Phoenix Commercial Vehicle Survey and Travel Models

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The primary objectives of the Phoenix urban truck travel model project, which was conducted for the Arizona Transportation Research Center, Arizona Department of Transportation, were to conduct a travel survey of commercial vehicles operating within the Phoenix metropolitan area and to use the data collected in this survey to develop commercial vehicle trip generation, distribution, and traffic assignment models. The models are designed to be incorporated into the Urban Transportation Planning System-based travel model system maintained by the Maricopa Association of Governments Transportation and Planning Office, which predicts highway and transit system usage throughout the Phoenix metropolitan area. The urban truck travel model project, including the methods used to collect commercial vehicle travel data, the types of information provided by the survey, and model development using the survey data, is summarized, and the issue of the transferability of the results of this project to other urban areas is discussed. Thus, the commercial vehicle travel patterns identified in Phoenix, and the travel forecasting models based on these patterns, may also be useful in other urban areas that are similar to Phoenix with respect to their mix of commercial and industrial activities and their history of growth and development into major metropolitan regions.

This paper presents the results of the Phoenix urban truck travel model project, which was conducted for the Arizona Transportation Research Center, Arizona Department of Transportation. The primary objectives of the project were to conduct a travel survey of commercial vehicles operating within the Phoenix metropolitan area and to use the data collected in the survey to develop commercial vehicle trip generation, distribution, and traffic assignment models. A full discussion of the project details and results is given elsewhere (*1*).

SURVEY METHODS

The Phoenix commercial vehicle survey provides detailed information on 3,402 trips made by 606 commercial vehicles registered in Maricopa County or used by the U.S. Postal Service (USPS) in the county. Each surveyed trip has its origin and its destination within the Maricopa Association of Governments (MAG) transportation study area. The survey does not include any commercial vehicles registered outside Maricopa County. In the Phoenix travel forecasting system, most of the trips made by these vehicles are included in external commercial vehicle trip tables. The purpose of this survey was to develop new models for internal commercial vehicle trips only.

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Two sources of data were used to determine the total population of commercial vehicles to be sampled in the survey. The first was a computerized file of approximately 157,000 commercial vehicles registered in Maricopa County in 1989. This file, obtained from the Department of Motor Vehicles (DMV), contains truck type identifiers and owners' names and addresses. The second was a listing, by garaging location in Maricopa County, of the 2,300 vehicles owned by the USPS but not registered in Arizona.

The data collection procedure used for vehicles selected from the DMV file was a combined telephone and mail method. This approach was adopted after low response rates were obtained in an initial pretest that relied entirely on a mailout-mailback method. The following procedure was used:

- *Telephone contact:* Vehicle owners for which telephone numbers could be obtained were called, initial screening questions were asked, and cooperation was requested in the mail portion of the survey.
- *Mail contact:* A mail-back questionnaire including a 1-day trip diary was mailed to those who agreed to participate in the survey and to selected owners who could not be contacted by telephone.

For USPS vehicles, with the assistance of the manager of fleet operations for the Phoenix postal district, vehicles were sampled by weight class and garaging location. Then, for the sampled vehicles, USPS forms detailing daily itineraries were obtained and translated into the format of the trip diary used for vehicles obtained from the DMV files.

Data Collection Forms

During the telephone portion of the survey, a script was used to introduce vehicle owners to the survey, elicit their cooperation, and obtain the following information on their registered vehicle, which had been chosen to be included in the survey:

- For vehicles leased by another firm or individual, name and address of the lessor;
- For vehicles not used on a specified survey day, the reason for no usage (no work, vehicle not operational, or other) and the registration number for a replacement vehicle, if any; and
- Person to whom the mailout questionnaire should be sent.

The mailout questionnaire used for the truck survey was patterned after that used previously by the Chicago Area

Transportation Study for a major commercial vehicle survey in the Chicago area (2). It was designed to obtain the following data for each surveyed commercial vehicle:

- Starting and ending addresses on survey day;
- Vehicle type, based on number of axles and body style;
- Estimated gross weight;
- Vehicle usage for transportation between home and work and for work-related purposes; and
- Total number of one-way trips on the survey day.

The DMV file also provides data items that were used along with the survey data. These items include the ZIP code of the owner and the registered vehicle weight.

In addition, the travel diary requests the following information on the first 10 one-way trips made by each vehicle on the selected survey day:

- Start and stop times;
- Stop odometer readings;
- Name and address of stop;
- Driver and vehicle activity at stop;
- Land use at stop; and
- Vehicle type and total axles during trip (to determine trailer pick-up and drop-off locations.)

Sample Design

DMV-Registered Vehicles

Stratified samples were selected from the DMV registration file and from the list of USPS vehicles. In both cases, the stratification was on the basis of vehicle weight. The initial sampling rate for light vehicles (under 8,000 lb) was 1 in 79. This rate increased to one in four for the heaviest vehicle class (over 64,000 lb). The total sample was designed to provide 4,000 vehicles distributed by vehicle weight to include light vehicles as 40 percent and each of the remaining three weight categories as 20 percent of the total sample.

By sorting the entire DMV file by ZIP code before sample selection, subsamples were obtained in which all geographic areas are represented in proportion to their vehicle weight category–specific distribution in the total population.

USPS Vehicles

USPS vehicles to be included in the survey were selected by the postal service's manager of fleet operations. All USPS vehicles in Phoenix fall into the two lightest-weight categories used in this project (2,180 in the under-8,000-lb category and 101 in the 8,000- to 28,000-lb category). The selection process provided 1 in 40 postal vehicles in the light category and 1 in 10 in the next heavier category.

Data Collection

DMV-Registered Vehicle Survey

After pretest and pilot surveys, which were essential in refining the data collection strategy, combined telephone and mail procedures were used to conduct the main survey. Tables 1 and 2 provide information on the levels of survey responses obtained in the main portion of the truck survey. After telephone contact, 37 percent of the total subsample agreed to participate in the survey. Most of those who did not agree to participate either could not be contacted or owned vehicles that did not qualify for the survey.

TABLE 1 Survey Results, Telephone Portion

Category		Number		Percentage
Total subsample		3855		100
No telephone contact possible		1393		36
Vehicles not qualified		538		14
No work/no alternative vehicle	214		6	
No information available	103		3	
Non-commercial vehicle	169		4	
Lessee name not available	35		1	
Out of state owner	17		0	
No agreement to participate		498		13
Agreement to participate – surveys mailed		1426		37

TABLE 2 Survey Results, Mail Portion

Category		Number		Percentage
Total surveys mailed to those agreeing to participate		1426		100
Not returned or not completed		1006		71
Responses		420		29
Trips made	358		25	
No trips made	62		4	
Total surveys mailed to other vehicle owners		300		100
Not returned or not completed		195		65
Responses		105		35
Trips made	60		20	
No trips made	45		15	
Total surveys mailed (1.1 + 2.1)		1726		100
Not returned or not completed (1.2 +2.2)		1201		70
Responses (1.3 + 2.3)		525		30
Trips made	418		24	
No trips made	107		6	

The results for the mail portion of the main survey (Table 2) show that the response rate was 29 percent for those who agreed to participate. The overall response rate to the mailed questionnaires was 30 percent. Before geocoding, the total number of survey responses was 720: 195 from the pilot survey and 525 from the main survey. Of these 720 responses, 527 (73 percent) represent vehicles that made commercial trips on the survey day.

USPS Vehicle Survey

Data collection for USPS vehicles was much simpler than for the vehicles in the DMV file because the cooperation of the manager of fleet operations for the Phoenix postal district was obtained before subsample selection. Travel diary data for the 62 selected vehicles were obtained from existing USPS forms and transferred directly to the vehicle and trip data sets used in the project.

Data Coding and Factoring

Vehicle Factors

The 1989 DMV file used to obtain a survey sample contained 156,645 commercial vehicle registration records, and the Phoenix postal district reported a total of 2,281 vehicles. The breakdown by vehicle weight class is shown in Table 3.

The telephone portion of the survey revealed that only 75.7 percent of the vehicle owners contacted via the DMV data set reported that their vehicles were available for use for commercial purposes within the Phoenix metropolitan region on a typical travel weekday. This fraction was used to obtain an initial estimate of the total population of qualified vehicles, subject to adjustment in later stages of the project (see the section on calibration). Thus, the survey data were expanded to represent 118,645 DMV vehicles in operation and 2,281 USPS vehicles.

Expansion factors for the DMV vehicles were developed separately by vehicle weight class and by owner's ZIP code as contained in the DMV file. USPS vehicles were weighted using a similar strategy, expanding to match the USPS totals by weight/postal garaging location category and to match totals by weight class. Overall, the survey represents a 0.5 percent sample of all commercial vehicles based in Maricopa County; the average vehicle expansion factor is 203.7.

Trip Factors

Because the commercial vehicle drivers responding to the survey were asked to report individual information for a maximum of 10 trips on their survey day, additional truck-specific expansion factors were required to account for each truck's unreported trips. These factors account for the reporting of trips to and from the overnight garaging location, which generally was available for each truck, and for the partial re-

TABLE 3 Summaries of Survey Responses

	Vehicle Weight (lbs)				
Vehicle Type	0-8,000	8-28,000	28-64,000	64,000+	Total
Total Population					
DMV Vehicles	127,427	19,440	4,830	4,948	156,645
Postal Service Vehicles	2,180	101	0	0	2,281
All Commercial Vehicles	**129,607**	**19,541**	**4,830**	**4,948**	**158,926**
Percentage of Total	81.6%	12.3%	3.0%	3.1%	100.0%
Daily Vehicle Trips					
All Commercial Vehicle Trips	**726,889**	**188,545**	**32,659**	**19,742**	**967,835**
Percentage of Total	75.1%	19.5%	3.4%	2.0%	100.0%
Average Trips per Vehicle	5.6	9.6	6.8	4.0	6.1
Daily Vehicle Mileage					
Average VMT per Vehicle	79.0	56.2	74.0	156.8	78.5
Average Miles per Trip	11.0	4.7	9.2	33.4	10.2

porting of all other trips by trucks making more than 10 trips per day. The factors also correct for unusable trip records.

The average total trip factor is 284.5, implying an overall trip sampling rate of 0.35 percent. When the trip factors are applied to the 3,402 usable reported commercial vehicle trips, an estimate of 967,835 total daily trips is obtained. The numbers of trips by weight class are provided in Table 3. Both the largest and the smallest weight classes have proportionately fewer trips than they have commercial vehicles. This is true because the trucks in the middle weight categories (8,000 to 64,000 lb) reported making more trips per day than those in the smallest and largest weight categories.

Survey Results

The weighted survey records were summarized statistically to provide information on a number of commercial vehicle and truck travel characteristics in the Phoenix region. All data summaries were obtained by vehicle weight category. Information on the following vehicle characteristics was obtained:

- Average vehicle weights per surveyed vehicle;
- Vehicle types;
- Vehicle usage for home-to-work travel;
- Vehicles not used on a typical weekday;
- Time of first daily trip;
- Vehicle trips per day; and
- Vehicle mileage per day.

Statistical summaries of this information are provided in the project's final report (*1*). For the two final data categories (vehicle trips and vehicle mileage per day), the totals reported by vehicle weight category are included in Table 3. The vehicle mileage results, obtained from measurements provided by odometer readings at the start and end of the day, are inversely related to the number of trips made, also summarized in Table 3. This apparently anomalous result is explained by the differences in average miles per trip by vehicle category. Vehicles in the 8- to 28,000-lb category make many short trips, typically for such activities as refuse pickup and package delivery. Vehicles in the heaviest category make a few long trips and in so doing generate many more vehicle miles per day than the lighter vehicles generated. As in the case of trips per day, the remaining vehicle classes exhibit average vehicle mileage and trip lengths similar to the overall averages. These averages are 78.5 mi/day and 10.2 mi/trip.

Information was also obtained on the following characteristic of commercial vehicle trips:

- Average vehicle weights per commercial vehicle trip;
- Trips by vehicle type;
- Time-of-day distributions;
- Activities at trip ends;
- Land uses at trip ends;
- Activity and land use linkages at trip ends;
- Stop locations (on- or off-street);
- Trips by time duration; and
- Trips by travel distance.

As in the case of vehicle characteristics, these results are reported in detail in the final report (*1*).

URBAN COMMERCIAL VEHICLE TRAVEL MODELS

Trip Generation

Because the commercial vehicle survey includes information on land uses at trip ends and the MAG zonal data include the number of residents and employment by land use category, it was possible to determine trip rates by land use category. As defined for use in this project, these rates have the following form:

$$\text{truck trip rate for land use category } i = \frac{\text{total study area trips to land use category } i}{\text{total study area employment at land use category } i}$$

The five categories of land use available in the MAG zonal data, and the corresponding categories used in the truck survey, are retail, industrial, public, office, and other.

An additional land use category—residential land—was included in the survey. For trips to and from this category, the trip rate was defined as:

$$\frac{\text{total study area trips to residential land}}{\text{total study area households}}$$

Each of the trip rates defined includes a minor specification error, because the reported trips include those made to construction sites but the land use data do not identify these sites explicitly. However, since construction activity is also not predicted explicitly for future years and all present and future commercial vehicle trips must be accounted for, this misspecification was required as part of a long-range forecasting model.

The trip generation modeling results obtained for the two heaviest vehicle weight classes combined indicated that, from the standpoint of predicting trip generation, this combination of two weight categories was preferable to keeping these weight categories separate. A final decision on this issue was not made, however, until the average travel times, based on MAG's network data, were determined for each category and preliminary distribution model results were obtained. Thus, models based on both classification strategies were initially developed and used at the beginning of the trip distribution modeling task. Because the combination strategy proved to be preferable for trip generation and trip distribution modeling, only the combined model is shown in Table 4.

The final estimated trip generation models are presented in Table 4, which contains the coefficients associated with each independent variable for each model. The following equation, for commercial vehicles less than 8,000 lb, illustrates how the rates shown in Table 4 are used in the trip generation models:

$$\begin{aligned} TRIPS_i = {} & 0.15433 * TOTHH_i + 0.59091 * RETEMP_i \\ & + 0.64087 * INDEMP_i + 0.29491 * PUBEMP_i \\ & + 0.30925 * OFFEMP_i + 0.76348 * OTHEMP_i \\ & + 0.04004 * RESHH_i \end{aligned}$$

TABLE 4 Trip Generation Models

Independent Variable	Vehicle Weight (lbs) 0-8,000	8-28,000	28,000+
Total households	0.15433[a]	0.06859	0.01260
Retail employment	0.59091	0.13253	0.03685
Industrial employment	0.64087	0.09972	0.04991
Public employment	0.29491	0.00596	0.02398
Office employment	0.30925	0.02119	0.00320
Other employment	0.76348	0.10567	0.07527
Resident households	0.04004	–	0.00288
Group quarter households	–	7.52348	–
Total area (acres * 100)	–	–	0.00365
Vehicles	–	–	0.00062

[a] Commercial vehicle one-way trips per one unit of the independent variable.

Note: The coefficients shown here do not reflect the results of the calibration/assignment phase of the project. See the Calibration/Assignment section for a discussion of the final regional factor used to estimate total commercial vehicle trip generation.

where

$TRIPS_i$ = total average weekday commercial vehicle trips for vehicles less than 8,000 lb originating in (and the total destined for) zone or district i,
$TOTHH_i$ = total households in zone or district i,
$RETEMP_i$ = total retail employees in zone or district i,
$INDEMP_i$ = total industrial employees in zone or district i,
$PUBEMP_i$ = total public employees in zone or district i,
$OFFEMP_i$ = total office employees in zone or district i,
$OTHEMP_i$ = total other employees in zone or district i, and
$RESHH_i$ = total resident (nongroup quarters, nontemporary, and nonseasonal) households in zone or district i.

Trip Distribution

Network-Based Average Trip Times

Zonal level trip tables for each of the three final vehicle weight categories were developed using the weighted truck travel survey data. A table of zone-to-zone off-peak highway skimmed travel times for Phoenix's existing highway system was obtained from MAG. This table was combined with the three truck trip tables to obtain travel time distributions and averages by vehicle class. The average times by vehicle weight category are much less than those obtained from vehicles' reported stopping times per trip, reflecting the elimination of stopped time from the averaging process and the differences between times based on minimum paths in a highway network and times reported by vehicle drivers.

Model Structure

For consistency with the MAG Transportation and Planning Office's (MAGTPO's) person trip models and with the state of the modeling practice in many U.S. metropolitan areas, the standard gravity-type model structure was selected for commercial vehicle trip distribution modeling in the Phoenix metropolitan area. This structure is one in which trips for a particular category (in this case, commercial vehicle trips by weight category) between a production zone i and an attraction zone j are directly proportional to the total number of trip productions in zone i, attractions in zone j, an attractiveness factor based on the impedance (in this case, off-peak highway travel time) from i to j (although this factor decreases for larger values of impedance as an attractiveness measure should, it is termed a friction factor in the transportation literature; to avoid confusion, the standard terminology is used here) and, optionally, an adjustment factor (K-factor) that varies by origin and destination superdistrict (no K-factors are included in these commercial vehicle models). Because a share formulation is used, the number of trips between zones i and j is inversely proportional to the numbers of attractions in all other zones, to the friction factors from i to each of these zones, and, optionally, to *K*-factors from zone *i* to each of these zones. The friction factors are normally estimated iteratively for each trip category using a gravity model calibration program that attempts to match the observed impedance distributions.

Gravity Model Calibration

Comparisons of the predicted and observed trip time distributions from initial calibration runs for all three vehicle weight categories revealed significant variations, even when average trip times were very nearly matched. Furthermore, increases in the number of calibration iterations did not improve these initial results. A careful review of the calibration algorithm used in the TRANPLAN package revealed that, as in other applications involving trip length distributions with higher-than-typical numbers of very short and very long trips, its friction factor smoothing process was apparently responsible for these results; by fitting a smooth log-linear function to the adjusted friction factors, the required adjustments were being canceled out on each iteration.

This problem with the available gravity model calibration program was overcome by switching to an iterative application of the TRANPLAN gravity model calculation program, supplemented by a spreadsheet to help make manual friction factor adjustments. As in the TRANPLAN calibration process before smoothing, the manual adjustments involved reestimating each friction using a correction term equal to the desired fraction of trips in a travel time range divided by the previously estimated fraction in this range. Rather than using constant travel time ranges of 1 min, the travel time ranges were selected to ensure that the resulting friction factors would always decrease as travel times increase. This procedure converged after just three to five iterations (beginning with the results of a five-iteration run of the calibration program) to models with acceptable travel time averages and distributions. Table 5 provides comparisons of the observed and predicted averages for these final models.

Calibration and Traffic Assignments

Prior Internal Commercial Vehicle Travel Forecasting

Before the development of the commercial vehicle models, MAG's travel modeling process, as updated in 1988, included a trip generation model for a single category of internal truck trips representing all weight classes and one gravity model. The trip generation model was borrowed from the forecasting system developed for the Detroit metropolitan area by the Southeast Michigan Council of Governments transportation staff. The gravity model was developed using Phoenix data collected more than 15 years ago. The internal commercial vehicle trips estimated by this gravity model were added to all other vehicle trips, including external truck trips that are estimated on the basis of a recent external vehicle trip survey and assigned to the Phoenix highway network using a network equilibrium procedure.

During the 1988 model updating process, these internal truck generation and distribution models were considered as temporary "place holders," to be replaced by the models developed in this project. However, they were also used to provide the final adjustments required to calibrate the complete vehicle trip modeling system to match current vehicle miles of travel (VMT) data for the entire Phoenix metropolitan region. Thus, a regionwide factor of 1.38 was applied to the results of the old trip generation and distribution models as these trips were added to all other vehicle trips before the traffic assignment step. The overall adjustment of 38 percent provided by this factor represents the total effect of each of the following components of changes in internal truck travel:

- The expansion of truck vehicle trips to the equivalent number of two-axle counts, as measured by the automatic traffic recorders used to estimate the total VMT in the Phoenix area.
- The adjustment of internal truck travel estimated with the current models used in Phoenix to represent the actual internal truck travel in the Phoenix area.
- The expansion of Phoenix internal truck travel to compensate for any underreporting in the latest Phoenix travel survey or underestimation in the updated nontruck Phoenix models.

Only the first component, accounting for internal truck axles rather than trucks, can be determined accurately using the available data. The other two factors cannot be isolated to determine the relative importance of the adjustments caused by model transfer and those caused by underreporting of nontruck travel.

Adjustments of New Truck Models

It was necessary to incorporate the first and third adjustment components in the calibration process for the new models. In addition, although no adjustments are required because of

TABLE 5 Observed and Predicted Average Trip Times for Final Distribution Models

Vehicle Weight (lbs)	Average Trip Times (minutes)		Percentage Error
	Observed	Predicted	
0-8,000	16.4	16.1	-2.0
8-28,000	11.9	12.2	+2.6
28,000+	18.8	18.8	+0.2

model transfer, an adjustment was required to account for the fact that only the trips made by commercial vehicles registered in Maricopa County (the Phoenix metropolitan study area) are included in the models developed in this project. Because these models are integrated into the MAG forecasting system, they must be adjusted to represent all internal commercial vehicle trips, including those made in the study area by vehicles registered outside Maricopa County. As in the case of the current models, the net effect of the factors related to vehicle registration location and underreporting can be determined, but the separate factors making up this total adjustment cannot be isolated. Thus, the calibration process for the new models consists of two steps:

- Expanding the commercial vehicle trips by weight class to account for the average number of axles per vehicle in each class.
- Expanding total commercial vehicle trips so that total estimated and observed VMT in the Phoenix region are equal. This expansion factor represents the net effect of internal trips by all commercial vehicles versus those by vehicles registered in Maricopa County, and of any underreporting or underestimation in any of the Phoenix models that affect the number of truck and nontruck vehicle trips.

When the average travel time statistics by weight class and the overall average speed for the entire expanded Phoenix travel survey are applied to the survey's total commercial vehicle equivalent two-axle trips, an estimate of 7.182 million vehicle mi is obtained. This value compares with 11.659 million VMT, the difference between the total observed two-axle VMT in the Phoenix area and the total estimated by all current Phoenix models, except the temporary internal truck trip model. Thus, the combined registration-underreporting factor, the ratio of the latter number to the former, is 1.623.

Model Implementation

The adjustment factors described were combined with the trip generation models listed in Table 4, the trip distribution models described in the previous section, and MAG's current vehicle trip assignment procedure to fully implement the new commercial vehicle models as an integral part of the total Phoenix travel forecasting system.

Model Transferability

Because travel patterns are often found to vary largely from one urban area to another, the safest means of using the results of this project in another city would be to repeat the travel survey and model development tasks using the procedures found to be most effective in this project. The information requirements of this strategy would be within the usual capabilities of local and regional agencies responsible for transportation planning. These requirements include

- A file from the state vehicle registration agency of all commercial vehicles registered to owners in the planning agency's study area;
- The ability to geocode street addresses to traffic analysis zones;
- Current zonal data on households and employment by type on vehicles and land area;
- A matrix of zone-to-zone off-peak highway travel times in the year of the commercial vehicle travel survey;
- An existing model system to which truck travel models can be added, or in which existing truck travel procedures can be replaced; and
- Estimates of regional VMT by commercial vehicle type and by private automobiles.

Although the information requirements of this strategy for transferring the procedures used in this project to other areas are reasonable, the costs of doing so will be significant. Thus, it is important to explore less expensive means of transferring the modeling strategies developed in this project to other urban areas. Recognizing the inherent trade-offs between the reductions in costs and possible reductions in precision and accuracy involved in alternative approaches, several possible approaches are described briefly. They are ordered from the least costly to the most costly in terms of resource requirements and development time.

Complete Transfer of Phoenix Models

If planners in another urban area have no current tools to predict commercial vehicle travel, they would be able to use the models developed in this project, including its modeling strategies, model parameters, and UTPS travel forecasting procedures and setups. In this way they could implement a complete new set of commercial vehicle models. To the extent that commercial vehicle travel patterns in Phoenix are representative of local conditions, this approach would provide a useful tool for local planning at a relatively small cost.

This approach would be reasonable for a number of large and growing cities in the South and West whose current or expected future levels of commercial vehicle travel are similar to those in Phoenix.

Adjusting Phoenix Models To Match Local Data

The previous strategy could be improved at low cost by adjusting the Phoenix models to match local information on commercial vehicle registrations or VMT for the entire study area, or both, following the strategies used for Phoenix. In this project, information on total vehicles registered by weight class was used to provide preliminary expansion factors for both vehicles and trips. Changes in registrations per employee could thus be used to adjust the Phoenix trip generation models for application in other cities. Similarly, changes in the resulting models could be adjusted to match total commercial VMT. As in the case of Phoenix, VMT data can be obtained from local vehicle classification counts. Thus, after the Phoenix trip generation models are revised, a set of commercial vehicle models calibrated to local regionwide data can be obtained.

The Phoenix trip distribution models can also be adjusted if local data on average commercial vehicle trip lengths are available. However, this information is not likely to be available unless a recent commercial vehicle travel survey has been conducted.

Model parameters that are revised to reflect local conditions in other urban areas require changes of various types in the programs that implement the models. These changes include

- Revisions to the trip generation models implemented in Fortran to reflect coefficient changes required to match local measures of vehicle registrations or VMT, or both; and
- Revisions of the friction factors input to the trip distribution models implemented in AGM to reflect changes required to match local data on average trip lengths.

Development of National Model

Perhaps the ultimate extension of the models developed in this project to other urban areas would involve generalizing them to create a national model, taking the quick-response system (*3*) as a pattern. This would involve combining the existing models with information in the FTA reports *Characteristics of Urban Travel Demand* and *Characteristics of Urban Travel Supply* to provide tables of each of its parameters as these are likely to vary by urban area type and size. Although this would involve a great deal of effort, it would provide all urban areas with versions of the models developed in this project that, in the absence of local data and model estimation, could be used to estimate commercial vehicle travel with acceptable levels of accuracy for sketch planning purposes, such as performing initial feasibility assessments of new highway facilities with or without features designed for exclusive use by either automobiles or commercial vehicles.

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REFERENCES

1. Cambridge Systematics, Inc. *Final Report: Phoenix Urban Truck Travel Model Project.* Arizona Department of Transportation, Phoenix, 1991.
2. F. G. Rawling and E. Ryan. CATS Commercial Vehicle Survey of 1986: A Discussion of Project Management Issues. *CATS Research News,* Vol. 26, No. 1, Feb. 1987.
3. A. B. Sosslau et al. *NCHRP Report 187: Quick-Response Urban Travel Estimation Techniques and Transferable Parameters: User's Guide.* TRB, National Research Council, Washington, D.C., 1978.

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