Design and Implementation of Intercity Origin-Destination Surveys

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This paper summarizes the results of a postcard origin-destination (O-D) survey conducted to estimate intercity travel patterns in the Interstate 35 corridor between Austin and San Antonio, Texas. The paper discusses the study design, data-collection and data-processing procedures, methods used to check the representativeness of the sampled data, expansion of the sampled data to represent total corridor travel, and study costs. The results of the study indicate that the postcard O-D survey method can be used to develop representative, reliable estimates of intercity corridor travel patterns. Additionally, the results of this study show that with a good traffic control plan and a well-trained survey crew, this survey method can be safely implemented without causing any substantial traffic delays, even on high-volume intercity and interstate freeways.

As a result of current and projected growth in the I-35 corridor between Austin and San Antonio (Figure 1), the Texas State Department of Highways and Public Transportation (SDHPT) is undertaking an analysis of alternative corridor improvements. The possibility of an alternate route to the east of I-35 (Figure 1) has received considerable attention in recent years. However, other alternatives have not been eliminated from consideration at this date.

Current and statistically reliable information concerning interurban origin-destination (O-D) travel patterns in the Austin–San Antonio study area was needed to conduct the analysis of alternative corridor improvements. This paper summarizes the O-D survey that was conducted to identify current travel patterns in the study corridor. The paper describes the O-D survey study design, field data collection and data processing procedures, checking the representativeness of the sampled data, expansion of the sampled data to represent total corridor travel, and the study costs. The details of the study are presented elsewhere (*1–3*).

STUDY DESIGN

This section describes the alternative survey methods evaluated for possible use in the study, criteria for selecting survey stations, scheduling of the survey, and the sample-size determination.

Survey Method

Five traditional O-D survey methods were evaluated for possible use in the study corridor (*1*). They were roadside interview, postcard survey, license plate "trace" survey, license plate "mail-out" survey, and tag-on-vehicle/lights-on survey. The advantages and disadvantages, manpower requirements, typical response rates, and approximate sample sizes for these methods are summarized in Table 1, with the methods listed in descending order of cost and accuracy.

Neither the license plate trace method nor the tag-on-vehicle/lights-on surveys are applicable to a large intercity traffic corridor, such as the Austin–San Antonio corridor, because of the extreme difficulties in planning and implementing the survey. The manpower requirements to implement either one of these methods on a corridor of this size would be unrealistic and the analysis of the field data would be extremely cumbersome.

The license plate mail-out survey has a number of short-

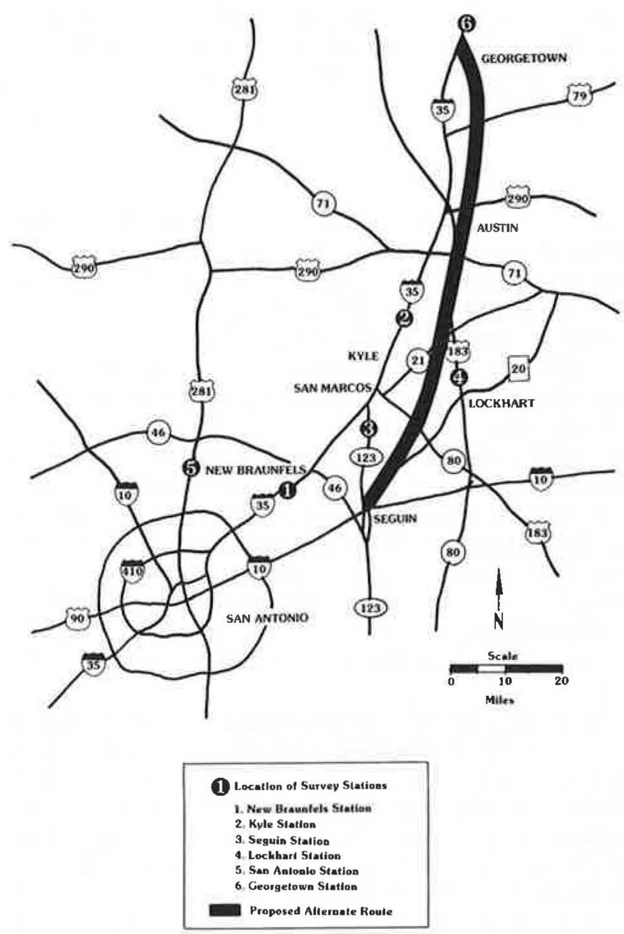

FIGURE 1 Austin/San Antonio study corridor.

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TABLE 1 SUMMARY OF O-D SURVEY METHODS

Survey Method	Advantages	Disadvantages	Manpower Requirements per Survey Station	Recommended Sample Size[b]	Typical Response Rates
1. Roadside Interview	• Complete information • High Response Rate • Better Sampling Control	• Relatively expensive • Traffic delays • Hazardous	• 10-20 persons/ station[a] • 2-4 police officers	20%-50%	100%
2. Postcard Surveys	• Can be completed quickly • Less traffic delay • Relatively inexpensive • Good population coverage	• Possible bias due to better response by some drivers • Low response by thru and out-of-state traffic • Requires stopping traffic • No provision for follow-up of non-responses	• 5-9 persons/ station • 1-2 police officers	60%-80%	25%-35%
3. License Plate Surveys a) "Trace" Method	• Simplicity of field organization • No interference with traffic • Unbiased Sample	• Data Analysis is difficult • Large number of stations required • Possible recording errors • Survey stations must operate simultaneously	• 2-3 persons/ station	35%-50%	60%[c]
b) "Mail-out"	• Similar to Method No. 2, except followup of non-responses is possible • Stations need not operate simultaneously	• Same as Method No. 2, except does not require stopping traffic • Requires access to vehicle registration files	• 2-3 persons/ station	60%-80%[d]	20%-35%[d]
4. Tag-on-vehicle/ Lights-on Surveys	• Same as Method 3a, except may result in minor traffic delays	• Same as Method 3a, except less recording errors	• 2-3 persons/ station	100%	-

[a]Number of interviewers varies with traffic volume but on the average is about 3-4 times the number of persons required to hand-out postcards. The above estimate is for relatively low hourly traffic volumes.
[b]Sample sizes have been adjusted for typical response rates to insure at least 20% sample.
[c]Response rate is estimate of percentage of license plates which can be traced.
[d]Response rate can be increased by follow-up of non-responses.

comings if applied to this study. The most notable problem is that after the vehicles passing a station are selected and their license-plate numbers read, it would be difficult to send questionnaires to drivers of trucks or out-of-state vehicles and it would be almost impossible to reach drivers of leased vehicles. This survey method might therefore result in noncoverage of many subgroups within the population that cannot be easily corrected for.

Postcard surveys may be based on the "controlled" or "roadside-distribution" method. The former utilizes vehicle-ownership or licensed-driver records, whereas the latter involves distributing the postcards to vehicles passing the survey stations. The controlled postcard method suffers the same shortcomings as the license plate mail-out method in its inability to effectively survey trucks and leased and out-of-state vehicles. This method was therefore considered unsuitable for this study.

The roadside-interview and the postcard-distribution methods are similar in providing good coverage of the vehicle population and in the amount of information that can be effectively sought from the drivers. In terms of costs and manpower requirements, the roadside-interview method, on the average, requires 3 to 4 times more field personnel than the postcard-distribution method, and this estimate can be much higher for very high-volume facilities. A trained interviewer can complete about 30 to 40 interviews in an hour, while postcards can be handed out to drivers every 4 to 5 sec. The response rate of the roadside-interview method, however, may be up to 3 times higher than the roadside-distribution postcard method. Despite its higher response rate, the interview crew would need to work at least as long as the postcard-distribution crew in order to obtain a sufficient number of responses. One disadvantage of the postcard-distribution method is that the nonresponses may introduce biases. Therefore, a survey based on postcard distribution must include a mechanism for checking the nonresponses to ensure that they are not substantially different from those who respond to the survey.

In terms of adaptability, the postcard-distribution method is more desirable in terms of traffic delays, station set-up, traffic control plans, survey management, and safety to the survey crew and motorists. On a high-volume facility, such as Interstate 35, it would not be practical to stop traffic to complete interviews with drivers on-site because traffic congestion and delays could become excessive, even with a large interview crew. Furthermore, as the number of interviewers increases, so does the complexity of setting up the site and managing the survey in order to maintain safety and to minimize traffic delays and confusion. Previous experiences (*4–6*) with the roadside-distribution postcard method have shown that with a good traffic control plan, well-trained survey personnel, and the use of an appropriate vehicle selection technique, this survey method can be safely implemented without causing any substantial delays to traffic.

A combination roadside-distribution postcard and roadside interview survey was also considered. This approach would involve distributing postcards to drivers during high-volume time periods and conducting on-site interviews during low-volume time periods. Past experience suggests that such a combination would not enhance the amount of information obtainable, nor would it improve the quality of the survey results.

On the basis of these considerations, the roadside-distribution postcard survey method was selected. A sample of the postcard questionnaire used in the study is shown in Figure 2. The survey form was designed to solicit information concerning vehicle type, trip purpose, trip origin and destination, vehicle occupancy, and trip frequency. The survey form requested street address, city, and zip code of the trip origin and destination. This information made it possible to code O-D zones with sufficient detail to evaluate the range of improvements being considered for the corridor. The questionnaire portion of the form was printed on the back of a prepaid, preaddressed postcard. Also, each questionnaire was individually numbered to facilitate recording the time and location of distribution.

Selecting Survey Stations

The following six survey stations were selected (Figure 1): (a) I-35, between San Marcos and San Antonio, south of SH-46 (New Braunfels Station); (b) I-35, between Austin and San Marcos (Kyle Station); (c) SH-123, between I-35 and I-10 (Seguin Station); (d) US-183, between SH-21 and I-10 (Lockhart Station); (e) US-281, north of San Antonio between FM 1604 and SH-46 (San Antonio Station); and (f) I-35, north of Georgetown (Georgetown Station).

The I-35 stations between Austin and San Antonio, and the stations on SH-123 and US-183 were chosen to provide samples of intercity and through-traffic, as well as traffic with

AUSTIN/SAN ANTONIO ORIGIN-DESTINATION STUDY

Survey Station:
Northbound US 281 Near San Antonio № 95217

1. Type of vehicle?
   Passenger Car ☐ Pickup ☐ Van ☐ Other Truck ☐
2. Purpose of trip today?
   Work ☐ School ☐ Shopping ☐ Recreation ☐ Other ☐
3. Where were you coming from when you received this questionnaire?
   Street Address (or nearest intersection) City Zip Code
4. Where were you going when you received this questionnaire?
   Street Address (or nearest intersection) City Zip Code
5. How many people in vehicle (including driver)? ________
6. How many days per week do you make this trip?
   1 ☐ 2 ☐ more than 2 ☐ Other (please specify) ________
7. Any additional information on your trip that you think might be helpful to us would be appreciated. ________

FIGURE 2 Sample postcard questionnaire.

O-Ds at key intermediate points. These stations were considered to be particularly important in terms of assessing the potential feasibility of an alternate Austin–San Antonio route to the east of I-35. The US-281 station was selected to sample potential traffic for an alternate route between Austin and San Antonio to the west of I-35. The I-35 station north of Georgetown was identified to obtain a sample of traffic that might use an I-35 Austin bypass.

The following criteria were used to identify precise survey station locations.

- *Sight-distance.* The primary consideration in selecting survey stations was safety. Survey stations were located on flat, straight roadway sections that were clear of structures or other obstructions that could reduce sight-distances. Level and straight sections of highways with an unrestricted sight distance of 800 ft or more in each direction from the station were sought (*7*). Stations at or near intersections were avoided.
- *Roadway cross-section.* Wherever possible, survey stations were located where roadway width was at its maximum. On I-35, survey stations were located on sections with inside and outside shoulders. By using the freeway shoulders it would be possible to set up four-channel service areas for postcard distribution. On non-interstate roadways, survey stations were established on four-lane sections.
- *Traffic catchment area.* Survey stations were located to intercept a representative sample of intercity traffic. As a general guide, survey stations were located near the midpoints of the roadway links surveyed.

Scheduling the Survey

The following issues were considered in scheduling the O-D survey.

- *Month and day-of-week considerations.* The choice of the month and day-of-week of the survey depended on whether "typical" or "peak" O-D data were desired. An examination of monthly, daily, and seasonal traffic volumes as a percent of average annual daily traffic (AADT) from several permanent traffic recorders in the corridor revealed that the summer months of June through August generally account for the highest percentages of AADT. The fall months of September through November, on the other hand, appeared to be more representative of the AADT. In terms of average variations in the AADT, Mondays through Thursdays appeared to be "typical" days. Fridays, with their high percentages of preweekend traffic, tended to be higher-than-average traffic days. The objective of the study was to estimate the peak demand within the corridor. Therefore, the O-D survey was conducted on Tuesday through Thursday during the month of July.
- *Time-of-day considerations.* The O-D survey may be conducted over a 24-hour period, or more typically, during daylight hours. Given the hazards associated with nighttime operations, survey operations were restricted to daylight hours.
- *One-directional versus two-directional station operations.* In scheduling the survey and estimating manpower needs, the issue of whether each direction of travel was to be surveyed separately or simultaneously needed to be resolved. The FHWA (*7*) guidelines on conducting O-D surveys state

". . . two-directional surveying is necessary if hourly data describing origins and destinations by direction are needed. It is generally assumed that although inbound traffic patterns are similar to outbound traffic patterns for a 24-hour period, the differences are significant enough on an hourly basis to warrant two-directional surveys. Some serious problems could arise in the analysis of the data if two-directional data are not available. Where sufficient personnel are available, it is desirable to survey traffic in both directions simultaneously."

Harmelink (*8*) suggests that one-directional surveys would produce larger errors than would two-directional surveys. Hajek (*9*) found from actual O-D data that the errors for a 50 percent two-directional survey were very similar to the errors for a 100 percent one-directional survey. Hajek attributed this similarity in errors to the daily variation in traffic that might have obscured the expected difference between the two-directional and the one-directional surveys.

Miller et al. (*10*) reported that inbound and outbound frequencies of O-D trips were not exact mirror images of one another and that some differences between the two directions existed. The percent differences were likely to be higher for small trip interchange volumes than for larger trip interchange volumes.

On the basis of findings from these past studies, and to maximize the usefulness of the resulting O-D data, two-directional surveys were conducted.

Sample Sizes

A minimum sample size required at a given survey station is the number of vehicles sampled at the station whose drivers successfully complete the postcards or the interview. A minimum sample size required for an O-D survey of vehicles passing through a survey station is usually expressed as a sampling rate (i.e., a ratio of the number of vehicles sampled to the total number of vehicles passing through). The sampling rate is a function of the following: (a) p (proportion of total traffic volume at the survey station that has a particular O-D); (b) w [desired accuracy (percent error) of p]; (c) N (traffic volume at the survey station); and (d) Z (normal variate that is associated with a specified level of confidence in estimating the O-D interchange volume). The sample size formula (*9*) is given by

$$r = (Z^2pq)/(N - 1)w^2 + (Z^2pq)$$

where r is the required sampling rate, and q is $(1 - p)$.

To apply the sample size formula, some estimate of N must be known. A desired accuracy of p must be specified, as must a level of confidence in estimating p. The proportion of traffic volume at the survey station with a particular O-D must be specified. This proportion is usually not known during sample size determination. What must be specified, instead, is a minimum O-D trip interchange volume to be obtained from the survey with the desired accuracy level. In the context of this study, this minimum O-D trip interchange volume was assumed to be in the range of 2 to 10 percent of the traffic volume at the survey site.

Table 2 presents approximate sampling rates (r) for a range of average daily traffic (ADT) (N) and accuracy levels (error rates) from ± 5 to ± 15 percent. All calculations assume 95 percent confidence interval. Lower confidence intervals would, of course, result in lower sampling rates for a given ADT and accuracy level. The sampling rates shown in Table 2 assume a 100 percent response and must be adjusted for nonresponses as follows: number of vehicles sampled = (sampling rate × traffic volume)/response rate.

Table 3 summarizes recommended sample sizes for each of the survey stations in the study corridor. The sample sizes are given in terms of the number of postcards to be distributed at each station. The sample sizes were estimated from rates given in Table 2 and have been adjusted on the basis of an assumed postcard response rate of 30 percent (*1*). These recommended sample sizes were based on a 95 percent confidence limit and desired accuracy of ± 15 percent.

FIELD DATA COLLECTION

This section describes methods for setting up the survey stations, implementing traffic control plans, distributing the

TABLE 2 APPROXIMATE SAMPLING RATES FOR ERRORS WITHIN ±5%, ±10%, AND ±15% AT 95% CONFIDENCE

N	p = 0.03			p = 0.05			p = .10		
	±5%	±10%	±15%	±5%	±10%	±15%	±5%	±10%	±15%
3,000	.94	.81	.65	.91	.71	.52	.82	.54	.34
5,000	.91	.72	.53	.86	.59	.40	.74	.41	.24
10,000	.84	.56	.36	.75	.42	.25	.58	.26	.14
20,000	.71	.39	.22	.59	.27	.14	.41	.15	.07
30,000	.63	.30	.16	.50	.20	.10	.32	.11	.05
40,000	.56	.24	.12	.42	.16	.08	.26	.08	.04
50,000	.50	.20	.10	.37	.13	.06	.22	.07	.03
60,000	.45	.17	.09	.33	.11	.05	.19	.06	.02
70,000	.42	.16	-	.30	.10	-	.17	.05	-
100,000	.33	.11	-	.23	.07	-	.12	.04	-

Notes: N = Traffic Volume at Survey Station; p = Minimum O-D trip interchange volume to be estimated from the survey with the desired accuracy level (expressed as proportion of N). Sampling rates assume 100% response and must be adjusted for non-responses as follows: Number of Vehicles Sampled = (Sampling Rate X Traffic Volume)/Response Rate.

TABLE 3 RECOMMENDED SAMPLE SIZES FOR AUSTIN–SAN ANTONIO O-D SURVEY

Survey Station and Direction[a]	1985 ADT[b]	n[c]	p[d]
1. New Braunfels (I-35)			
NB	19,000	9,500	0.05
SB	19,000	9,500	0.05
2. Kyle (I-35)			
NB	20,000	10,000	0.05
SB	20,000	10,000	0.05
3. Seguin (SH 123)			
NB	4,000	4,000	0.10
SB	4,000	4,000	0.10
4. Lockhart (US 183)			
NB	3,300	3,300	0.10
SB	3,300	3,300	0.10
5. San Antonio (US 281)			
NB	9,650	5,800	$0.05<p<0.10$
SB	9,650	5,800	$0.05<p<0.10$
6. Georgetown (I-35)			
NB	13,500	8,100	$0.05<p<0.10$
SB	13,500	8,100	$0.05<p<0.10$

[a]NB = Northbound, SB = Southbound.
[b]Directional ADT assumes 50/50 split. Source: District Highway Maps, Texas State Department of Highways and Public Transportation.
[c]n = No. of postcards to be distributed.
[d]p = minimum O-D trip interchange volume which can be estimated from survey results with ±15% accuracy (expressed as proportion of ADT).

questionnaires, and collecting data to check the representativeness of the sampled data.

Survey Station Set-up and Traffic Control

With the high traffic volumes encountered on many of the roadways surveyed, great care was taken to ensure that the surveys were conducted in a safe, efficient, and professional manner. The actual distribution of the postcard questionnaires did not result in any substantial delay to individual motorists. The overall efficiency of the survey stations, therefore, was determined by the vehicle entry and exit set up at the survey station (i.e., the physical layout of the survey stations). Figures 3 and 4 show the basic setups used at the Interstate and non-Interstate survey stations, respectively. All survey stations had law enforcement officers on duty to ensure safety and to enhance motorist cooperation.

The survey stations were in operation from 7:00 a.m. to 8:00 p.m. each day. However, survey operations were occasionally suspended in order to minimize motorist delays. As a general rule, if traffic queues extended to the advance signing of the survey stations, survey operations were temporarily suspended until the queue was reduced.

Questionnaire Distribution and Data Collection

Four persons per Interstate site and two persons per non-Interstate site were required to distribute the postcard questionnaires. The questionnaire forms were bundled according to the 15-min time period during which they were to be distributed. The number of questionnaires per bundle was based on the sample sizes shown in Table 3. Additionally, postcard questionnaire identification numbers were recorded at the beginning and end of each 15-min survey period to ensure that the time and location of distribution could be identified when tabulating the survey responses.

In addition to distributing postcards, the survey crews also conducted manual counts of traffic volumes, vehicle classifications, and vehicle occupancies. At the Kyle Station, a nighttime vehicle classification study was conducted. Survey crews also recorded samples of vehicle license plate numbers at each of the survey stations. At the Kyle Station, postcard survey form numbers were recorded along with the license plate numbers of a sample of the vehicles surveyed.

The volume counts were used to expand the sample data to represent the entire vehicle population for the corridor, and the license plate data were collected to evaluate the representativeness of the sample data. The use of these data is discussed below.

DATA PROCESSING

To facilitate data analysis, the survey results and the volume classification and license plate data were coded for computer processing. The following accuracy checks were performed on the survey data.

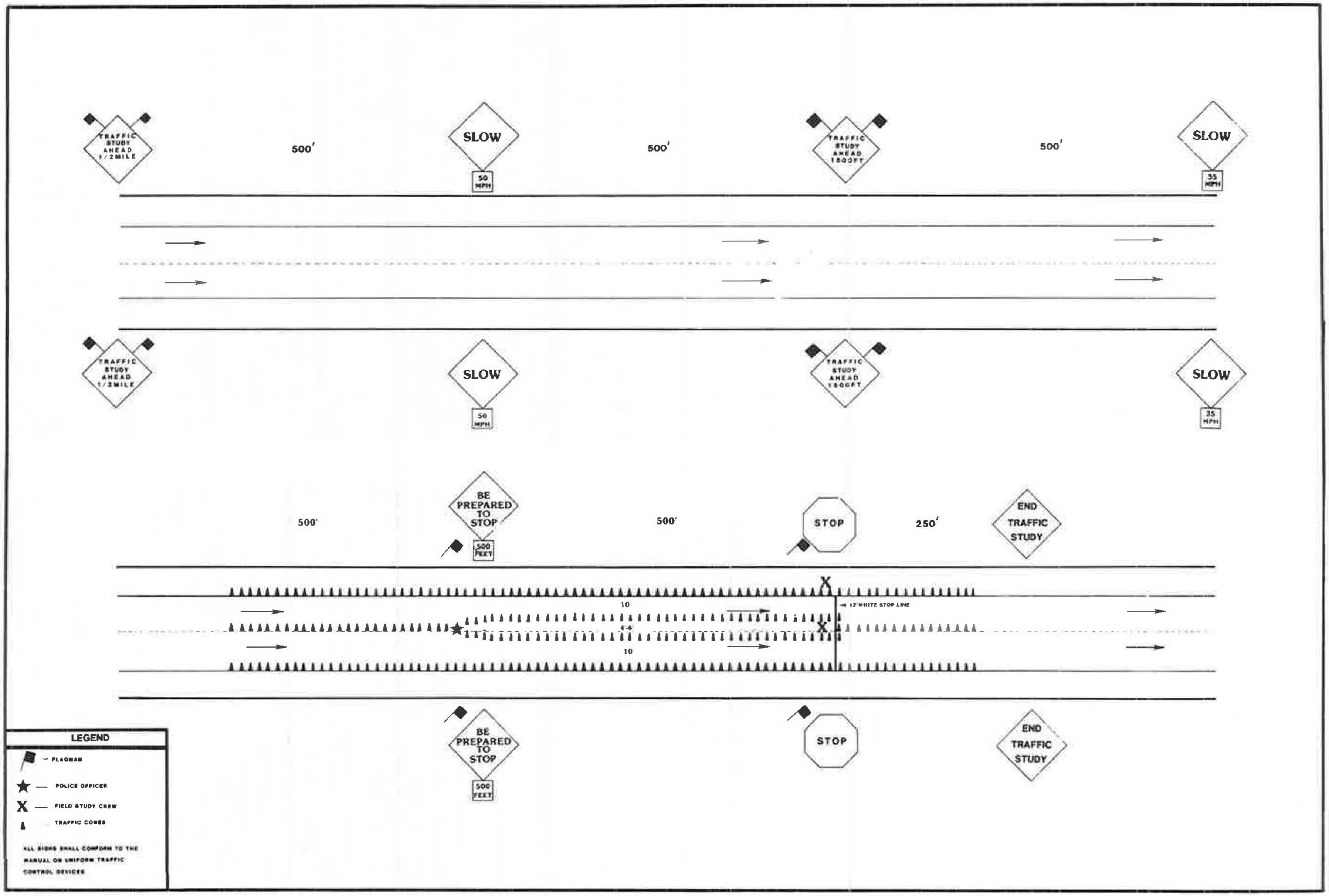

FIGURE 3 Interstate highway traffic control plan.

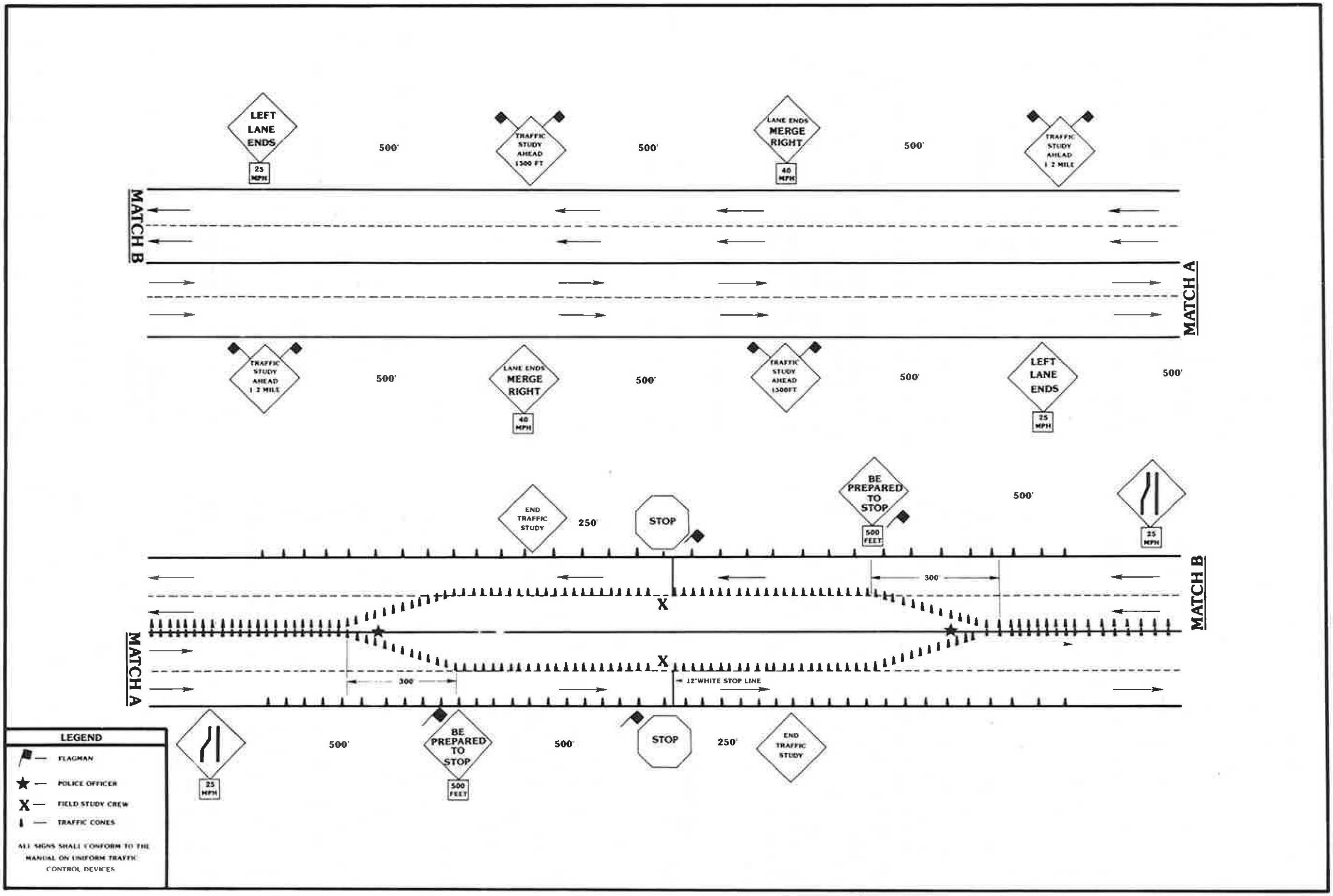

FIGURE 4 Non-Interstate highway traffic control plan.

- *Key-punch errors.* Tight quality control procedures were established for the data processing phases of the study. However, given the enormous amount of data that needed to be processed, it was recognized that coding and input (key-punching) errors would be unavoidable. In order to assess the magnitude and nature of these errors, approximately 1000 of the survey responses from the Kyle Station were processed a second time. These 1000 responses were manually checked to ensure they had been inputted correctly. Once this data set was "clean," it was merged with the initial entries and any mismatches were identified and evaluated. The results of this accuracy check indicated that the error in computer processing of the survey data was about 4 percent. However, the majority of the errors were for information not directly related to the primary objectives of the study (e.g., errors or inconsistencies in categorizing and coding comments or trip frequency).
- *Zip code reporting errors.* A zip code atlas and street address information provided by the respondents were used to compare the actual and reported zip codes of origins and destinations for 10 percent of the responses received from the Kyle Station. Approximately 5 percent of the responses examined were found to have errors in the zip codes reported for the origins or destinations. However, the errors were predominantly in the last two digits of the zip code. Because the zip code data were aggregated into large zones in the final data tabulations, these reporting errors had little effect on the overall accuracy of the results.

CHECKING REPRESENTATIVENESS OF SAMPLED DATA

The sample data were checked for possible biases caused by nonresponses, in order to ensure the representativeness of the population surveyed. Specifically, the data collected at the Kyle Station were used to perform the following analysis. The results of these checks indicate that the sample of travel patterns in the corridor obtained from the survey was representative of the population surveyed.

- *Geographic distribution of responses.* A comparison of the geographic areas (zip codes) of vehicle registrations for respondents and nonrespondents was performed to identify any bias in the survey results caused by the over- or under-representation of one or more geographic areas in the responses. This evaluation was performed using data from the Kyle Station, where it was possible to identify respondents and nonrespondents from the subset of vehicles whose license plate numbers had been matched with survey postcard numbers. The analyses revealed no significant geographic bias in the survey results.
- *Travel patterns of nonrespondents.* In an effort to assess whether the travel patterns of the survey respondents represented the travel patterns of all travelers in the corridor, a follow-up survey of nonrespondents was conducted. Approximately 80 nonrespondents, as identified from the subset of vehicles at the Kyle Station, were interviewed in a telephone survey. Although the sample size was too small to draw any definite conclusions, the analyses indicate that there was no substantial differences in the travel patterns of respondents and nonrespondents.

EXPANDING THE SAMPLE

A summary of the O-D sample by survey station is presented in Table 4, which shows nearly 83,000 survey forms were distributed during a 3-day survey period. Over 28,000 (35 percent) of the postcard questionnaires were returned. This response rate represents over one-fourth of the total traffic observed during the survey period. That is, more than one in four (29 percent) of the vehicles observed responded to the survey. The aggregate summary in Table 4 shows that roughly 90 percent of the vehicles observed were passenger vehicles. Trucks and other commercial vehicles accounted for the remaining 10 percent.

Once the O-D survey data were tabulated and checked, the sample results were expanded to obtain estimates of O-D volumes for the entire vehicle population of the study corridor. The observed traffic volumes were used to expand the sample data.

The sample data were expanded by survey station and direction for each of the following three time periods: (a) morning (7:00 a.m. to 11:00 a.m.); (b) midday (11:00 a.m. to 3:00 p.m.); and (c) afternoon (3:00 p.m. to 8:00 p.m.). The data were expanded by time period to account for possible differences in the travel patterns by time of day. Aggregate estimates of O-D volumes for the vehicle population were then obtained by simply summing over site and direction of travel.

Expansion Formula

The basic formulas used to obtain the estimates of the population O-D volumes and their standard errors are as follows:

$$p = t/n$$

$$T = pN$$

$$S_p = [p(1-p)/n]^{\frac{1}{2}}$$

$$S_T = N[p(1-p)/n]^{\frac{1}{2}}$$

where:

p = proportion of the reported trips having a particular O-D (for each site and direction),
t = number of trips reported for a particular O-D (for each site and direction),
n = total number of trips reported for each site and direction,
T = estimate of O-D volumes for the entire vehicle population,
N = observed traffic volume for each site and direction;
S_p = standard error of p, and
S_T = standard error of T.

A discussion of the relative efficiencies of alternative expansion procedures can be found elsewhere (*11*).

Total Corridor Travel

The estimated 1987 vehicle trip interchanges for the major O-D zones in the corridor are summarized in Table 5. Also

TABLE 4 SUMMARY OF AUSTIN–SAN ANTONIO O-D SAMPLE

	OBSERVED TRAFFIC VOLUME (7:00 A.M. - 8:00 P.M.)						SURVEY DISTRIBUTION		SURVEY RESPONSE		
		Commercial Vehicles									
SURVEY STATION	Passenger Vehicles	Single Unit	Combination	Tractor Only	Buses	Total Vehicles	Number Distributed	% Traffic Surveyed	Number	Return Rate	% Tot. Veh. Responding
1. NB	12322	612	1130	40	25	14129	12009	85%	4152	35%	29%
SB	12335	704	1116	20	18	14193	12484	88	4560	36	32
Total	24657	1316	2246	60	43	28322	24494	86	8712	36	31
2. NB	12498	396	939	19	19	13871	12461	90	4128	33	30
SB	12931	566	1025	8	23	14553	12583	86	4119	33	28
Total	25429	962	1964	27	42	28424	25044	88	8247	33	29
3. NB	1933	108	81	3	2	2127	1914	90	698	36	33
SB	2098	116	97	4	1	2316	1919	83	638	33	28
Total	4031	224	178	7	3	4443	3833	86	1336	35	30
4. NB	2014	303	74	5	5	2401	2178	91	778	36	32
SB	2559	99	89	3	3	2753	1898	70	822	43	30
Total	4573	402	163	8	8	5154	4076	79	1600	39	31
5. NB	4485	207	59	1	3	4755	3858	81	1617	42	34
SB	4252	165	71	1	2	4491	3335	74	1481	44	33
Total	8737	372	130	2	5	9246	7193	78	3098	43	34
6. NB	8198	500	956	18	13	9685	9000	93	2510	28	26
SB	8608	430	898	13	19	9969	9000	90	2561	28	26
Total	16806	930	1855	31	32	19654	18000	92	5071	28	26
Total	84,233	4,206	6,536	135	133	95,243	82,639	87	28,064	34	29

shown in the Table are the cell percentages and the standard errors of the estimates.

As shown in Table 5, the Austin, San Antonio, and San Marcos–New Braunfels areas account for over 75 percent of the O-Ds in the corridor. The relatively high percentage of O-Ds observed for the San Marcos area (23 percent) is particularly significant in terms of the need for an alternate route in the corridor. Since nearly one-quarter of the trips in the corridor have origins and destinations on I-35 between Austin and San Antonio, it seems unlikely that a substantial percentage of these trips would find an alternate route east of I-35 particularly attractive.

The diagonal of the trip table represents round-trips in the corridor. Since the survey questionnaire (Figure 2) requested information concerning origins and destinations on a directional basis (i.e., one-way trip information), the information in the diagonal of the trip table probably stems from "reporting errors." However, the diagonal elements account for only about 6 percent of the total vehicle trips (Table 5) and the resulting error is not considered to be substantial. Any bias resulting from the nonzero values in the diagonal would be in the form of slightly over-estimating long trips. This possible over-estimation of long trips could slightly increase the attractiveness of an alternate route in the corridor.

STUDY COSTS

A summary of estimated study costs is presented in Table 6, which shows the total study cost was $87,500, or approximately $3 per response. The data-collection phase of the study was the most costly, accounting for 57 percent of the total cost and nearly 50 percent of the person-hours expended. The data-collection costs are based on the following field crew manpower requirements.

- *Interstate Highway Survey Crews*
  - 3 Traffic data recorders (volume, classification, occupancy counts, and license plate readings)
  - 5 Survey form distributors
  - 2 Police officers
  - 1 Crew chief

11 Persons/Crew/Survey Station

- *Non-Interstate Highway Survey Crews*
  - 2 Traffic data recorders
  - 3 Survey form distributors
  - 2 Police officers
  - 1 Crew chief

8 Persons/Crew/Survey Station

The traffic recorder and questionnaire distribution personnel estimates each include provisions for one substitute crew member for use when rests become necessary, or in case of an emergency. The data collection costs do not include costs incurred by the SDHPT in implementing the survey station traffic control plans (Table 6).

Student workers were used extensively in the data-collection and keypunching phases of the study. As a result, the

TABLE 5 ESTIMATED 1987 VEHICLE TRIPS BY MAJOR O-D ZONES (7:00 A.M.–8:00 P.M.): ALL VEHICLES

Origins	Destinations						
	M1	M2	M3	M4	M5	M6	Total
M1	586 44.9 0.6	8686 152.6 9.1	10768 138.6 11.3	698 48.9 0.7	76 16.4 0.1	3483 107.7 3.7	24297 242.4 25.5
M2	8867 153.6 9.3	2304 90.0 2.4	5611 120.6 5.9	3774 82.8 4.0	767 51.3 0.8	5554 105.9 5.8	26877 258.7 28.2
M3	11448 136.9 12.0	5630 117.9 5.9	2356 88.6 2.5	1362 60.3 1.4	266 30.4 0.3	760 53.0 0.8	21822 218.8 22.9
M4	671 46.0 0.7	3625 80.3 3.8	1426 58.3 1.5	567 43.3 0.6	51 13.4 0.1	939 57.8 1.0	7278 131.8 7.6
M5	81 16.9 0.1	678 48.8 0.7	229 28.9 0.2	25 9.6 0.0	27 10.1 0.0	963 59.5 1.0	2002 85.1 2.1
M6	3881 115.1 4.1	58855 108.7 6.2	956 60.6 1.0	1082 63.6 1.1	974 60.2 1.0	189 27.6 0.2	12067 192.8 13.6
TOTAL	25533 245.0 26.8	26808 256.8 28.1	21346 222.5 22.4	7509 137.5 7.9	2161 87.9 2.3	11887 182.4 12.5	95243 485.1 100.0

Major Interchange Zones (See Figure 1):
M1 = San Antonio
M2 = Austin
M3 = New Braunfels/San Marcos
M4 = Seguin/Lockhart
M5 = South of San Antonio
M6 = North of Austin

Legend: XXX = Vehicle Trips
XX.X = Standard Error (vehicles)
XX.X = Cell Percent

TABLE 6 STUDY COSTS

Study Phase	Person Hours	Cost[a]
Design/Planning	440	$12,000
Data Collection	2200	50,000[b]
Data Processing		
"Keypunching"[c]	1280	17,000[d]
Editing	160	1,300
Data Analysis[e]	250	3,200
Documentation	200	4,000
Total	4530	$87,500
Cost/Response[f]	0.16	$3.12

[a]Costs include travel-related expenses and fringe benefits.
[b]Includes $14,000 in questionnaire printing and postage expenses. Does not include costs incurred by SDHPT for implementation of traffic control plans.
[c]Data entry for questionnaires, manual volume/classification count data, and license plate data.
[d]Includes $3000 for computer time.
[e]Includes costs incurred in checking the representativeness of the sample.
[f]Based on 28,064 responses (see Table 4).

costs shown in Table 6 for these activities should be viewed as conservative estimates.

CONCLUSIONS

The results of this study indicate that the postcard O-D survey method can be used to develop representative, reliable estimates of intercity travel patterns. The results show that with a good traffic control plan and a well-trained survey crew, this survey method can be safely implemented without causing any substantial traffic delays, even when conducted on high-volume intercity freeways.

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