coefficients of the Non Home-Based Trip End Models (Trip Creation Model and the Trip Allocation Model linked by means of a balancing process) are clearly stated. Household interviews and roadside interviews were conducted to collect cross-cordon trip information. The Trip Creation Model is a disaggregated (household level) behavioural model based upon the trip and data contained in both the house-hold and household interview survey. The Trip Allocation Model is based upon the roadside interview surveys. A balancing procedure was derived to constrain the Trip Allocation Model's estimates to those of the Trip Creation Model. Proceedings of the Summer Annual Meeting, University of Warwick, England, July, 1978. Cosponsored by the Transportation Research Board.

COMPREHENSIVE ARTERIAL HIGHWAY PLAN FOR THE CLEVELAND METROPOLITAN AREA
Fratar, TJ
Highway Research Board Bulletin 1957 No. 153, pp 28-43, 16 Fig.
SUBFILE: HRIS
A comprehensive origin and destination survey of vehicular trips was conducted in the Cleveland metropolitan area in Cuyahoga County, by means of postcard questionnaires, supplemented by roadside interviews. The county was responsible for traffic volume counts and traffic pattern investigations. The existing land use pattern of the area was influenced by many things, including transportation facilities and zoning regulations. Forecasts of the future population of the county were based on studies made for the Regional Planning Commission. To determine the future growth of trip generation, the future population of each zone was estimated, industrial and business trends were examined, and the zones were rated according to their probable future development. A method is described to estimate the logical distribution which is compatible with the anticipated future conditions of development, using a new theory of distribution and a method of successive approximations. A comprehensive highway plan must be fully integrated with the land use pattern. Various proposals for freeway layouts were analyzed. An analysis was made of possible extentions of the rail rapid transit system. The procedure used in the assignment of traffic to alternative freeway layouts was as follows: (1) travel-time measurements were made on all principal routes within the county, (2) operating speeds were selected for the various sections of each freeway system, and travel time ratios were computed for each zone-to-zone movement for travel via the freeway systems versus travel on city streets, (3) the time ratios were related to the trips that would use the freeway systems, (4) for each freeway system, punched cards were prepared to show the numbers of passenger car trips and truck trips that would be diverted to the system, (5) by sorting the punched cards for each possible movement at each interchange and summarizing the traffic volumes on the cards relative to the respective movements, the basic freeway use was forecast, (6) a traffic expansion factor was determined for each traffic zone for 1975 and, by the method of successive approximations, the interzonal and intrazonal trips to be made in 1975 were estimated, and (7) estimates were made of the generation of new traffic which would result from the construction of each of the proposed freeway systems and the anticipated new traffic volumes were added to the 1952 and 1975 freeway traffic volumes diverted from existing streets.

A SMALL SCALE ORIGIN AND ESTINATION SURVEY IN HYDERABAD CITY
Kantjha, R: Raghavachari, S
Indian Highways N243 Sept 1970 pp 5-14 6 Fig. 4 Tab.
SUBFILE: TRRL: IRRD: HRIS
A small scale origin-destination survey carried out in Hyderabad City is

described in which both roadside and office interviews were conducted. Information requested in the interviews included places of origin and destination, mode of transport, frequency and purpose of trip, income, and purpose of work. The results of the survey show that about 88 percent of all trips are work trips, or which about 11 percent are made by cars, nearly 13 percent by bicycles and only four percent by cycle rickshaw. It is concluded that by staggering work times, some of the present traffic congestion would be eliminated, and that segregation of cyclists from other traffic would improve their safety. (TRRL)

A CLOSED CIRCUIT TELEVISION SYSTEM FOR TRAFFIC SURVEYS
Traffic Quart Eno Fdn for Transp VOL. 28 Nn Jan 1974 pp 87-100 4 Fig.
SUBFILE: HRIS
A closed circuit television survey system was developed in Rhode Island to replace roadside interview surveys. The requirements and goals of the survey were to use close circuit television equipment to video tape all license plates, to identify the lane, time, and direction of travel of each vehicle, to search registry files from Rhode Island, Massachusetts, Connecticut and New York for the name and address of the driver , or owner, of the vehicle and mail questionnaires to these addresses to obtain information of the trip being made at the time of recording. The four months prior to the actual survey were devoted to developing a workable television system, training a surveying crew, developing computer programming techniques for rapid accessing of registry files, and designing and printing questionnaires. At actual survey time a closed circuit television positioned off the roadway recorded plate numbers of passing vehicles on video tape, the tapes were then reviewed on a TV monitor and a sample selected. The sample selections were then recorded on coding sheets along with the state of registration, time, date and direction of trip, and the information keypunched. Using state registry files the plate numbers were matched with names and addresses. A questionnaire was then sent to the owner of the vehicle, filled out and returned. The advantages of this system are that it is safer for the surveyor as well as the driver, the motorists are not delayed, the quality of the data is more consistent and more detailed questions can be answered, and this method is more economical.

ORIGIN AND DESTINATION SURVEY METHODS AS APPLIED TO THE TRANSPORTATION STUDY BALTIMORE METROPOLITAN AREA

Childs, WF

Highway Research Board Proceedings VOL. 26 pp 422-430 1 Fig. 1 Tab
SUBFILE: HRIS

The transportation study was divided into three phases: (1) internal survey, including (a) sampling, (b) home interviews, (c) truck interviews, and (d) taxi interviews; (2) external survey; and (3) parking survey. The sample was five percent for home interviews selected from land use maps and 20 percent for trucks and taxis. The truck sample was selected from the records of the commissioner of motor vehicles and the taxi sample was obtained from the Office of the Public Service Commission. To check the accuracy and completeness of the expanded interview data against actual counts, three control points, outstanding easily recognized structures, and a screen line were selected. Daily volume counts were made and classified by type of vehicle at each of the control points and each of the ten streets and roads crossing the screen line. These volumes were then compared with volumes crossing the control points and streets and roads on the screen line as determined by the expanded interview data. For the 16-hour period from 6:00 a.m. to 10:00 p.m. the interview accuracy was 89 percent while a similar check for the morning and afternoon peak hours showed an accuracy of 98.5 percent. The external survey determined the travel habits of persons driving inside and out of the metropolitan area. This was accomplished by roadside interviews at selected stations where all vehicles, other than military, federal, state-owned and regularly scheduled buses, were stopped. The data obtained were used to prepare desired line of travel for all types of motor vehicles including passenger cars, taxis and trucks and for mass transportation passengers. A traffic flow map prepared in 1938 was adjusted to compensate for the differences in traffic flow volume since that year, caused by changing certain streets from two-way to one-way travel. When compared to the major directional desire lines, it shows where motorists are not traveling and the direction and volumes in which they would travel if suitable facilities were available. Fifteen routes closely conforming to the 16 major directional desire lines were studied. Because of the seriousness of the parking situation a separate parking survey of the downtown area of Baltimore city comprising 127 city blocks was conducted. An inventory was made of all parking facilities, both on-street and off-street, in the selected area and for two blocks immediately outside of that area. Over 35,000 cars are parked in the downtown area during the 8-hour period from 10:00 a.m. until 6:00 p.m. Of this total, 45 percent were parked at curbs, 17 percent in garages, and 38 percent on lots. The principal purposes of trips were found to be: work - 42.7 percent; business - 30.8 percent; and shopping - 17.3 percent.

DEVELOPMENT AND USE OF A STATEWIDE ORIGIN AND DESTINATION DATA BANK
Bates, JW
Georgia State Highway Department
50 Pp. FIG, TABS, APPS
SUBFILE: HRIS
A procedure is described which can be used to develop at least a partial statewide trip table using only previously available origin and destination data collected as a part of urban cordon roadside interviewed or for other purposes. The system for combining the data from various locations into a single trip table and maintaining, as well as adding to, the table is discussed. The "statewide corridor network" which was developed for network assignment analyses is described and several probable uses for the system are discussed. /author/

EVALUATION OF BIAS IN LICENSE PLATE TRAFFIC SURVEY RESPONSE
McCann, H: Maring, G
Highway Research Record, Highway Research Board No. 322, pp 77-83, 4 FIG., 4 TAB, 1 REF
SUBFILE: HRIS
This report presents the results of a second trial of license plate traffic survey procedures. The results of the initial trial were reported in Highway Research Record 297. The second survey was primarily designed to evaluate bias in response to mail questionnaires. Trip data from a license plate survey were compared with trip data from a conventional roadside interview. The study was conducted on Interstate 70 near Junction City, Kansas. The State Highway Commission of Kansas conducted conventional roadside interviews on August 12-15, 1968. The license plate traffic survey was conducted on August 27-28, 1968. This report provides background information, describes operating procedures during the survey, presents results of the survey, and gives conclusions and recommendations. /author/

SAMPLING PROCEDURES FOR ROADSIDE INTERVIEWS IN ORIGIN-AND-DESTINATION TRAFFIC SURVEYS
Winfrey, R; Hansen, RJ
Highway Research Board Bulletin No. 76, pp 52-65, 6 FIG. 3 TAB
SUBFILE: HRIS
In the origin-and-destination traffic study of the main routes at Ames, Iowa, in the fall of 1949, the roadside interviews, 7:00 a.m. to 11:00 p.m. were recorded in time intervals of 2 minutes. It is possible, therefore, to reconstruct the traffic flow through any of the interview stations in road sequence of vehicles, except within the 2-minute intervals. Five samples were drawn from the IBM cards. The resulting trips between pairs of origin-

and-destination zones were compared with the trips found in the 100 percent interviews. Systematic samples of 10 and 20 percent were drawn by selecting for each direction of travel every 10th and every 5th trip in sequence throughout the 16-hour period for the four external stations on US 30 and US 69 at the city limits. Statistically, these two samples adhered to the characteristics of a normal distribution and are of value in predicting the probable maximum percent errors to be expected from comparable samples. The third sample was drawn from Station 3 only on a time-controlled basis by taking all vehicles reaching the interview station in the first two minutes of each 10-minute period. This sample had about the same characteristics as the systematic 20 percent sample. Since these three samples were selected by a procedure difficult to maintain at a roadside station, the fourth sample was taken on a time-and-size-controlled procedure that could be easily performed at the roadside. This sample was satisfactory and of about the same quality as the time-controlled sample. These third and fourth samples were expanded to the 10-minute, 1-hour, and 16-hour 100 percent traffic volumes. The 10-minute and the 16-hour basic gave better results that the 1-hour expansion. The fifth test was applied to traffic in one direction only. The results indicate that for these stations at Ames, Iowa, acceptable results could be obtained by sampling one direction only. These brief results are insufficient, even for Ames, to determine the best basis of taking an origin-and-destination sample at roadside interview stations. The results do show, however, that the time-and-size controlled sample of about 20 percent of the total traffic should yield acceptable results. When the traffic by direction balances each other in interchanges between pairs of origin-and-destination zones, the undirectional method of sampling could be used. /author/

SAMPLING METHODS FOR ROADSIDE INTERVIEWING
Miller, I; Irick, PE; Michael, HL; Brown, RN
Highway Research Board Bulletin No. 76, pp 31-51, 10 FIG, 12 TAB, 6 REF
SUBFILE: HRIS
An appraisal was made of the sampling errors in the estimates of the trip frequencies for the various cells of an origin-destination traffic survey tabulation. A mathematical exposition is given of the expected errors when the sampling is done at random, by time clusters, and by volume clusters. The paper also discloses the results of an empirical investigation into the sampling errors that actually arose when various sampling methods were applied to the origin-destination tabulations of the Lebanon and Kokomo, Indiana, surveys. These experimental results were in general accord with the theory. It is concluded that on the average, for the large number of estimates involved in any one survey, the theory of random sampling will satisfactorily explain the errors which arise from the various sampling methods proposed. The results given make it possible to predict the average

errors and probability limits for these errors when a particular amount and type of sampling has been done. Conversely, one can determine the amount of sampling necessary to keep the sampling errors within specified probability limits. In the second part, the practical application of sampling to actual field conditions is presented. Station arrangement and sampling procedure for obtaining samples of 50 percent and 25 percent as developed during the conduct of an origin-destination survey at Richmond, Indiana, are discussed. Operational procedure for two sampling methods -- volume cluster and time cluster -- is given for two sample sizes and for locations with various roadway conditions. Sampling on two-lane, three-lane, and four-lane highways carrying traffic volumes ranging from 1,000 to 12,000 vehicles per day is shown to be both practical and economical. The advantages of each of the two sampling methods for various locations are enumerated. It is concluded that the use of systematic sampling in the taking of roadside interviews is not only practical and economical, but that it has definite operational advantages. The conclusions indicate that a predetermined sampling procedure will place interviewing on a business-like basis that: (1) is recognized by the vehicle operator and the community, (2) promotes efficient operation of the interviewing stations, and (3) produces statistically sound results. /author/

POSTCARD METHOD OF OBTAINING ORIGIN AND DESTINATION OF TRAFFIC AND COMPARISON WITH ROADSIDE-INTERVIEW METHOD
Winfrey, R
Highway Research Board Bulletin No. 76, pp 10-30, 42 FIG, 7 TAB
SUBFILE: HRIS
A project was conducted in Iowa to: (1) assemble origin-and-destination information useful to the Highway Commission. Iowa State College, and the City of Ames, in connection with their ordinary traffic handling and transportation planning, (2) collect field data by which research could be conducted on the improvement of methods of making origin-and-destination studies of traffic, and (3) compare the field postcard method of getting origins and destinations with the roadside-interview method. Traffic volume counts were taken daily by hours with traffic recorders by the Highway Commission from September 27 through November 13. A field party of six persons passed out postcards. The roadside-interview phase was conducted by the same field parties, plus additional personnel. From the results of the study of the field postcard method, there is evidence that the expansion factors should be carefully determined, preferably by classes of vehicles, registration plate, and by hours of the day. A wide variation of expansion factors was developed for the various origin-and-destination trip groups without sufficient consistency between the expansion factor and the geographical location. Trips from one state across Iowa to another state resulted in higher expansion factors than did other types of trips. Correct

factors could be anticipated and assumed ahead of knowing the true distribution of the trips. It is concluded that there is no means available of checking the correctness of the expanded returns from the postcard survey once they are expanded to trips between specific origins and destinations. It appears that roadside interviews should be conducted in addition to the postcard survey to get a basis of evaluation of the reliability of the postcard returns.

NEW YORK STATE TRAFFIC PLANNING AND ORIGIN-DESTINATION SURVEYS FOR URBAN ARTERIAL ROUTES
Bebee, MA
Highway Research Board Bulletin No. 41, pp 25-29, 6 FIG
SUBFILE: HRIS
Procedures are analyzed for urban area traffic and planning studies in New York state. The arterial program in New York City is progressing in accordance with an overall plan based on land-use requirements, general origin-and-destination investigations and overwhelming traffic volumes. Postcard surveys, roadside interviews and origin-and-destination studies were conducted. Procedures and results of these surveys are described.

HOLIDAY AND SUMMER WEEKEND TRAFFIC SURVEY
Plummer, AV; Wilkie, LG; Gran, RF
Highway Research Board Bulletin No. 297, pp 74-85, 10 FIG
SUBFILE: HRIS
The traffic engineering division of the Cook County Highway Department (Illinois) conducted roadside interviews with 12,000 motorists on holiday and summer weekends. Two sites were selected for the interviews, and the motorists were directed by a flagman into a special interview lane. The basic questions on the interview form pertained to origin, destination and trip purpose. Data were compiled on (1) the number of recreational trips for a non-holiday summer weekend by time of day, (2) recreational trips as a function of day of return trip for holiday and non-holiday summer weekends, (3) recreational and non-recreational trips by destination for toll road and non-toll road users, (4) toll road use as a function of trip frequency for recreational trips, and (5) recreational trips for a holiday summer weekend by time of day.

COST-SAVING TECHNIQUES FOR COLLECTION AND ANALYSIS OF ORIGIN-DESTINATION SURVEY DATA
Brant, AE; Low, DE
Highway Research Record, Highway Research Board Eno 205, pp 50-66, 1 FIG, 8 REF
SUBFILE: HRIS
The traditional approach in the field of urban transportation planning requires the collection of sufficient travel data on a sample basis to permit stability at the zonal level after expansion, analysis of zonal trip generation as a function of zonal characteristics, and, until recently, distribution of generated trip ends by expansion of current patterns. With the advent of models, the trip distribution process has been given over to simulation rather than expansion techniques. A procedure for the use of limited origin-destination survey data for other phases of the travel forecasting process with attendant savings in data collection and analysis is summarized. In the area of trip generation, relationships should be derived directly from home interview information at the household level, rather than after aggregation of origin-destination survey travel data and socio-economic and land use data to the zonal level. A second cost-savings technique involves eliminating the traffic zone as the basic unit of analysis for all phases of the planning process. As a result, layouts of planning areas could be made that would better serve fewer functions. Other cost savers include alternative methods of home interview sampling, use of mailed questionnaires for parts of the truck survey, roadside interviewing in one direction only, and adherence to rigid sampling techniques.

OPTIMAL SAMPLE SIZE OF ROADSIDE INTERVIEW ORIGIN-DESTINATION SURVEYS
Hajek, JJ
Ontario Ministry of Transportation & Communication, Canada; Research and Development Division, 1201 Wilson Avenue, Downsview, Ontario MCM 1J8, Canada
Jan. 1977 20 pp 11 FIG 5 TAB 12 REF
SUBFILE: HRIS
REPORT NO.: RR 208
The objective of the study reported herein was to establish an optimal sample size for roadside interview origin-destination (O-D) surveys for various conditions and to investigate the cost effectiveness of O-D surveys and means to improve it. Three representative survey locations were selected -- a major intercity and international route, a busy intercity route with commuter traffic, and a rural highway with local agricultural traffic. The study examines the effect of variables such as sample size, sampling technique, survey location, and trip purpose on sampling error for trips involving personal vehicles. It appears that the theoretical sampling errors provide a good estimate of the magnitude and probable distribution of

observed sampling errors and may be used for the selection of field sampling rates to achieve a desired survey accuracy. The significance of sampling errors was evaluated in view of the magnitudes of other errors common in the transportation planning process. Fifty percent bidirectional sampling over a 12-hour period is recommended for models used mainly as predictors of future traffic patterns. On the other hand, five to ten percent bidirectional interviewing is probably sufficient if the model objective is mainly educational, permitting decision-makers to appreciate the complex relationships between transportation and land use and the probable consequences of alternative policies. The cost effectiveness of roadside interview O-D surveys was evaluated by calculating the marginal costs of improving the total inventory phase error by making improvements in sampling error and factoring error. In general, it appears that the extension of the 12-hour survey period is usually more cost effective than an increase in sampling rate during the 12-hour period.

TRAVEL SURVEY PROCEDURES FOR STATEWIDE TRANSPORTATION PLANNING. HOUSEHOLD/ROADSIDE/MODAL-SURVEYS

DiRenzo, JF

Peat, Marwick, Mitchell and Company, 1025 Connecticut Avenue, NW, Washington, D.C., 20036

April 1976, 153 pp FIGS TABS REFS 1 APP

Available From: National Tecnical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161

SUBFILE: NTIS: HRIS

CONTRACT NO.: DOT-FH-11-8592

REPORT NO.: FHWA/HHP-12-76-1

The report describes and evaluates alternative travel survey procedures that have been used for or are potentially applicable to statewide transportation planning. The types of survey procedures discussesd in the report include household, roadside, and modal passenger survey techniques. The potential uses, strengths, and weaknesses of each type of survey are assessed. The report presents illustrative survey instruments, survey costs, and procedures for administering surveys for statewide transportation planning.

APPENDIX B

External Trips and Average Trip Distance By Stations Cross-Classified by Trip Purpose and Vehicle Type

APPENDIX B

This appendix contains a one-page summary for each station presenting external survey trips by purpose versus vehicle class and average trip distance (miles) by the same cross-classification. Both external-internal and external-external trips are included. The average trip distances are based on the 1302-zone network developed by MAG as part of the external survey effort. The reader will note some extreme average trip distances in a few cells. This is attributable to the low sample sizes contained in the cross-classification survey results.

TABLE B-1
PHOENIX EXTERNAL TRIP STUDY
STATION 1194

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	777	652	3	37	14	3	1485
Work	508	385	-	17	39	114	1063
Business	428	587	-	7	108	342	1473
Personal	428	278	-	-	28	-	734
Shopping	200	109	-	-	-	-	309
Social-Rec	210	107	45	-	4	-	366
Other	134	16	2	-	-	-	152
Total	2683	2134	50	62	194	460	5582

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	48	51	20	29	38	44	49
Work	39	35	-	55	51	154	50
Business	89	64	-	80	48	101	79
Personal	66	79	-	-	67	-	71
Shopping	35	32	-	-	-	-	34
Social-Rec	131	127	148	-	206	-	133
Other	89	104	55	-	-	-	90
Total	64	58	137	42	54	120	66

TABLE B-2
PHOENIX EXTERNAL TRIP STUDY
STATION 1195

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	87	60	-	-	3	-	150
Work	37	70	-	3	-	-	110
Business	20	109	-	-	34	45	208
Personal	75	43	-	-	-	-	118
Shopping	50	8	-	-	-	-	58
Social-Rec	8	16	-	-	-	-	24
Other	5	-	-	2	-	-	7
Total	282	307	-	5	36	45	676

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	32	52	-	-	20	-	40
Work	30	23	-	26	-	-	26
Business	86	31	-	-	36	146	62
Personal	40	42	-	-	-	-	40
Shopping	25	25	-	-	-	-	25
Social-Rec	14	205	-	-	-	-	18
Other	113	-	-	-	-	-	81
Total	37	34	-	15	31	146	43

TABLE B-3
PHOENIX EXTERNAL TRIP STUDY
STATION 1196

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	2204	1336	28	77	26	14	3685
Work	691	393	-	15	26	687	1812
Business	1233	1068	15	-	238	2349	4904
Personal	1021	383	33	18	13	-	1469
Shopping	174	68	-	-	-	-	242
Social-Rec	1392	450	95	29	-	-	1966
Other	221	130	11	-	7	-	369
Total	6935	3829	182	140	310	3051	14447

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	89	64	132	89	193	20	81
Work	47	64	-	36	206	4411	98
Business	137	115	106	-	133	1657	147
Personal	173	161	197	206	158	-	171
Shopping	62	70	-	-	-	-	64
Social-Rec	206	182	190	194	-	-	199
Other	209	195	167	-	379	-	206
Total	133	106	174	119	151	1644	134

TABLE B-4
PHOENIX EXTERNAL TRIP STUDY
STATION 1197

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	1210	762	28	27	51	23	2101
Work	271	268	-	36	-	23	597
Business	757	707	18	-	141	309	1933
Personal	980	287	24	13	9	-	1315
Shopping	151	121	-	-	-	-	272
Social-Rec	913	271	48	11	9	-	1251
Other	80	12	-	-	-	-	93
Total	4361	2429	118	87	211	355	7561

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	116	81	361	37	64	124	104
Work	48	61	-	15	-	185	53
Business	109	98	133	-	122	208	122
Personal	107	84	258	75	332	-	106
Shopping	59	37	-	-	-	-	49
Social-Rec	193	174	293	97	132	-	192
Other	159	187	-	-	-	-	161
Total	123	93	278	41	117	201	118

TABLE B-5
PHOENIX EXTERNAL TRIP STUDY
STATION 1198

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	335	190	19	27	-	-	572
Work	32	59	-	-	-	6	97
Business	229	252	13	-	41	183	718
Personal	141	113	28	-	-	-	282
Shopping	17	8	-	-	-	-	25
Social-Rec	641	638	8	12	13	-	1313
Other	28	30	-	10	-	5	72
Total	1423	1290	68	49	55	194	3078

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	107	106	144	93	-	-	107
Work	51	126	-	-	-	341	115
Business	161	154	241	-	47	217	168
Personal	116	148	92	-	-	-	127
Shopping	49	168	-	-	-	-	88
Social-Rec	94	73	233	19	122	-	84
Other	72	7	-	36	-	72	99
Total	108	105	191	63	64	217	113

TABLE B-6
PHOENIX EXTERNAL TRIP STUDY
STATION 1199

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	2393	1408	56	13	-	88	3958
Work	455	445	23	20	45	243	1231
Business	1874	1380	29	19	177	1088	4566
Personal	1973	805	15	23	83	-	2898
Shopping	227	138	-	-	-	-	364
Social-Rec	2368	695	165	36	20	-	3285
Other	110	18	-	-	-	-	129
Total	9399	4888	288	111	325	1419	16430

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	144	145	229	160	-	-	142
Work	102	119	104	41	61	225	130
Business	140	137	126	100	148	219	158
Personal	161	165	102	122	161	-	162
Shopping	92	122	-	-	-	-	103
Social-Rec	185	151	196	211	135	-	178
Other	176	57	-	-	-	-	158
Total	154	144	183	137	138	207	156

TABLE B-7
PHOENIX EXTERNAL TRIP STUDY
STATION 1200

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	161	179	3	11	6	-	361
Work	13	18	-	-	-	-	32
Business	58	98	-	11	15	5	188
Personal	108	27	-	2	8	-	145
Shopping	26	3	-	-	-	-	29
Social-Rec	213	318	32	8	-	-	571
Other	8	21	-	-	-	-	30
Total	587	664	35	33	29	5	1354

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	113	91	209	54	33	-	100
Work	77	100	-	-	-	-	88
Business	145	110	-	206	53	19	120
Personal	95	106	-	230	35	-	95
Shopping	49	36	-	-	-	-	48
Social-Rec	80	78	66	59	-	-	78
Other	130	61	-	-	-	-	78
Total	97	87	78	115	44	10	91

TABLE B-8
PHOENIX EXTERNAL TRIP STUDY
STATION 1201

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	568	407	46	-	-	-	1021
Work	39	79	-	-	-	-	118
Business	308	373	16	7	74	170	948
Personal	426	237	-	-	-	-	663
Shopping	27	43	-	3	-	-	73
Social-Rec	578	330	29	36	-	-	974
Other	38	27	-	-	-	-	65
Total	1983	1497	92	47	74	170	3863

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	158	154	156	-	-	-	157
Work	122	132	-	-	-	-	129
Business	162	157	511	107	102	165	161
Personal	146	168	-	-	-	-	162
Shopping	107	126	-	110	-	-	119
Social-Rec	166	154	172	120	-	-	160
Other	163	174	-	-	-	-	168
Total	160	155	250	115	102	165	158

TABLE B-9
PHOENIX EXTERNAL TRIP STUDY
STATION 1202

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	274	269	8	25	-	-	576
Work	68	68	-	-	-	-	136
Business	77	106	-	-	34	97	314
Personal	252	170	8	4	-	-	434
Shopping	88	58	4	2	4	-	155
Social-Rec	526	265	23	70	6	-	890
Other	-	-	-	-	-	-	-
Total	1284	936	43	101	44	97	2505

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	54	59	44	35	-	-	56
Work	48	59	-	-	-	-	54
Business	55	50	-	-	42	41	48
Personal	56	51	38	27	-	-	53
Shopping	61	64	66	-	61	-	62
Social-Rec	46	50	48	37	69	-	47
Other	-	-	-	-	-	-	-
Total	52	54	47	35	47	41	52

TABLE B-10
PHOENIX EXTERNAL TRIP STUDY
STATION 1203

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	1410	810	13	16	9	160	2418
Work	476	432	-	17	41	320	1286
Business	1112	912	10	8	159	-	2200
Personal	975	473	16	26	-	-	1490
Shopping	217	115	-	6	-	-	338
Social-Rec	790	445	62	21	21	-	1339
Other	124	44	12	5	-	-	185
Total	5104	3230	112	99	231	480	9257

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	107	95	182	202	254	110	105
Work	71	84	-	91	120	80	80
Business	11	224	158	196	81	-	108
Personal	114	107	90	88	-	-	111
Shopping	79	90	-	40	-	-	82
Social-Rec	162	153	212	141	86	-	160
Other	113	137	168	73	-	-	121
Total	114	107	183	123	94	90	111

TABLE B-11
PHOENIX EXTERNAL TRIP STUDY
STATION 1204

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	615	480	-	7	53	-	1155
Work	110	200	-	14	-	30	353
Business	99	159	-	-	53	82	393
Personal	293	198	-	-	-	-	491
Shopping	150	106	-	-	-	-	256
Social-Rec	49	23	-	-	-	-	72
Other	8	17	-	-	-	-	25
Total	1324	1185	-	21	106	112	2746

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	53	52	-	68	52	-	53
Work	51	50	-	51	-	57	51
Business	55	54	-	-	56	52	54
Personal	59	56	-	-	-	-	58
Shopping	51	50	-	-	-	-	51
Social-Rec	55	53	-	-	-	-	54
Other	59	55	-	-	-	-	56
Total	54	53	-	57	54	53	54

TABLE B-12
PHOENIX EXTERNAL TRIP STUDY
STATION 1205

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor- cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	132	128	1	-	-	3	264
Work	92	136	-	-	24	7	259
Business	61	126	-	-	-	2	189
Personal	149	131	-	-	-	-	280
Shopping	50	60	-	-	2	-	112
Social-Rec	29	17	3	4	-	-	53
Other	9	13	-	-	-	-	21
Total	521	611	4	4	26	11	1178

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor- cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	52	51	105	-	-	52	52
Work	55	52	-	-	68	38	55
Business	52	52	-	-	-	36	52
Personal	50	53	-	-	-	-	52
Shopping	66	62	-	-	59	-	64
Social-Rec	54	48	29	54	-	-	51
Other	30	25	-	-	-	-	29
Total	53	53	48	54	67	45	53

TABLE B-13
PHOENIX EXTERNAL TRIP STUDY
STATION 1206

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	40	26	-	5	-	-	70
Work	-	2	-	-	-	-	2
Business	32	13	-	-	5	12	63
Personal	44	32	-	-	-	-	77
Shopping	27	25	-	-	-	-	52
Social-Rec	16	13	-	-	-	-	29
Other	-	-	-	-	-	-	-
Total	160	112	-	5	5	12	294

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	54	68	-	36	-	-	59
Work	-	66	-	-	-	-	67
Business	51	53	-	-	38	53	50
Personal	63	52	-	-	-	-	58
Shopping	46	51	-	-	-	-	49
Social-Rec	79	54	-	-	-	-	68
Other	-	-	-	-	-	-	-
Total	57	56	-	36	38	53	56

TABLE B-14
PHOENIX EXTERNAL TRIP STUDY
STATION 1207

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	144	127	-	-	-	-	271
Work	20	32	-	-	4	-	56
Business	63	122	2	-	27	27	241
Personal	81	36	-	-	-	-	117
Shopping	12	5	-	-	-	-	17
Social-Rec	36	11	-	2	-	-	50
Other	-	-	-	-	-	-	-
Total	356	333	2	2	31	27	751

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	85	50	-	-	-	-	68
Work	63	62	-	-	105	-	65
Business	73	54	139	-	52	25	56
Personal	63	56	-	-	-	-	61
Shopping	45	47	-	-	-	-	45
Social-Rec	799	64	-	162	-	-	581
Other	-	-	-	-	-	-	-
Total	146	54	139	162	58	25	97

TABLE B-15
PHOENIX EXTERNAL TRIP STUDY
STATION 1208

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	698	416	18	14	7	14	1167
Work	581	419	-	25	89	140	1254
Business	764	649	-	2	125	350	1889
Personal	675	334	6	-	-	-	1016
Shopping	274	90	-	-	-	-	364
Social-Rec	227	64	8	11	-	-	310
Other	14	-	-	-	-	-	14
Total	3233	1972	32	52	221	504	6013

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	60	241	246	53	123	48	127
Work	53	49	-	55	84	68	56
Business	115	63	-	47	76	121	96
Personal	60	65	86	-	-	-	62
Shopping	52	423	-	-	-	-	144
Social-Rec	85	607	121	97	-	-	194
Other	56	-	-	-	-	-	56
Total	73	132	185	63	81	104	96

TABLE B-16
PHOENIX EXTERNAL TRIP STUDY
STATION 1209

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	1869	805	-	-	32	92	2797
Work	470	389	-	17	79	711	1667
Business	4136	2234	45	27	444	2260	9146
Personal	1959	640	10	10	8	25	2652
Shopping	59	19	-	-	-	-	79
Social-Rec	1488	351	135	30	4	-	2008
Other	64	-	-	-	-	-	64
Total	10045	4439	190	84	568	3088	18413

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	118	106	-	-	211	147	117
Work	75	86	-	47	66	162	114
Business	120	179	165	130	134	157	145
Personal	245	177	239	120	279	207	226
Shopping	81	202	-	-	-	-	110
Social-Rec	196	210	256	256	295	-	204
Other	193	-	-	-	-	-	193
Total	154	159	234	157	132	158	156

TABLE B-17
PHOENIX EXTERNAL TRIP STUDY
STATION 1210

Number of Trips

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	674	646	9	7	7	13	1355
Work	102	174	14	12	6	60	367
Business	270	437	21	9	66	136	938
Personal	218	155	17	-	-	7	398
Shopping	37	23	-	-	-	-	60
Social-Rec	108	37	3	7	-	-	155
Other	54	37	-	-	-	-	91
Total	1462	1510	63	34	78	216	3363

Average Trip Distance

	Vehicle Class						
	Auto 1	Pickup/ Van 2	RV 3	Motor-cycle 4	Truck (6 Tire) 5	Truck > 6 Tire 6	Total
Home	58	60	149	55	46	87	60
Work	50	60	61	130	41	70	61
Business	54	55	53	51	53	75	58
Personal	84	69	148	-	-	188	82
Shopping	45	50	-	-	-	-	47
Social-Rec	105	65	181	75	-	-	96
Other	59	79	-	-	-	-	67
Total	64	60	101	86	52	78	64

APPENDIX C

FINAL FACTORED RESPONSE

SAS

TABLE 1 OF ORGSTA BY TYPE
CONTROLLING FOR ODTYP=EXT-INT DIR=INBOUND

ORGSTA(INTERVIEW STAION) TYPE(VEHICLE TYPE)

FREQUENCY PERCENT ROW PCT COL PCT	OTHER VEH	MED TRK	HVY TRK	TOTAL
1194	2398.82 5.71 90.53 6.47	108.589 0.26 4.10 10.26	142.456 0.34 5.38 3.72	2649.86 6.31
1195	251.044 0.60 87.97 0.68	16.3866 0.04 5.74 1.55	17.9325 0.04 6.28 0.47	285.363 0.68
1196	4397.48 10.47 81.63 11.85	103.251 0.25 1.92 9.76	886.076 2.11 16.45 23.12	5386.8 12.83
1197	3079.04 7.33 93.88 8.30	108.008 0.26 3.29 10.21	92.8206 0.22 2.83 2.42	3279.87 7.81
1198	1182.83 2.82 96.46 3.19	15.299 0.04 1.25 1.45	28.1538 0.07 2.30 0.73	1226.28 2.92
1199	6318.29 15.05 89.20 17.03	152.609 0.36 2.15 14.43	612.267 1.46 8.64 15.98	7083.17 16.87
TOTAL	37094.8 88.35	1057.91 2.52	3832.46 9.13	41985.2 100.00

(CONTINUED)

SAS

TABLE 1 OF ORGSTA BY TYPE
CONTROLLING FOR ODTYP=EXT-INT DIR=INBOUND

ORGSTA(INTERVIEW STAION)   TYPE(VEHICLE TYPE)

FREQUENCY PERCENT ROW PCT COL PCT	OTHER VEH	MED TRK	HVY TRK	TOTAL
1200	588.398 1.40 96.58 1.59	17.7337 0.04 2.91 1.68	3.0769 0.01 0.51 0.08	609.209 1.45
1201	1416.05 3.37 92.65 3.82	32.7362 0.08 2.14 3.09	79.658 0.19 5.21 2.08	1528.45 3.64
1202	1018.05 2.42 94.58 2.74	20.2938 0.05 1.89 1.92	38.0247 0.09 3.53 0.99	1076.38 2.56
1203	4251.55 10.13 93.10 11.46	103.494 0.25 2.27 9.78	211.488 0.50 4.63 5.52	4566.53 10.88
1204	1286.47 3.06 94.29 3.47	33.0262 0.08 2.42 3.12	44.8209 0.11 3.29 1.17	1364.32 3.25
1205	550.7 1.31 96.49 1.48	14.364 0.03 2.52 1.36	5.6392 0.01 0.99 0.15	570.703 1.36
TOTAL	37094.8 88.35	1057.91 2.52	3832.46 9.13	41985.2 100.00

(CONTINUED)

SAS

TABLE 1 OF ORGSTA BY TYPE
CONTROLLING FOR ODTYP=EXT-INT DIR=INBOUND

ORGSTA(INTERVIEW STAION) TYPE(VEHICLE TYPE)

FREQUENCY / PERCENT / ROW PCT / COL PCT	OTHER VEH	MED TRK	HVY TRK	TOTAL
1206	133.989 0.32 94.86 0.36	0 0.00 0.00 0.00	7.2673 0.02 5.14 0.19	141.257 0.34
1207	347.156 0.83 91.62 0.94	15.3207 0.04 4.04 1.45	16.449 0.04 4.34 0.43	378.926 0.90
1208	2461.27 5.86 88.68 6.64	92.711 0.22 3.34 8.76	221.563 0.53 7.98 5.78	2775.55 6.61
1209	6178.54 14.72 80.64 16.66	187.742 0.45 2.45 17.75	1295.45 3.09 16.91 33.80	7661.74 18.25
1210	1235.16 2.94 88.17 3.33	36.3388 0.09 2.59 3.43	129.311 0.31 9.23 3.37	1400.81 3.34
TOTAL	37094.8 88.35	1057.91 2.52	3832.46 9.13	41985.2 100.00

SAS

TABLE 2 OF ORGSTA BY TYPE
CONTROLLING FOR ODTYP=EXT-INT DIR=OUTBOUND

ORGSTA(INTERVIEW STAION) TYPE(VEHICLE TYPE)

FREQUENCY / PERCENT / ROW PCT / COL PCT	OTHER VEH	MED TRK	HVY TRK	TOTAL
1194	2005.04 4.79 88.14 5.52	61.9645 0.15 2.72 5.00	207.916 0.50 9.14 4.86	2274.92 5.44
1195	195.175 0.47 92.03 0.54	16.8941 0.04 7.97 1.36	0 0.00 0.00 0.00	212.069 0.51
1196	3806.31 9.10 72.12 10.49	116.867 0.28 2.21 9.43	1354.68 3.24 25.67 31.67	5277.86 12.62
1197	2984.7 7.14 92.14 8.22	94.0176 0.22 2.90 7.59	160.537 0.38 4.96 3.75	3239.26 7.75
1198	1229.45 2.94 93.74 3.39	25.7542 0.06 1.96 2.08	56.3523 0.13 4.30 1.32	1311.56 3.14
1199	6621.53 15.83 89.87 18.24	162.264 0.39 2.20 13.09	584.456 1.40 7.93 13.66	7368.25 17.62
TOTAL	36301.3 86.81	1239.19 2.96	4277.11 10.23	41817.6 100.00

(CONTINUED)

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TABLE 2 OF ORGSTA BY TYPE
CONTROLLING FOR ODTYP=EXT-INT DIR=OUTBOUND

ORGSTA(INTERVIEW STAION) TYPE(VEHICLE TYPE)

FREQUENCY PERCENT ROW PCT COL PCT	OTHER VEH	MED TRK	HVY TRK	TOTAL
1200	644.188 1.54 97.93 1.77	11.2917 0.03 1.72 0.91	2.3276 0.01 0.35 0.05	657.807 1.57
1201	1924.76 4.60 93.59 5.30	41.5274 0.10 2.02 3.35	90.2148 0.22 4.39 2.11	2056.5 4.92
1202	1141.49 2.73 93.25 3.14	23.5956 0.06 1.93 1.90	58.989 0.14 4.82 1.38	1224.07 2.93
1203	3119.81 7.46 88.75 8.59	127.332 0.30 3.62 10.28	268.294 0.64 7.63 6.27	3515.44 8.41
1204	1143.03 2.73 89.10 3.15	72.935 0.17 5.69 5.89	66.8571 0.16 5.21 1.56	1282.82 3.07
1205	537.717 1.29 96.82 1.48	11.8535 0.03 2.13 0.96	5.8 0.01 1.04 0.14	555.371 1.33
TOTAL	36301.3 86.81	1239.19 2.96	4277.11 10.23	41817.6 100.00

(CONTINUED)

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TABLE 2 OF ORGSTA BY TYPE
CONTROLLING FOR ODTYP=EXT-INT DIR=OUTBOUND

ORGSTA(INTERVIEW STAION) TYPE(VEHICLE TYPE)

FREQUENCY PERCENT ROW PCT COL PCT	OTHER VEH	MED TRK	HVY TRK	TOTAL
1206	142.743 0.34 93.74 0.39	4.7666 0.01 3.13 0.38	4.7668 0.01 3.13 0.11	152.276 0.36
1207	309.253 0.74 95.31 0.85	15.2204 0.04 4.69 1.23	0 0.00 0.00 0.00	324.473 0.78
1208	2520.59 6.03 87.97 6.94	113.865 0.27 3.97 9.19	230.981 0.55 8.06 5.40	2865.43 6.85
1209	6262.95 14.98 81.69 17.25	297.55 0.71 3.88 24.01	1106.35 2.65 14.43 25.87	7666.85 18.33
1210	1712.59 4.10 93.45 4.72	41.4879 0.10 2.26 3.35	78.5933 0.19 4.29 1.84	1832.67 4.38
TOTAL	36301.3 86.81	1239.19 2.96	4277.11 10.23	41817.6 100.00

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TABLE 3 OF ORGSTA BY TYPE
CONTROLLING FOR ODTYP=EXT-EXT DIR=INBOUND

ORGSTA(INTERVIEW STAION) TYPE(VEHICLE TYPE)

FREQUENCY / PERCENT / ROW PCT / COL PCT	OTHER VEH	MED TRK	HVY TRK	TOTAL
1194	212.011 2.93 87.41 3.55	0 0.00 0.00 0.00	30.5432 0.42 12.59 2.73	242.554 3.36
1195	55.8791 0.77 84.73 0.93	2.8969 0.04 4.39 2.35	7.173 0.10 10.88 0.64	65.949 0.91
1196	1624.67 22.49 73.33 27.17	51.6255 0.71 2.33 41.87	539.394 7.47 24.34 48.16	2215.69 30.67
1197	491.686 6.81 86.21 8.22	0 0.00 0.00 0.00	78.6255 1.09 13.79 7.02	570.311 7.90
1198	250.976 3.47 75.70 4.20	13.4985 0.19 4.07 10.94	67.0917 0.93 20.24 5.99	331.556 4.59
1199	920.322 12.74 89.94 15.39	0 0.00 0.00 0.00	102.984 1.42 10.06 9.19	1023.21 14.16
TOTAL	5980.23 82.79	123.302 1.71	1120.06 15.51	7223.59 100.00

(CONTINUED)

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TABLE 3 OF ORGSTA BY TYPE
CONTROLLING FOR ODTYP=EXT-EXT DIR=INBOUND

ORGSTA(INTERVIEW STAION) TYPE(VEHICLE TYPE)

FREQUENCY / PERCENT / ROW PCT / COL PCT	OTHER VEH	MED TRK	HVY TRK	TOTAL
1200	81.9079 1.13 100.00 1.37	0 0.00 0.00 0.00	0 0.00 0.00 0.00	81.9079 1.13
1201	152.847 2.12 100.00 2.56	0 0.00 0.00 0.00	0 0.00 0.00 0.00	152.847 2.12
1202	113.461 1.57 100.00 1.90	0 0.00 0.00 0.00	0 0.00 0.00 0.00	113.461 1.57
1203	421.62 5.84 100.00 7.05	0 0.00 0.00 0.00	0 0.00 0.00 0.00	421.62 5.84
1204	16.7528 0.23 100.00 0.28	0 0.00 0.00 0.00	0 0.00 0.00 0.00	16.7528 0.23
1205	25.3625 0.35 100.00 0.42	0 0.00 0.00 0.00	0 0.00 0.00 0.00	25.3625 0.35
TOTAL	5980.23 82.79	123.302 1.71	1120.06 15.51	7223.59 100.00

(CONTINUED)

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TABLE 3 OF ORGSTA BY TYPE
CONTROLLING FOR ODTYP=EXT-EXT DIR=INBOUND

ORGSTA(INTERVIEW STAICN) TYPE(VEHICLE TYPE)

FREQUENCY PERCENT ROW PCT COL PCT	OTHER VEH	MED TRK	HVY TRK	TOTAL
1206	0 0.00 . 0.00	0 0.00 . 0.00	0 0.00 . 0.00	0 0.00
1207	15.615 0.22 100.00 0.26	0 0.00 0.00 0.00	0 0.00 0.00 0.00	15.615 0.22
1208	201.674 2.79 81.22 3.37	6.6757 0.09 2.69 5.41	39.9573 0.55 16.09 3.57	248.307 3.44
1209	1333.51 18.46 81.48 22.30	48.6152 0.67 2.97 39.43	254.394 3.52 15.54 22.71	1636.52 22.66
1210	61.9253 0.86 100.00 1.04	0 0.00 0.00 0.00	0 0.00 0.00 0.00	61.9253 0.86
TOTAL	5980.23 82.79	123.302 1.71	1120.06 15.51	7223.59 100.00

TABLE 4 OF ORGSTA BY TYPE
CONTROLLING FOR ODTYP=EXT-EXT DIR=OUTBOUND

ORGSTA(INTERVIEW STAION) TYPE(VEHICLE TYPE)

FREQUENCY PERCENT ROW PCT COL PCT	OTHER VEH	MED TRK	HVY TRK	TOTAL
1194	316.409 4.75 75.66 5.75	23.1769 0.35 5.54 18.53	78.5894 1.18 18.79 7.62	418.175 6.28
1195	91.9628 1.38 79.65 1.67	3.1019 0.05 2.69 2.48	20.3885 0.31 17.66 1.98	115.453 1.73
1196	1273.55 19.14 80.49 23.16	37.8546 0.57 2.39 30.27	270.936 4.07 17.12 26.28	1582.34 23.78
1197	439.859 6.61 93.18 8.00	9.2541 0.14 1.96 7.40	22.9338 0.34 4.86 2.22	472.047 7.09
1198	166.579 2.50 79.82 3.03	0 0.00 0.00 0.00	42.12 0.63 20.18 4.09	208.699 3.14
1199	855.109 12.85 86.81 15.55	10.1744 0.15 1.03 8.14	119.697 1.80 12.15 11.61	984.98 14.80
TOTAL	5499.07 82.63	125.053 1.88	1030.9 15.49	6655.03 100.00

(CONTINUED)

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TABLE 4 CF ORGSTA BY TYPE
CONTROLLING FOR ODTYP=EXT-EXT DIR=OUTBOUND

ORGSTA(INTERVIEW STAION)   TYPE(VEHICLE TYPE)

FREQUENCY / PERCENT / ROW PCT / COL PCT	OTHER VEH	MED TRK	HVY TRK	TOTAL
1200	18.4931 0.28 100.00 0.34	0 0.00 0.00 0.00	0 0.00 0.00 0.00	18.4931 0.28
1201	147.723 2.22 100.00 2.69	0 0.00 0.00 0.00	0 0.00 0.00 0.00	147.723 2.22
1202	98.6326 1.48 100.00 1.79	0 0.00 0.00 0.00	0 0.00 0.00 0.00	98.6326 1.48
1203	768.24 11.54 100.00 13.97	0 0.00 0.00 0.00	0 0.00 0.00 0.00	768.24 11.54
1204	87.8635 1.32 100.00 1.60	0 0.00 0.00 0.00	0 0.00 0.00 0.00	87.8635 1.32
1205	26.7267 0.40 100.00 0.49	0 0.00 0.00 0.00	0 0.00 0.00 0.00	26.7267 0.40
TOTAL	5499.07 82.63	125.053 1.88	1030.9 15.49	6655.03 100.00

(CONTINUED)

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TABLE 4 OF ORGSTA BY TYPE
CONTROLLING FOR ODTYP=EXT-EXT DIR=OUTBOUND

ORGSTA(INTERVIEW STATON)   TYPE(VEHICLE TYPE)

FREQUENCY PERCENT ROW PCT COL PCT	OTHER VEH	MED TRK	HVY TRK	TOTAL
1206	0 0.00 . 0.00	0 0.00 . 0.00	0 0.00 . 0.00	0 0.00
1207	22.2621 0.33 68.69 0.40	0 0.00 0.00 0.00	10.1469 0.15 31.31 0.98	32.409 0.49
1208	118.329 1.78 85.91 2.15	7.8229 0.12 5.68 6.26	11.58 0.17 8.41 1.12	137.732 2.07
1209	1001.74 15.05 67.60 18.22	33.6682 0.51 2.27 26.92	446.545 6.71 30.13 43.32	1481.95 22.27
1210	65.5953 0.99 89.17 1.19	0 0.00 0.00 0.00	7.9659 0.12 10.83 0.77	73.5612 1.11
TOTAL	5499.07 82.63	125.053 1.88	1030.9 15.49	6655.03 100.00

APPENDIX D

ZONAL CALIBRATION DATA

APPENDIX D

ZONAL CALIBRATION DATA

The zonal data used for calibration came from two sources. The variable total households (TOTHH) was taken from the MAG STANDARD UTPS TAZ DEMAND FORECASTING data file. This file was reformatted for the purposes of external model calibration since much of the data therein was not relevant to the external model. In addition, the total external-to-internal productions by vehicle type were added for the external zones -- zones 1194 to 1210. The format of the resultant file named TP242.MAGTPO.EXT.ZONAL.DATA is as follows:

Columns	Descriptions
1-4	Year (1985)
7-11	Zone Number
12-16	Total Households
17-21	Retail Employment
22-26	Total Employment
32-36	Total Other Vehicle Productions
37-41	Total Medium Truck Productions
42-46	Total Heavy Truck Productions

Note that the employment values contained in this file were not used in the calibration as a more reliable and disaggregate source became available from MAG in the course of the calibration preparation.

Employment data was taken from the results of a recent employment survey. A file named TP242.MAGTPO.EXT.EMP.DATA was created having the following format:

Columns	Descriptions
7-11	Zone Number
12-18	Total Employment
19-25	Industrial Employment
26-32	Retail Employment
33-39	Other Employment

While the calibration was carried out at zone level using the above referenced files, for analysis purposes the zonal data was aggregated to 48 districts. A district summary of the data is given on the following page. The zone-district equivalences used for this purpose (in UTPS format) are also included for reference.

District data identification is as follows:

(1) District Number
(2) Total Households
(3) Retail Employment (Source 1)
(4) Total Employment (Source 1)
(5) Total Employment (Source 2)
(6) Industrial Employment (Source 2)
(7) Retail Employment (Source 2)
(8) Other Employment (Source 2)

DISTRICT SUMMARY OF ZONAL CALIBRATION DATA
(TP242.MAGTPO.DISTRICT.DATA)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	3194	160	530	158	0	7	151
2	9130	1149	4243	5259	911	1238	3108
3	21849	1486	14636	14253	6638	2878	4736
4	5855	1698	8631	12497	3354	1124	8020
5	6036	420	2264	2235	193	147	1894
6	30178	1840	9976	14141	223	2117	11802
7	9677	679	2579	6780	413	762	5606
8	23099	2892	14530	14923	2322	4410	8192
9	12526	1585	7687	9843	418	1974	7448
10	25396	3634	11193	13131	547	5479	7102
11	4202	329	2115	901	36	327	538
12	3964	306	12356	10320	14	185	10121
13	30903	5850	24520	25252	8692	7725	8839
14	25088	6341	25546	27812	4330	7665	15818
15	25369	6316	19499	23660	271	7719	15669
16	6959	2164	8514	13350	66	1477	11807
17	5899	814	3659	6653	0	162	6491
18	15134	1960	7596	16981	0	1498	15483
19	9311	342	1449	3249	59	1874	1318
20	21135	1877	8506	13397	1805	3801	7787
21	21193	4580	20480	20158	3787	4721	11654
22	26326	10305	62331	83276	732	8841	73704
23	29893	6996	24795	31857	503	7738	23610
24	28834	10988	39100	25033	2993	7596	14443
25	2631	479	2227	1962	404	456	1102
26	8018	936	5721	4129	983	794	2353
27	826	85	219	745	0	126	619
28	2201	381	7013	139213	41796	24892	72526
29	17597	5499	44532	27580	16907	4293	6380
30	4495	1816	16067	20686	10755	2127	7804
31	14036	7514	74945	78251	9380	6181	62690
32	23731	5419	35327	34944	3315	6648	24979
33	2377	2502	33639	31669	10933	3037	17701
34	22688	6858	40787	31659	10786	3895	16982
35	35675	9634	42245	36183	5628	10267	20291
36	18937	575	3763	4749	269	1467	3015
37	34309	902	3983	14755	1349	2389	11017
38	27135	3086	22456	19887	11317	3204	5367
39	22267	5580	22695	24438	11519	4755	8164
40	11078	2670	12185	8004	1435	2251	4314
41	16850	383	2274	0	0	0	0
42	578	0	43	6	0	6	0
43	14938	2263	8129	5898	2109	1487	2303
44	1764	1212	12275	549	544	5	0
45	15683	2828	16955	10740	1952	3362	5428
46	4963	434	2521	2349	691	622	1035
47	3075	217	3119	1112	615	108	388
48	2176	214	5429	3541	456	78	3006

```
&EQUIV DIST= 1,
 Z=1078,1079,1080,1081,1082,1083,1091,1092,1093,1094,1095,1096,
     1097,1098,1099,1100,1101,1102,1103,1104,
      &END
&EQUIV DIST= 2,
 Z= 42,43, 66, 69, 70,91, 92, 93,119,120,121,122,123,143,144,
     145,146,147,166,167,168,169,170,171,
      &END
&EQUIV DIST= 3,
 Z=    1,  2,  4,  5,  6,  8,  9, 16, 17, 18, 19, 20, 21, 22, 29,
      30, 31, 32, 33, 34, 35, 36,841,842,843,844,845,1110,1111,
      1112,1113,1114,1115,1116,1117,1118,1119,1120,1121,1122,1034,
      1035,1036,1037,1038,1039,1040,1041,1042,1043,1045,1048,1049,
      1044,1046,1047,1050,
      &END
&EQUIV DIST= 4,
 Z=   60, 61, 86,109,110,135,813,815,816,817,818,819,820,
     821,822,823,826,827,828,829,830,1013,1012,
      &END
&EQUIV DIST= 5,
 Z=   7,10,12,13,24, 37, 38,  62, 63, 87, 88, 89,111,112,113,114,
     1057,1058,1059,1060,1061,1062,1063,1064,1069,1070,1071,1072,107
3,
     1074,1075,1076,1077,1084,1085,1086,1087,1088,1089,1090,
      &END
&EQUIV DIST= 6,
 Z=   14,26,25,39,40,41,64,68, 65, 90,108,115,116,117,118,139,164,16
5,
      140,141,142,1068,
      &END
&EQUIV DIST= 7,
 Z=    3, 11, 15, 27, 28, 44, 45, 67, 71, 72, 94, 95,124,125,
       1051,1052,1053,1054,1055,1056,
      &END
&EQUIV DIST= 8,
 Z=   46, 47, 48, 49, 50, 51, 52, 53, 73, 74, 75, 76, 77, 78, 79,
    . 96, 97, 98, 99,
      &END
&EQUIV DIST= 9,
 Z=  100,101,130,131,154,155,156,182,846,848,849,850,
      &END
&EQUIV DIST=10,
 Z=   54, 55, 56, 57, 58, 59, 80, 81, 82, 83, 84, 85,102,103,104,
     105,106,107,132,133,134,157,158,847,
      &END
&EQUIV DIST=11,
 Z=  270,312,357,358,359,400,447,448,512,824,825,831,832,833,
     1136,1137,
      &END
&EQUIV DIST=12,
 Z=  136,137,138,161,162,163,186,187,188,189,190,191,212,213,236,
     237,238,239,240,271,272,273,274,275,313,314,360,
      &END
&EQUIV DIST=13,
 Z=  148,149,150,172,173,174,175,192,193,194,195,196,197,198,199,
     200,214,215,216,217,218,219,220,221,222,243,244,245,246,247,
     248,249,250,
      &END
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&EQUIV DIST=14,
 Z=  126,127,128,129,151,152,153,176,177,178,201,202,203,962,
      &END
&EQUIV DIST=15,
 Z=  179,180,181,204,205,206,207,226,227,228,229,254,255,256,257,
     258,259,260,851,853,854,855,856,857,858,860,861,863,864,865,
      &END
&EQUIV DIST=16,
 Z=  208,209,230,261,262,263,862,866,
      &END
&EQUIV DIST=17,
 Z=  159,183,184,210,231,232,266,852,859,
      &END
&EQUIV DIST=18,
 Z=  160,185,211,233,234,235,267,268,269,840,
      &END
&EQUIV DIST=19,
 Z=  242,276,277,278,279,280,281,320,321,322,368,369,370,
      &END
&EQUIV DIST=20,
 Z=  282,283,284,285,323,324,325,326,371,372,373,374,
      &END
&EQUIV DIST=21,
 Z=  223,224,225,251,252,253,286,287,288,289,964,965,
      &END
&EQUIV DIST=22,
 Z=  290,291,292,293,294,331,332,333,334,335,336,337,338,339,340,
     341,342,380,381,382,383,384,385,867,868,869,876,877,878,884,
     885,886,887,888,889,890,891,892,893,
      &END
&EQUIV DIST=23,
 Z=  241,264,265,295,296,297,298,299,300,301,343,344,345,346,347,
     348,349,350,870,871,872,873,874,875,879,880,881,882,883,899,
      &END
&EQUIV DIST=24,
 Z=  302,303,304,305,306,307,308,309,310,311,351,352,353,354,355,
     356,393,394,395,396,397,398,399,442,444,445,446,834,835,836,
     837,838,839,
      &END
&EQUIV DIST=25,
 Z=  361,362,363,405,406,407,408,455,456,457,458,459,524,525,569,
     570,571,622,623,1129,1130,1131,1132,1133,1134,1135,
      &END
&EQUIV DIST=26,
 Z=  315,316,317,318,319,364,365,366,367,409,410,411,412,
     413,414,460,461,
     462,463,464,465,466,467,526,527,572,573,624,
      &END
&EQUIV DIST=27,
 Z=  23,814,1105,1106,1107,1108,1109,1014,1015,1016,1017,1018,1019,
     1020,
      &END
&EQUIV DIST=28,
 Z=  415,416,417,418,419,468,469,470,471,
     528,529,530,531,532,533,534,535,574,575,576,577,625,
      &END
&EQUIV DIST=29,
 Z=  327,328,329,330,375,376,377,378,379,420,421,422,423,472,473,
     474,475,476,477,966,
      &END
```

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       &EQUIV DIST=30,
        Z=  536,537,538,539,540,541,542,543,544,545,578,579,
              &END
       &EQUIV DIST=31,
        Z=  424,425,426,427,428,429,430,431,432,433,434,478,479,480,481,
            482,483,484,485,486,487,488,489,490,491,492,493,494,495,900,
            901,
              &END
       &EQUIV DIST=32,
        Z=  386,387,388,389,390,391,392,435,436,437,438,439,440,441,894,
            895,896,897,898,902,903,904,905,
              &END
       &EQUIV DIST=33,
        Z=  496,497,498,499,500,501,502,503,504,505,506,507,546,547,548,
            549,907,908,
              &END
       &EQUIV DIST=34,
        Z=  443,508,509,510,511,550,551,552,553,554,555,586,587,588,589,
            590,591,592,593,594,595,596,967,1138,
              &END
       &EQUIV DIST=35,
        Z=  513,514,515,516,556,557,558,559,560,561,597,598,599,600,601,
            602,603,604,605,606,607,608,609,610,642,643,644,645,646,647,
            648,935,936,1139,1140,1141,1142,1143,1144,1145,1146,
              &END
       &EQUIV DIST=36,
        Z=  401,402,449,450,451,452,517,518,519,520,562,563,564,
            611,612,613,614,615,616,649,650,651,679,680,
            952,953,954,955,1006,1007,1008,
              &END
       &EQUIV DIST=37,
        Z=  403,404,453,454,521,522,523,565,566,567,568,617,618,619,620,
            621,652,653,681,682,906,909,910,912,913,914,915,916,956,957,
            958,959,960,961,992,993,994,995,996,997,998,999,1000,1001,1002,
            1009,1010,1011,1025,1026,1027,1028,1029,1030,1031,1032,1033,
            1147,1148,1151,1152,1153,1154,1156,1157,1158,1159,1160,1161,
            1162,1149,1150,1155,
              &END
       &EQUIV DIST=38,
        Z=  580,581,582,583,584,585,626,627,628,629,630,631,632,633,634,
            635,636,654,655,656,657,658,659,660,661,662,663,664,665,666,
            683,684,685,686,687,688,689,690,691,706,707,708,709,759,
            911,917,918,919,921,924,927,928,932,933,934,
            968,969,970,971,1021,1065,1066,1067
              &END
       &EQUIV DIST=39,
        Z=  637,638,639,640,641,667,668,669,670,671,930,937,939,940,941,
            942,943,944,
              &END
       &EQUIV DIST=40,
        Z=  672,673,674,675,676,677,678,696,697,698,714,715,716,945,946,
            947,948,949,950,951,
              &END
       &EQUIV DIST=41,
        Z=  1181,1182,1183,1184,1185,1186,1187,1188,1189,1190,1191,1192,119
3,
              &END
```

```
&EQUIV DIST=42,
 Z=  1123,1124,1125,1126,1127,1128,
      &END
&EQUIV DIST=43,
 Z=  692,693,694,695,710,711,712,713,721,722,723,724,725,736,737,
     738,739,929,931,938,
      &END
&EQUIV DIST=44,
 Z=  744,745,746,747,748,760,972,973,974,1022,
      &END
&EQUIV DIST=45,
 Z=  726,727,728,729,740,741,742,743,749,750,751,752,753,761,762,
     763,764,765,771,
      &END
&EQUIV DIST=46,
 Z=  699,700,701,702,703,704,717,718,719,730,731,732,733,734,754,
     755,756,757,766,767,768,769,777,778,779,920,922,923,925,926,
     983,984,985,986,987,988,989,990,991,1003,
     1168,1169,1170,1171,1172,1173,1174,1175,
      &END
&EQUIV DIST=47,
 Z=  772,774,775,776,781,782,783,784,789,790,791,792,796,797,
     798,799,800,805,806,807,811,812,
     975,976,977,978,979,980,981,982,
     1023,1024,1176,
      &END
&EQUIV DIST=48,
 Z=  705,720,735,758,770,780,785,786,787,788,793,794,795,801,802,
     803,804,808,809,810,1004,1005,
     1163,1164,1165,1166,1167,1177,1178,1179,1180,
      &END
&EQUIV DIST=49,Z=1194  &END
&EQUIV DIST=50,Z=1195  &END
&EQUIV DIST=51,Z=1196  &END
&EQUIV DIST=52,Z=1197  &END
&EQUIV DIST=53,Z=1198  &END
&EQUIV DIST=54,Z=1199  &END
&EQUIV DIST=55,Z=1200  &END
&EQUIV DIST=56,Z=1201  &END
&EQUIV DIST=57,Z=1202  &END
&EQUIV DIST=58,Z=1203  &END
&EQUIV DIST=59,Z=1204  &END
&EQUIV DIST=60,Z=1205  &END
&EQUIV DIST=61,Z=1206  &END
&EQUIV DIST=62,Z=1207  &END
&EQUIV DIST=63,Z=1208  &END
&EQUIV DIST=64,Z=1209  &END
&EQUIV DIST=65,Z=1210  &END
```

APPENDIX E

UMODEL SUBROUTINE AND PRODUCTION RUN SETUPS

FOR CREATING CALIBRATION DATASET FOR INPUT TO UFIT

```
//TP007C JOB (1000,6617,30,9),'TP242000L 108P BAA'
//*
//*        PHOENIX EXTERNAL TRAVEL SURVEY PROJECT
//*
//*        CREATE UMODEL LIB FOR MODEL CALIBRATION FILE
//*
//* *************************************************
//SCR EXEC PGM=IEHPROGM,REGION=64K
//SYSPRINT DD SYSOUT=Q
//DD1 DD UNIT=3350,VOL=SER=DOT471,DISP=SHR
//SYSIN DD *
  SCRATCH DSNAME=TP242.MAGTPO.TRPAUGM5,VOL=3350=DOT471,PURGE
  UNCATLG DSNAME=TP242.MAGTPO.TRPAUGM5
//USERCODE  EXEC PGM=IEBUPDTE,PARM=MOD,REGION=64K
//SYSPRINT  DD SYSOUT=Q
//SYSUT1   DD DSN=TP242.MAGTPO.URD85.DATA,DISP=SHR,UNIT=3350,
// VOL=SER=DOT471
//SYSUT2     DD DSN=&&PROGTEMP,UNIT=SYSDA,
//              DISP=(,PASS,DELETE),
//              SPACE=(TRK,(50,10,1),RLSE),
//              DCB=(RECFM=FB,LRECL=80,BLKSIZE=2400)
//USERCODE.SYSIN DD *
./ CHANGE NAME=UMODEL
./ NUMBER INSERT=YES,SEQ1=442000,NEW1=442001,INCR=1
      IF(IZ .LT. 1194) RETURN
      X(15) = IZ
      X(16) = JZ
       WRITE(10,90100) (X(I),I=1,16)
90100 FORMAT(16F6.0)
//FORT       EXEC PGM=IGIFORT,PARM='SOURCE,LOAD'
//STEPLIB  DD DSN=TP242.MAGTPO.FORTG.COMPLIB,DISP=SHR,
//           UNIT=3350,VOL=SER=DOT471
//SYSPRINT DD SYSOUT=Q
//SYSPUNCH DD SYSOUT=B
//SYSLIN   DD DSNAME=&LOADSET,DISP=(MOD,PASS),UNIT=SYSDA,
//           SPACE=(TRK,(19,19)),DCB=(BLKSIZE=400,LRECL=80,
//           RECFM=FB)
//SYSIN  DD DSN=&&PROGTEMP(UMODEL),DISP=(OLD,DELETE)
//LKED   EXEC PGM=IEWL,REGION=128K,
//             PARM=(XREF,LIST,LET,OVLY,MAP,DC),
//             COND=((0,NE,USERCODE),(4,LT,FORT))
//PROGLIB  DD DSN=TP242.MAGTPO.URD85.PROGLIB,DISP=SHR,VOL=SER=DOT471,
//           UNIT=3350
//SYSLIB   DD DSN=TP242.MAGTPO.URD85.SUBRLIB,DISP=SHR,VOL=SER=DOT471,
//           UNIT=3350
//           DD DSN=SYS1.FORTLIB,DISP=SHR
//           DD DSN=EU209.P.FORTSUB,DISP=SHR
//SYSLIN   DD DSN=*.FORT.SYSLIN,DISP=(OLD,DELETE)
//           DD DDNAME=SYSIN
//SYSLMOD  DD DSN=TP242.MAGTPO.TRPAUGM5(UMODEL),
//             UNIT=3350,DISP=(,CATLG,DELETE),VOL=SER=DOT471,
//             SPACE=(TRK,(20,10,1),RLSE),
//             DCB=(RECFM=U,LRECL=3072,BLKSIZE=3072)
//SYSPRINT DD SYSOUT=Q
//SYSUT1   DD UNIT=(SYSDA,SEP=SYSLIN),
//             SPACE=(3072,(50,20))
//SYSIN    DD *
   INCLUDE PROGLIB(UMODEL)
   ENTRY MAIN
```

```
//TP007U JOB (1000,6617,420,10),'TP242000L 108P BAA',CLASS=L
//*
//*     PHOENIX EXTERNAL TRAVEL SURVEY PROJECT
//*
//*     UMODEL CALIBRATION FILE PROGRAM
//*
//*
//* ***********************************************************
//UMODEL  PROC CLASS=Q,
//             CORE=704K,
//             LIB='TP242.MAGTPO.URD85.PROGLIB',
//             UNITLIB='3350,VOL=SER=DOT471',
//             J1=DUMMY,UNITJ1=3350,
//             J2=DUMMY,UNITJ2=3350,
//             J3=DUMMY,UNITJ3=3350,
//             J4=DUMMY,UNITJ4=3350,
//             J5=DUMMY,UNITJ5=3350,
//             J6=DUMMY,UNITJ6=3350,
//             J7=DUMMY,UNITJ7=3350,
//             J8=DUMMY,UNITJ8=3350,
//             J9=DUMMY,UNITJ9=3350,
//             A1=DUMMY,UNITA1=3350,
//             A2=DUMMY,UNITA2=3350,
//             A3=DUMMY,UNITA3=3350,
//             A4=DUMMY,UNITA4=3350,
//             A5=DUMMY,UNITA5=3350,
//             A6=DUMMY,UNITA6=3350,
//             A7=DUMMY,UNITA7=3350,
//             A8=DUMMY,UNITA8=3350,
//             A9=DUMMY,UNITA9=3350,
//             Z1=DUMMY,UNITZ1=3350,
//             SPACEZ1=,DISPZ1=OLD,
//             UMMY,UNITZ2=3350,
//             SPACEZ2=,DISPZ2=OLD,
//             Z3=DUMMY,UNITZ3=3350,
//             SPACEZ3=,DISPZ3=OLD,
//             Z4=DUMMY,UNITZ4=3350,
//             SPACEZ4=,DISPZ4=OLD,
//             Z5=DUMMY,UNITZ5=3350,
//             SPACEZ5=,DISPZ5=OLD,
//             Z6=DUMMY,UNITZ6=3350,
//             SPACEZ6=,DISPZ6=OLD,
//             Z7=DUMMY,UNITZ7=3350,
//             SPACEZ7=,DISPZ7=OLD,
//             Z8=DUMMY,UNITZ8=3350,
//             SPACEZ8=,DISPZ8=OLD,
//             Z9=DUMMY,UNITZ9=3350,
//             SPACEZ9=,DISPZ9=OLD,
//             UNITSCR=SYSDA
//*
//UMODEL EXEC PGM=UMODEL,REGION=&CORE
//STEPLIB  DD DSN=&LIB,UNIT=&UNITLIB,DISP=SHR
//FT05F001 DD DDNAME=SYSIN
//FT06F001 DD SYSOUT=&CLASS
//FT10F001 DD DUMMY
```

```
//FT11F001 DD &J1,UNIT=&UNITJ1,DISP=SHR
//FT12F001 DD &J2,UNIT=&UNITJ2,DISP=SHR
//FT13F001 DD &J3,UNIT=&UNITJ3,DISP=SHR
//FT14F001 DD &J4,UNIT=&UNITJ4,DISP=SHR
//FT15F001 DD &J5,UNIT=&UNITJ5,DISP=SHR
//FT16F001 DD &J6,UNIT=&UNITJ6,DISP=SHR
//FT17F001 DD &J7,UNIT=&UNITJ7,DISP=SHR
//FT18F001 DD &J8,UNIT=&UNITJ8,DISP=(,KEEP),
//            DCB=(RECFM=VBS,LRECL=1604,BLKSIZE=12836)
//FT19F001 DD &J9,UNIT=&UNITJ9,DISP=(,KEEP),
//            DCB=(RECFM=VBS,LRECL=1604,BLKSIZE=12836)
//FT20F001 DD UNIT=&UNITSCR,SPACE=(TRK,(1,1)),
//            DCB=(RECFM=FB,LRECL=72,BLKSIZE=720)
//FT21F001 DD DUMMY
//FT22F001 DD UNIT=&UNITSCR,SPACE=(TRK,(1,1)),
//            DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//A1       DD &A1,UNIT=&UNITA1,DISP=SHR
//A2       DD &A2,UNIT=&UNITA2,DISP=SHR
//A3       DD &A3,UNIT=&UNITA3,DISP=SHR
//A4       DD &A4,UNIT=&UNITA4,DISP=SHR
//A5       DD &A5,UNIT=&UNITA5,DISP=SHR
//A6       DD &A6,UNIT=&UNITA6,DISP=SHR
//A7       DD &A7,UNIT=&UNITA7,DISP=SHR
//A8       DD &A8,UNIT=&UNITA8,DISP=SHR
//A9       DD &A9,UNIT=&UNITA9,DISP=(,KEEP)
//Z1       DD &Z1,UNIT=&UNITZ1,
//            DISP=&DISPZ1,SPACE=&SPACEZ1
//Z2       DD &Z2,UNIT=&UNITZ2,
//            DISP=&DISPZ2,SPACE=&SPACEZ2
//Z3       DD &Z3,UNIT=&UNITZ3,
//            DISP=&DISPZ3,SPACE=&SPACEZ3
//Z4       DD &Z4,UNIT=&UNITZ4,
//            DISP=&DISPZ4,SPACE=&SPACEZ4
//Z5       DD &Z5,UNIT=&UNITZ5,
//            DISP=&DISPZ5,SPACE=&SPACEZ5
//Z6       DD &Z6,UNIT=&UNITZ6,
//            DISP=&DISPZ6,SPACE=&SPACEZ6
//Z7       DD &Z7,UNIT=&UNITZ7,
//            DISP=&DISPZ7,SPACE=&SPACEZ7
//Z8       DD &Z8,UNIT=&UNITZ8,
//            DISP=&DISPZ8,SPACE=&SPACEZ8
//Z9       DD &Z9,UNIT=&UNITZ9,
//            DISP=&DISPZ9,SPACE=&SPACEZ9
//             PEND
//SCR EXEC PGM=IEHPROGM,REGION=64K
//SYSPRINT DD SYSOUT=Q
//DD1 DD UNIT=3350,VOL=SER=DOT471,DISP=SHR
//SYSIN DD *
  SCRATCH DSNAME=TP242.MAGTPO.EXTCALIB.FILE1,VOL=3350=DOT471,PURGE
  UNCATLG DSNAME=TP242.MAGTPO.EXTCALIB.FILE1
SCRATCH DSNAME=TP242.MAGTPO.EXTCALIB.FILE2,VOL=3350=DOT471,PURGE
  UNCATLG DSNAME=TP242.MAGTPO.EXTCALIB.FILE2
//HBW EXEC UMODEL,
```

```
// LIB='TP242.MAGTPO.TRPAUGM5',
// UNITLIB='3350,VOL=SER=DOT471',
// J1='DSN=TP242.MAGTPO.Z1210.EIPA3TAB.TRIPS',
// UNITJ1='3350,VOL=SER=DOT471',
// J2='DSN=TP242.MAGTPO.Y1985OF.HWYSKIM',
// UNITJ2='3350,VOL=SER=DOT471',
// A1='DSN=TP242.MAGTPO.EXT.ZONAL.DATA',
// UNITA1='3350,VOL=SER=DOT471',
// A2='DSN=TP242.MAGTPO.INDEMP85.DATA',
// UNITA2='3350,VOL=SER=DOT471',
// J8='DSN=TP242.MAGTPO.EXTCALIB.FILE1,VOL=SER=DOT471',
// UNITJ8='3350,SPACE=(CYL,(10,10),RLSE)'
//UMODEL.FT10F001 DD UNIT=3350,VOL=SER=DOT471,DISP=(,CATLG),
//          DSN=TP242.MAGTPO.EXTCALIB.FILE2,SPACE=(TRK,(10,10),RLSE),
//          DCB=(RECFM=FB,LRECL=96,BLKSIZE=1920)
//UMODEL.SYSIN DD *
 CREATE CALIBRATION FILE1 AND FILE2
 &PARAM ZONES=1210  &END
 &SELECT I=1194,-1210 &END
 &DATA
  1 T   1001                             XIOTHVEH
  2 T   1002                             XIMEDTRK
  3 T   1003                             XIHVYTRK
  4 X   2001                             TIME
  5 A      7    11  1 1                  ZONE NUMBER
  6 A     12    16  2 1                  TOTHH
  7 A     27    31  3 1                  SQMIAREA
  8 P     32    36  4 1                  OTHVEHPR
  9 P     37    41  5 1                  MEDTRKPR
 10 P     42    46  6 1                  HVYTRKPR
 11 A      7    11  7 2                  OLDZONE
 12 A     31    37  8 2              INDEMP
 13 A     44    50  9 2                  RETEMP
 14 A     57    63 10 2                  OTHEMP
 15 X*                                   OZONE
 16 X*                                   DZONE
/*
```

APPENDIX F

SAMPLE UFIT RUN

```
//TP007F  JOB (1000,6617,260,2),'TP242000L 108P BAA'
//*
//*                PHOENIX EXTERNAL TRIP SURVEY
//*                EXTERNAL TRIP MODEL CALIBRATION
//*
//UFIT PROC LIB='TP242.MAGTPO.URD84.PROGLIB'
//UFIT   EXEC PGM=UFIT,REGION=256K
//STEPLIB   DD DSN=&LIB,UNIT=3350,VOL=SER=DOT471,DISP=SHR
//FT05F001  DD DDNAME=SYSIN
//FT06F001  DD SYSOUT=Q
//FT10F001  DD UNIT=SYSDA,DISP=(,PASS),
//             SPACE=(TRK,(5,5),RLSE),
//             DCB=(RECFM=FB,LRECL=72,BLKSIZE=1008)
//FT11F001  DD &J1,UNIT=3350,DISP=SHR,VOL=SER=DOT471
//FT20F001  DD UNIT=SYSDA,DISP=(,PASS),
//             SPACE=(TRK,(1,1)),
//             DCB=(RECFM=FB,LRECL=72,BLKSIZE=720)
//FT21F001  DD DUMMY
//FT49F001  DD UNIT=SYSDA,DISP=(,PASS),
//             SPACE=(TRK,(1,1)),
//             DCB=(RECFM=FB,LRECL=72,BLKSIZE=144)
//*
//UFIT1  EXEC  PGM=UFIT1,REGION=400K,
//             COND=(4,LT,UFIT)
//STEPLIB   DD DSN=&LIB,UNIT=3350,VOL=SER=DOT471,DISP=SHR
//FT05F001  DD DSN=*.UFIT.FT20F001,DISP=(OLD,DELETE)
//FT06F001  DD SYSOUT=Q
//FT10F001  DD DSN=*.UFIT.FT10F001,DISP=(OLD,DELETE)
//FT11F001  DD &J1,UNIT=3350,DISP=SHR,VOL=SER=DOT471
//FT19F001  DD DUMMY
//FT20F001  DD UNIT=SYSDA,SPACE=(TRK,(1,1)),
//             DCB=(RECFM=FB,LRECL=72,BLKSIZE=720)
//FT21F001  DD DUMMY
//FT49F001  DD DSN=*.UFIT.FT49F001,DISP=(OLD,DELETE)
//             PEND
//REGR  EXEC  UFIT,J1='DSN=TP242.MAGTPO.EXTCALIB.FILE1'
//UFIT.SYSIN DD *
 PHX EXT MODEL CALIBRATION - 5/4/86 - RUN OVF2
 &OPTION &END
 &SELECT   NOBS=20570,
    LET(LRETE:=IF RETEMP=0 THEN 0 ELSE LOG(RETEMP))
    LET(LINDE:=IF INDEMP=0 THEN 0 ELSE LOG(INDEMP))
    LET(LO=IF OTHEMP=0 THEN 0 ELSE LOG(OTHEMP))
    LET(LPI:= IF OTHVEHPR=0 THEN 0 ELSE LOG(OTHVEHPR))
    LET(TIJ:=IF TIME=0 THEN 0 ELSE (EXP(0.0074*TIME))/(TIME**1.09))
    LET(LTIJ:=IF TIJ=0 THEN 0 ELSE LOG(TIJ))
    LET(LOVT:=IF XIOTHVEH=0 THEN 0 ELSE LOG(XIOTHVEH))
 FIT(LOVT=A1+A4*LTIJ+A2*LPI+A6*TOTHH+A7*LRETE+A8*LINDE+A9*LOTHE)
    SKIP(DZONE>1193)
    REPORT=1,-5,7 &END
```

M O D E L   S P E C I F I C A T I O N

THE 7 COEFFICIENTS TO BE ESTIMATED ARE:

NO.	COEFFICIENT	INITIAL VALUE	LOWER BOUND	UPPER BOUND
1	A1	.0		
2	A4	.0		
3	A2	.0		
4	A6	.0		
5	A7	.0		
6	A8	.0		
7	A9	.0		

THE 1 FIT STATEMENTS ARE:

```
LOVT                          =  A1
                                +A4        * LTIJ
                                +A2        * LPI
                                +A6        * TOTHH
                                +A7        * LRETE
                                +A8        * LINDE
                                +A9        * LOTHE
```

THE 16 INPUT VARIABLES ON THE CALIBRATION FILE ARE:

XIOTHVEH	XIMEDTRK	XIHVYTRK	TIME	ZONE NUMBER
TOTHH	SQMIAREA	OTHVEHPR	MEDTRKPR	HVYTRKPR
OLDZONE	INDEMP	RETEMP	OTHEMP	OZONE
DZONE				

THE 7 GENERATED VARIABLES ARE:

```
LRETE     := IF'RETEMP'=(0)THEN(0)ELSELOG('RETEMP')
LINDE     := IF'INDEMP'=(0)THEN(0)ELSELOG('INDEMP')
LOTHE     := IF'OTHEMP'=(0)THEN(0)ELSELOG('OTHEMP')
LPI       := IF'OTHVEHPR'=(0)THEN(0)ELSELOG('OTHVEHPR')
TIJ       := IF'TIME'=(0)THEN(0)ELSE(EXP((0.0074)*
             'TIME'))/('TIME'**(1.09))
LTIJ      := IF'TIJ'=(0)THEN(0)ELSELOG('TIJ')
LOVT      := IF'XIOTHVEH'=(0)THEN(0)ELSELOG('XIOTHVEH')
```

20570 OBSERVATIONS ARE EXPECTED FROM THE CALIBRATION FILE

OBSERVATIONS FROM THE CALIBRATION FILE ARE SKIPPED WHEN THE FOLLOWING EXPRESSION IS TRUE:

('DZONE'>(1193))

S T A T I S T I C A L   S U M M A R Y

THE 7 VARIABLES USED FOR REGRESSION ARE:

NAME	MEAN	ST. DEV.	MIN	MAX	UNITS
LOVT	.5584	1.056	.0	7.062	
LTIJ	-3.839	.3228	-4.314	-1.175	
LPI	7.924	1.096	5.620	9.474	
TOTHH	594.4	706.6	.0	5720.	
LRETE	2.479	2.532	.0	10.11	
LINDE	1.356	2.329	.0	10.26	
LOTHE	3.138	2.935	.0	11.19	

THERE WERE 20570 OBSERVATIONS PROCESSED AND 20281 WERE ACCEPTED.

PHX EXT MODEL CALIBRATION - 5/4/86 - RUN OVF2
12MAY86 13.41.22 UFIT REPORT 3

R A N K   A N D   L I N E A R   D E P E N D E N C E

THE REGRESSION MATRIX HAS RANK 7 AND RANK LOSS 0 .

THE COLUMNS WHICH CORRESPOND TO THE COEFFICIENTS BELOW FORM A LINEARLY INDEPENDENT SUBSYSTEM:

COEFFICIENT	RANK INDICATOR
A6	1.000
A8	.9197
A2	.7216
A9	.5553
A7	.4296
A4	.1608
A1	.7037E-01

PHX EXT MODEL CALIBRATION - 5/4/86 - RUN OVF2
12MAY86 13.41.22 UFIT REPORT 4

E S T I M A T E D   C O E F F I C I E N T S

COEFFICIENT	VALUE	STANDARD ERROR	T-RATIO	BOUND	MARGINAL DECREASE
A1	1.675776	.899E-01	18.6		
A4	1.015233	.196E-01	51.7		
A2	.3128647	.578E-02	54.2		
A6	.2365115E-03	.109E-04	21.8		
A7	.2645372E-01	.416E-02	6.37		
A8	.1874183E-01	.317E-02	5.91		
A9	.2225295E-01	.327E-02	6.81		

MEAN OF RESIDUALS = -.341768D-12

DEGREES OF FREEDOM = 20274

STANDARD DEVIATION = .90073

R-SQUARED = 0.27316

V A R I A N C E - C O V A R I A N C E   M A T R I X

BY ROW FOR EACH COEFFICIENT:

A1
```
   0:   .11783E-09   .69911E-08  -.35615E-10  -.66349E-08  -.14417E-07
   5:   .39290E-08  -.75836E-08
```

A4
```
   0:   .69911E-08   .10063E-04   .19886E-07  -.73443E-06  -.48518E-05
   5:  -.21879E-05  -.12020E-04
```

A2
```
   0:  -.35615E-10   .19886E-07   .33364E-04  -.79504E-08   .74751E-08
 :  -.34980E-05  -.27779E-03
```

A6
```
   0:  -.66349E-08  -.73443E-06  -.79504E-08   .10691E-04  -.78993E-05
   5:   .87521E-06  -.56016E-05
```

A7
```
   0:  -.14417E-07  -.48518E-05   .74751E-08  -.78993E-05   .17265E-04
   5:  -.82299E-06  -.60887E-05
```

A8
```
   0:   .39290E-08  -.21879E-05  -.34980E-05   .87521E-06  -.82299E-06
   5:   .38512E-03   .15062E-02
```

A9
```
   0:  -.75836E-08  -.12020E-04  -.27779E-03  -.56016E-05  -.60887E-05
   5:   .15062E-02   .80776E-02
```


B R A C K E T   A N A L Y S I S   O F   R E S I D U A L S

DEPENDENT VARIABLE 'LOVT'

INDEPENDENT VARIABLE 'LTIJ'

THE RESIDUALS ARE COLLECTED INTO TEN CATEGORIES DEPENDING ON WHICH OF THE INTERVALS BETWEEN -4.3144 AND -1.1753 CONTAINS THE CORRESPONDING VALUE OF THE INDEPENDENT VARIABLE

		CONTAINED		MINIMUM		MAXIMUM	
BRACKET	SIGN	NUMBER	WEIGHT	OBS.NO.	RESIDUAL	OBS.NO.	RESIDUAL
1	-	7464	0.3680	11512	-4.627	16981	1.896
2	+	7492	0.3694	6598	-4.876	19062	2.047
3	-	3607	0.1779	6202	-3.717	11802	2.070
4	-	1154	0.0569	10869	-4.745	17527	2.105
5	-	364	0.0179	12880	-5.201	19091	2.409
6	+	138	0.0068	456	-3.517	19172	2.179
7	+	34	0.0017	15329	-2.178	18961	2.694
8	+	21	0.0010	15698	-3.002	17747	2.419
9	-	3	0.0001	1832	-.9473	17746	-.3709
10	+	4	0.0002	14490	-3.607	17964	3.160

SINOFF 6460 (WARNING): EARLY EOF ON LOG
SINOFF 6700 (INFORMATION): UFIT1   ENDED AT 13.42.46 (RETURN CODE= 0)
SINOFF 7000 (WARNING): LOG FILE IS NOT AVAILABLE OR IS DEFECTIVE

APPENDIX G

UMODEL SUBROUTINE AND PRODUCTION MODEL SETUP

```
//TP007C JOB (1000,6617,30,9),'TP242000L 108P BAA'
//*
//*        PHOENIX EXTERNAL TRAVEL SURVEY PROJECT
//*
//*        CREATE UMODEL LIB FOR  EXT MODEL APPLICATION
//*        ------ MAY 03,1986 ------
//*
//* ****************************************************
//SCR EXEC PGM=IEHPROGM,REGION=64K
//SYSPRINT DD SYSOUT=Q
//DD1 DD UNIT=3350,VOL=SER=DOT471,DISP=SHR
//SYSIN DD *
  SCRATCH DSNAME=TP242.MAGTPO.XITRIPS,VOL=3350=DOT471,PURGE
  UNCATLG DSNAME=TP242.MAGTPO.XITRIPS
//USERCODE  EXEC PGM=IEBUPDTE,PARM=MOD,REGION=64K
//*******************************************************************
//*      THIS STEP EXECUTES IBM UTILITY PROGRAM IEBUPDTE TO INSERT   *
//*      THE USER'S CODE INTO THE SUBROUTINE'S SKELETON CODE TAKEN   *
//*      FROM 'URD81.DATA'.                                          *
//*******************************************************************
//SYSPRINT  DD SYSOUT=Q
//SYSUT1  DD DSN=TP242.MAGTPO.URD85.DATA,DISP=SHR,UNIT=3350,
// VOL=SER=DOT471
//SYSUT2    DD DSN=&&PROGTEMP,UNIT=SYSDA,
//             DISP=(,PASS,DELETE),
//             SPACE=(TRK,(50,10,1),RLSE),
//            DCB=(RECFM=FB,LRECL=80,BLKSIZE=2400)
//USERCODE.SYSIN DD *
./ CHANGE NAME=UMODEL
./ NUMBER INSERT=YES,SEQ1=442000,NEW1=442001,INCR=1
C CODE FOR PHX EXT MODEL APPLICATION
C
C VARIABLE DICTIONARY:
C
C    X(#) = DESCRIPTION
```

```
C       1  = OBS OTH VEH TRIPS (NONTRUCKS)
C       2  = OBS MED TRK TRIPS
C       3  = OBS HVY TRK TRIPS
C       4  = OFF-PEAK HWY TIME
C       6  = TOTAL HOUSEHOLDS
C       8  = OBS OTH VEH PRODUCTIONS
C       9  = OBS MED TRK PRODUCTIONS
C      10  = OBS HVY TRK PRODUCTIONS
C      12  = INDUSTRIAL EMPLOYMENT
C      13  = RETAIL EMPLOYMENT
C      14  = OTHER EMPLOYMENT
C      15  = EST OTH VEH TRIPS
C      16  = EST MED TRK TRIPS
C      17  = EST HVY TRK S
C
      REAL*4 XPI,XAJ,XTIJ,YPI,YAJ,YTIJ,ZPI,ZAJ,ZTIJ
      REAL*4 OVFAC(17),MTFAC(17),HTFAC(17)
C
      DATA OVFAC/1.80,0.75,2.55,2.40,1.46,3.57,1.15,1.79,2.15,
     *           4.17,1.80,0.86,0.68,0.70,1.32,2.18,0.90/
      DATA MTFAC/0.50,0.50,0.50,0.50,0.50,0.45,0.50,0.50,0.50,
     *           0.50,0.50,0.50,0.50,0.50,0.50,0.50,0.50/
      DATA HTFAC/0.67,0.45,1.76,0.56,0.50,1.00,0.50,0.75,0.60,
     *           0.91,0.50,0.45,0.45,0.45,0.53,1.35,0.45/
C
      IF( IZ .LT. 1194 ) RETURN
C
      IF(X(4) .LT. 1.) X(4)=1.
      IF(X(12) .LT. 1.) X(12)=1.
      IF(X(13) .LT. 1.) X(13)=1.
      IF(X(14) .LT. 1.) X(14)=1.
C***********************************************************
C
C  CALC OTHER VEH TRIPS
C
C  CALC PRODUCTION VARIABLE XPI
      XPI = X(8)**0.3129
C
C  CALC ATTRACTION VARIABLE XAJ
      XAJ = EXP( 0.00025*X(6) + 0.0265*ALOG(X(13))
     1      + 0.0187*ALOG(X(12)) + 0.0223*ALOG(X(14)) )
C
```

```
C  CALC TIME VARIABLE XTIJ
       XTIJ = ( X(4) ** 1.20 ) / (120. * EXP( 0.08 * X(4) ))
C
C  CALC EST OTH TRIPS
       X(15) = 5.343 * XPI * XAJ * XTIJ * OVFAC(IZ-1193)
       IF(X(15) .LT. 1.) X(15)=0.
C
       IF(IZ .NE. 1201) GO TO 1000
       WRITE(6,90001) (X(I),I=1,14)
90001 FORMAT(1X,14F6.0)
       WRITE(6,90000) IZ,JZ,X(15),XPI,XAJ,XTIJ
90000 FORMAT(1X,2I6,4F10.5)
 1000 CONTINUE
C*****************************************************************
C
C  CALC MED TRK TRIPS
C
C  CALC PROD VAR
       YPI = X(9)**0.0368
C
C  CALC ATTR VAR
       YAJ = EXP( 0.00001284*X(6) + 0.00441*ALOG(X(12)) )
C
C  CALC TIME VAR
       YTIJ = ( X(4) ** 2.2 ) / (160. * EXP( 0.07* X(4) ))
C
C  CALC EST TRIPS
       X(16) = 1.264 * YPI * YAJ * YTIJ * MTFAC(IZ-1193)
       IF(X(16) .LT. 1.) X(16)=0.
C
C*****************************************************************
C
C CALC HVY TRK TRIPS
C
C  CALC PROD VAR
       ZPI = X(10)**0.0217
C
C  CALC ATTR VAR
       ZAJ = EXP( 0.000008*X(6) + 0.00212*ALOG(X(13))
      1       + 0.0163*ALOG(X(12)) )
C
C  CALC TIME VAR
       ZTIJ = ( X(4) ** 2.4 ) / (150. * EXP( 0.10* X(4) ))
C
C  CALC EST TRIPS
       X(17) = 1.62 * ZPI * ZAJ * ZTIJ * HTFAC(IZ-1193)
       IF(X(17) .LT. 1.) X(17)=0.
C
C*****************************************************************
C
C  OUTPUT TRIPS
       TABSO(1) = X(15)
       TABSO(2) = X(16)
```

```
           TABSO(3) = X(17)
      C
      C  FORM OBS VS EST TRIP END SUMMARIES
      C
      C  OTH VEHS
           TETAB(1,1) = X(15)
           TETAB(2,1) = X(15) - X(1)
           TEPERS(1) = X(1)
      C
      C  MED TRKS
           TETAB(1,2) = X(16)
           TETAB(2,2) = X(16) - X(2)
           TEPERS(2) = X(2)
      C
      C  HVY TRK
           TETAB(1,3) = X(17)
           TETAB(2,3) = X(17) - X(3)
           TEPERS(3) = X(3)
      C
      C***********************************************************
      //FORT     EXEC PGM=IGIFORT,PARM='SOURCE,LOAD'
      //STEPLIB  DD DSN=TP242.MAGTPO.FORTG.COMPLIB,DISP=SHR,
      //            UNIT=3350,VOL=SER=DOT471
      //SYSPRINT DD SYSOUT=Q
      //SYSPUNCH DD SYSOUT=B
      //SYSLIN   DD DSNAME=&LOADSET,DISP=(MOD,PASS),UNIT=SYSDA,
      //            SPACE=(TRK,(19,19)),DCB=(BLKSIZE=400,LRECL=80,
      //            RECFM=FB)
      //SYSIN  DD DSN=&&PROGTEMP(UMODEL),DISP=(OLD,DELETE)
      //LKED   EXEC PGM=IEWL,REGION=128K,
      //               PARM=(XREF,LIST,LET,OVLY,MAP,DC),
      //               COND=((0,NE,USERCODE),(4,LT,FORT))
      //*****************************************************************
      //*                                                               *
      //*     THIS STEP EXECUTES THE LINKAGE EDITOR TO CREATE A NEW UTPS  *
      //*     PROGRAM WHICH CONTAINS THE USER-CODED SUBROUTINE IN PLACE   *
      //*     OF THE DEFAULT SUBROUTINE.                                  *
      //*                                                               *
      //*****************************************************************
      //PROGLIB  DD DSN=TP242.MAGTPO.URD85.PROGLIB,DISP=SHR,VOL=SER=DOT471,
      //            UNIT=3350
      //SYSLIB   DD DSN=TP242.MAGTPO.URD85.SUBRLIB,DISP=SHR,VOL=SER=DOT471,
      //            UNIT=3350
      //            DD DSN=SYS1.FORTLIB,DISP=SHR
      //            DD DSN=EU209.P.FORTSUB,DISP=SHR
      //SYSLIN   DD DSN=*.FORT.SYSLIN,DISP=(OLD,DELETE)
      //            DD DDNAME=SYSIN
      //SYSLMOD  DD DSN=TP242.MAGTPO.XITRIPS(UMODEL),
      //               UNIT=3350,DISP=(,CATLG,DELETE),VOL=SER=DOT471,
      //               SPACE=(TRK,(20,10,1),RLSE),
      //               DCB=(RECFM=U,LRECL=3072,BLKSIZE=3072)
      //SYSPRINT DD SYSOUT=Q
      //SYSUT1   DD UNIT=(SYSDA,SEP=SYSLIN),
      //               SPACE=(3072,(50,20))
      //SYSIN    DD *
        INCLUDE PROGLIB(UMODEL)
        ENTRY MAIN
```

```
//TP007U JOB (1000,6617,420,10),'TP242000L 108P BAA',CLASS=L
//*
//*      PHOENIX EXTERNAL TRAVEL SURVEY PROJECT
//*
//*      EXTERNAL TRIP MODEL APPLICATION PROGRAM
//*
//*      ------ MAY 3, 1986  ------
//*
//* ***********************************************************
//UMODEL  PROC CLASS=Q,
//               CORE=704K,
//               LIB='TP242.MAGTPO.URD85.PROGLIB',
//               UNITLIB='3350,VOL=SER=DOT471',
//               J1=DUMMY,UNITJ1=3350,
//               J2=DUMMY,UNITJ2=3350,
//               J3=DUMMY,UNITJ3=3350,
//               J4=DUMMY,UNITJ4=3350,
//               J5=DUMMY,UNITJ5=3350,
//               J6=DUMMY,UNITJ6=3350,
//               J7=DUMMY,UNITJ7=3350,
//               J8=DUMMY,UNITJ8=3350,
//               J9=DUMMY,UNITJ9=3350,
//               A1=DUMMY,UNITA1=3350,
//               A2=DUMMY,UNITA2=3350,
//               A3=DUMMY,UNITA3=3350,
//               A4=DUMMY,UNITA4=3350,
//               A5=DUMMY,UNITA5=3350,
//               A6=DUMMY,UNITA6=3350,
//               A7=DUMMY,UNITA7=3350,
//               A8=DUMMY,UNITA8=3350,
//               A9=DUMMY,UNITA9=3350,
//               Z1=DUMMY,UNITZ1=3350,
//               SPACEZ1=,DISPZ1=OLD,
//               Z2=DUMMY,UNITZ2=3350,
//               SPACEZ2=,DISPZ2=OLD,
//               Z3=DUMMY,UNITZ3=3350,
//               SPACEZ3=,DISPZ3=OLD,
//               Z4=DUMMY,UNITZ4=3350,
//               SPACEZ4=,DISPZ4=OLD,
//               Z5=DUMMY,UNITZ5=3350,
//               SPACEZ5=,DISPZ5=OLD,
//               Z6=DUMMY,UNITZ6=3350,
//               SPACEZ6=,DISPZ6=OLD,
//               Z7=DUMMY,UNITZ7=3350,
//               SPACEZ7=,DISPZ7=OLD,
//               Z8=DUMMY,UNITZ8=3350,
//               SPACEZ8=,DISPZ8=OLD,
//               Z9=DUMMY,UNITZ9=3350,
//               SPACEZ9=,DISPZ9=OLD,
//               UNITSCR=SYSDA
```

```
//*************************************************************************
//*      UTPS PROCEDURE FOR UMODEL - 19APR82                              *
//*      TO ESTIMATE AND APPLY TRAVEL DEMAND MODELS, AND TO BUILD         *
//*      Z-FILES, J-FILES, AND CALIBRATION FILES FROM EBCDIC DATA         *
//*      CONTACT:  UTPS SUPPORT GROUP  (800) 638-8747                     *
//*
//*      MODIFIED FOR MAG-TPO  (AUG 1983)
//*
//*************************************************************************
//*                          SYMBOLIC DICTIONARY                          *
//* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
//*      CLASS    = PRINT CLASS                                           *
//*      CORE     = REGION SIZE                                           *
//*      LIB      = PROGRAM LIBRARY                                       *
//*      J1 - J7 = INPUT INTERCHANGE DATA FILES                           *
 &EQUIV DIST=65,Z=1210  &END
 &DATA
  1 T   1001                              OBS OTHER VEH TRIPS
  2 T   1002                              OBS MED TRK TRIPS
  3 T   1003                              OBS HVY TRK TRIPS
  4 X   2001                              OFF-PEAK HWY TIME
  5 A      7    11  1 1                   ZONE NUMBER
  6 A     12    16  2 1                   TOTHH
  7 A     27    31  3 1                   SQMIAREA
  8 P     32    36  4 1                   OTHVEHPR
  9 P     37    41  5 1                   MEDTRKPR
 10 P     42    46  6 1                   HVYTRKPR
 11 A      7    11  7 2                   OLDZONE
 12 A     31    37  8 2                   INDEMP
 13 A     44    50  9 2                   RETEMP
 14 A     57    63 10 2                   OTHEMP
 15 X*                                    EST OTH VEH TRIPS
 16 X*                                    EST MED TRK TRIPS
 17 X*                                    EST HVY TRK TRIPS
/*
//UFMTR    EXEC PGM=UFMTR,REGION=512K
//STEPLIB  DD  DSN=TP242.MAGTPO.URD85.PROGLIB,DISP=SHR
//FT05F001 DD *
 &PARAM ZONES=1210   &END
 &SELECT I1=1194,-1210,J1=1,-1193    &END
 &PLOT PAIR=101,201,301,SCALE=5,FREQ=T,
    TTITLE=' EST AND OBS OTHER VEH TRIPS VS OFF-PEAK TIME ' &END
 &PLOT PAIR=101,202,302,SCALE=5,FREQ=T,
    TTITLE=' EST AND OBS MED TRK TRPS VS OFF-PEAK TIME '    &END
 &PLOT PAIR=101,203,303,SCALE=5,FREQ=T,
    TTITLE=' EST AND OBS HVY TRK TRPS VS OFF-PEAK TIME '    &END
//FT06F001 DD SYSOUT=Q
//FT11F001 DD DSN=TP242.MAGTPO.Y1985OF.HWYSKIM,
//             UNIT=3350,VOL=SER=DOT471,DISP=SHR
//FT12F001 DD DSN=TP242.MAGTPO.Z1210.EIPA3TAB.TRIPS,DISP=SHR,
//     UNIT=3350,VOL=SER=DOT471
//FT13F001 DD DSN=TP242.MAGTPO.ESTXI.TRIPS,DISP=SHR,
//     UNIT=3350,VOL=SER=DOT471
//FT20F001 DD UNIT=SYSDA,SPACE=(TRK,(1,1)),
//              DCB=(RECFM=FB,LRECL=72,BLKSIZE=720)
//FT21F001 DD DUMMY
//FT49F001 DD UNIT=SYSDA,DISP=(,PASS),
//             SPACE=(TRK,(1,1)),
//             DCB=(RECFM=FB,LRECL=72,BLKSIZE=144)
/*
```

APPENDIX H

STATISTICAL ANALYSIS OF OBSERVED VS ESTIMATED EXTERNAL TRAVEL

OTHER VEH ATTRACTIONS - ALL DISTRICTS
CALCULATED INTERCEPT

Regression Output:

Constant	625.6198
Std Err of Y Est	740.4396
R Squared	0.372378
No. of Observations	48
Degrees of Freedom	46

X Coefficient(s)	0.612322
Std Err of Coef.	0.117208

OTHER VEH ATTRACTIONS - EX DIST's 37,38,41,46
CALCULATED INTERCEPT

Regression Output:

Constant	461.0039
Std Err of Y Est	438.1156
R Squared	0.655170
No. of Observations	44
Degrees of Freedom	42

X Coefficient(s)	0.662604
Std Err of Coef.	0.074174

OTHER VEH ATTRACTIONS - ALL DISTRICTS
FORCED ZERO INTERCEPT

Regression Output:

Constant	0
Std Err of Y Est	797.2522
R Squared	0.256552
No. of Observations	48
Degrees of Freedom	47

X Coefficient(s)	0.908517
Std Err of Coef.	0.062813

OTHER VEH ATTRACTIONS - EX DIST's 37,38,41,46
FORCED ZERO INTERCEPT

Regression Output:

Constant	0
Std Err of Y Est	492.6393
R Squared	0.553621
No. of Observations	44
Degrees of Freedom	43

X Coefficient(s)	0.887934
Std Err of Coef.	0.042025

MEDIUM TRK ATTRACTIONS - ALL DISTRICTS
CALCULATED INTERCEPT

Regression Output:

Constant	40.10248
Std Err of Y Est	50.35848
R Squared	0.319072
No. of Observations	48
Degrees of Freedom	46

X Coefficient(s)	0.608194
Std Err of Coef.	0.130999

MEDIUM TRK ATTRACTIONS - EX DIST's 37,38,41,4
CALCULATED INTERCEPT

Regression Output:

Constant	35.39187
Std Err of Y Est	38.84920
R Squared	0.416173
No. of Observations	44
Degrees of Freedom	42

X Coefficient(s)	0.562886
Std Err of Coef.	0.102872

HEAVY TRK ATTRACTIONS - ALL DISTRICTS
CALCULATED INTERCEPT

Regression Output:

Constant	142.8148
Std Err of Y Est	110.1083
R Squared	0.169606
No. of Observations	48
Degrees of Freedom	46

X Coefficient(s)	0.237294
Std Err of Coef.	0.077415

HEAVY TRK ATTRACTIONS - EX DIST's 37,38,41,46
CALCULATED INTERCEPT

Regression Output:

Constant	138.5165
Std Err of Y Est	83.63420
R Squared	0.145003
No. of Observations	44
Degrees of Freedom	42

X Coefficient(s)	0.170416
Std Err of Coef.	0.063852